DEDICATION

This little work is dedicated to the glory of God Almighty, the most gracious father.

ACKNOWLEDGEMENT

By all standard, this project should not have been possible, but many individual have been helpful. I hardly know where to commence the process of thanks, nevertheless I thank God Almighty first, for He is the giver of life.

Next is my supervisor,, Engr. M.D. Abdullahi, for with his fatherly tenderness he mentored me through the completion of the project.

Thanks to friends and colleagues; Emma Ajibola, Kunle Oyinloye, Kunle Elijah, Wumi Alamuoye, Jumoke Akinwale, Jacob Idowu, Wale Anjoorin, Temidayo Ofusori and the body of Christ, many members of one heart, CACSF FUTMinna Chapter.

Miss Grace Akomolafe is wonderful, Lekan Adebayo and all my friends are encouraging all the days long, I thank you all.

Ultimately, I thank all the AJEWOLES in their various domains, most especially my loving father, Pastor Timothy A. Ajewole, my heartfelt thanks to you all.

ABSTRACT

Communication is an important tool in information dissemination and it is always well appreciated when a means of communication is highly effective. This project focuses on the design and construction of a high quality audio amplifier which is to be used as a public address system in lecture theatres or halls in order to enhance the effectiveness of communication by boosting up the audio capacity that a lecturer can discharge during a lecture.

The design and construction procedures of a 20W audio amplifier are highlighted here. The amplifier is designed to be used with an 8ohms loud speaker when powered with a ± 15 V symmetrical supply. Necessary means of tone and volume control is incorporated, as well as filtering and decoupling networks. The amplifying stage was designed with discrete components while the incorporated networks are ICs – based.

The amplifier has been tested and it delivered the expected output power. The output voltage is 0V as expected with the symmetrical supply.

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CHAPTER ONE

1.0 INTRODUCTION

Signal amplification is an important facet of electronic designs. Within nearly every electronic system, it is essential to have an amplifier of some sort, because the small signal associated with electronic circuitry is often too small to get many desired tasks accomplished. To this end, signal augmentation is inevitable.

It is not an exaggeration to say that an amplifier is as essential a device in electronics as regulated d.c. power supply. Amplifier therefore, is an electronic circuit that is designed to raise the current, voltage or power level (as the case may be) of the signal applied to its input and it output the amplified version accordingly.

1.1 AN OVERVIEW OF AUDIO AMPLIFIER

An audio amplifier is a device for increasing the power associated with an electrical signal in audio frequency range. It is often employed for sound augmentation in a public address system, since human voice falls within this frequency range.

To make a complete public address system, an input and an output transducers need be incorporated for the necessary energy conversion. The input signal, which is human voice, is converted from sound energy into an electrical waveform of voltage variation by means of a microphone, which is the input transducer. After the signal is processed, the amplifier then delivers the amplified version of the signal to a loudspeaker, which is the output transducer. This device functions to convert the output signal back into an audible sound wave.

It must be stated that an audio amplifier performs all its duty with an ideally no frequency alteration.

1.2 PROJECT MOTIVATION AND OBJECTIVES

It is easily noticed in this academic system that studies are undergone under a very tensile atmosphere as learning facilities are inadequate, ineffective and inefficient. Lecture Theatres are often filled beyond their capacities and this has led to the use of part of the dinning hall of the University's cafeteria for lectures.

The ever-noisy condition of this hall and other lecture arenas, in no small measures impairs with the effectiveness of communication between lecturers and students since there is a limitation to human audio capacity that a speaker can discharge.

Being part of these sufferings for years, the project is embarked upon since audio amplifier comes into place when voice augmentation is needed.

It is aimed that this amplifier will be of high quality to provide a measure of solution to these challenging situations. Its design will make it cost-effective both in construction and running to enhance affordability, so that each Lecture Theatre/Hall will be provided with one. The cost-effectiveness is not acquired by quality trade-off meanwhile.

1.3 LITERATURE REVIEW

Every amplifying circuit increases the amplitude of a given input signal. A small a. c. Signal fed into the amplifier is obtained as a large a.c. signal of the same frequency at the output. Depending on the nature and level of amplification, and impedance matching requirement, there are different types of amplifiers.

These classifications may base on:

i. Transistor Configuration: -- Common Base, Common Emitter or Common Collector Amplifiers.

ii. The Active Device: -- Junction Transistors (BJT) or Field Effect (FET) Transistors Amplifiers.

iii. Operating Condition: -- Class A, Class B, Class AB or Class C Amplifiers.

iv. Number of Stages: -- Single stage or Multistage Amplifiers.

v. Frequency Response_ Audio Frequency, Intermediate Frequency or Radio Frequency Amplifier.

The design of this project is an audio (power) amplifier using transistors as components.

1.3.1. TRANSISTORS AMPLIFIER

The basic building block for an amplifier is transistor. Design of amplifying circuits has also been made easy with the advent of ICs yet; transistors remain the main active components. These come in two families of Bipolar Junction Transistors (BJT) and Field Effect Transistors (FETs). BJT is more common and it is a three terminal discrete device that comes in either NPN or PNP. The three terminals are the Emitter, the Base and the Collector.

When transistor is connected in any of the three basic configuration of Common Base, Common Collector or Common Emitter, it becomes an amplifier.

The connections are shown in figure 1.1(a)-(c).

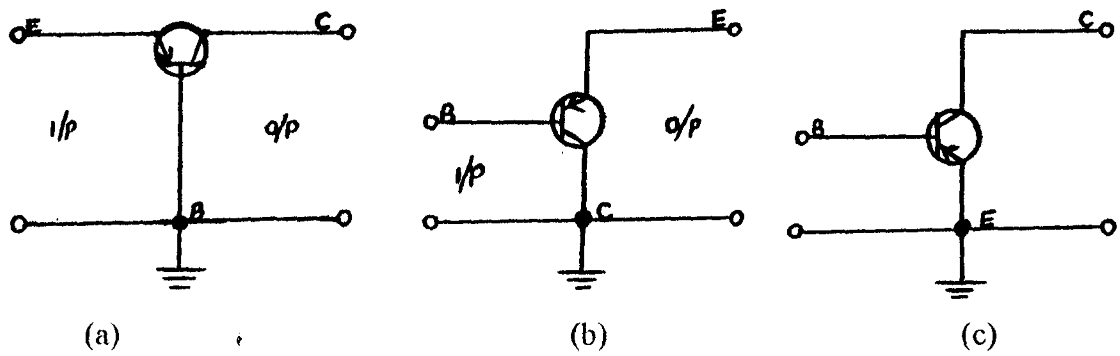


Fig. 1.1

COMMON BASE MODE: As shown in fig. 1.1(a) the base lead is common to both input and output.

COMMON COLLECTOR MODE: The collector lead is common in this case as shown in fig.1.1(b) above.

COMMON EMITTER MODE: In this mode emitter lead is common to both input and output signal. Fig. 1.1(c)

$$V_{CC} = V_{BE} + I_B R_B$$

$$I_B = (V_{CC} - V_{BE}) / R_B$$

$$I_C = B I_B$$

$$V_{CE} = V_{CC} - I_C R_C$$

The common Emitter Configuration is often employed for amplification purposes because of its large current, voltage and power gains and voltage shift of 180.

1.3.2. TRANSISTOR BIASING AND STABILISATION

For proper operation of transistor input signal is superimposed on D.C signal so that both half cycles of the signal will be effective. The process of setting this operating point for a transistor is known as biasing. The actual biasing current must be set at a value which allows equal changes in input current for equal positive and negative swing. The fundamental principle of biasing is that the Emitter Base (EB) junction is forward biased and Collector – Base (CB) junction is reverse-biased. This is achieved by the following methods.

FIXED BIAS This is also called base biased as the bias current is supplied through a base resistor. It is given in fig.1.2 (a).

$V_{CC}=I_BR_B+V_{BE}+I_ER_E$

$I_B=I_C/B$ and $I_E=I_C$

$V_{CC}=I_CR_L+V_C$

$V_C=V_{CE}+V_E$

FEEDBACK BIAS When the stabilization is provided via collector voltage, this is known as feedback bias or collector bias. Fig. 1.2(b)

$$V_{CC}= V_C+[I_B+I_R] R_L$$

$$V_C= I_BR_B+V_{BE}$$

POTENTIAL DIVIDER BIAS This is the most employed biasing. An emitter resistor is involved and so called emitter bias. Fig 1.2©

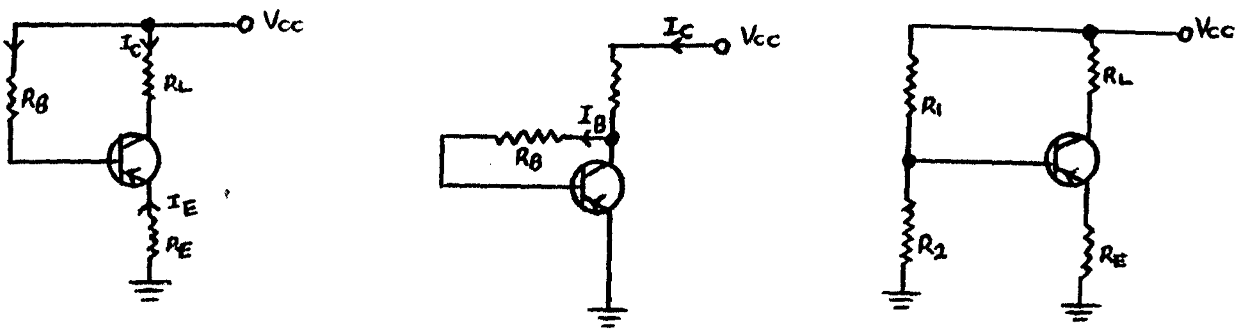
$$V_{CC}= V_{CE}+I_CR_L+I_E R_E$$

$V_{CE} = V_C - V_E$

$V_C = V_{CC} - I_C R_L$

$V_E = V_2 - V_{BE}$

$V_2 = V_{CC}[R_2/R_1+R_2]$



(a) (b) (c)

Fig. 1.2

1.3.3 AMPLIFIER CLASSIFICATION

Output power and efficiency are the main consideration in audio amplifier. For an appreciable output power, the large amplitude input signal is necessary in order to obtain large swing of output current and voltage. Transistors used in power amplifier must be chosen and biased that maximum current, voltage and power rating are not exceeded.

Based on the amount of bias, amplitude of input signal as well as the cycle for which the transistor conducts, amplifiers are classified into classes: A, B, AB and C.

CLASS [A] AMPLIFIER

Class A amplifier is the one whose transistor is so biased that the current flows in the output during the whole period of input. It operates over a linear region. Such amplifier is characterized with low distortion, low signal output and low efficiency of the order of 50%. The graphical representation is as in fig. 1.3 below:

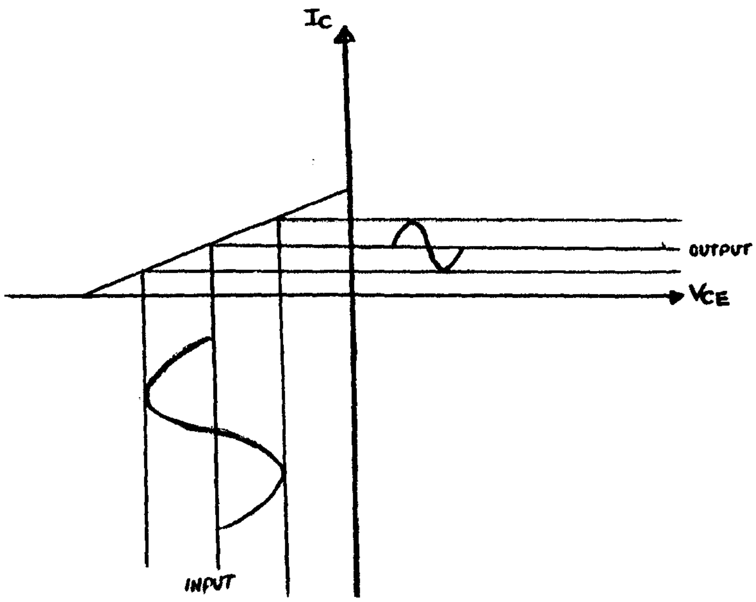


Fig. 1.3 Class A amplifier

CLASS [B] AMPLIFIER

The biasing of class B amplifier makes the operating point and the input signal to be such that the current flows in the output for half cycle of the input. This has efficiency up to 80% in an ideal sense. The output is considerably distorted.

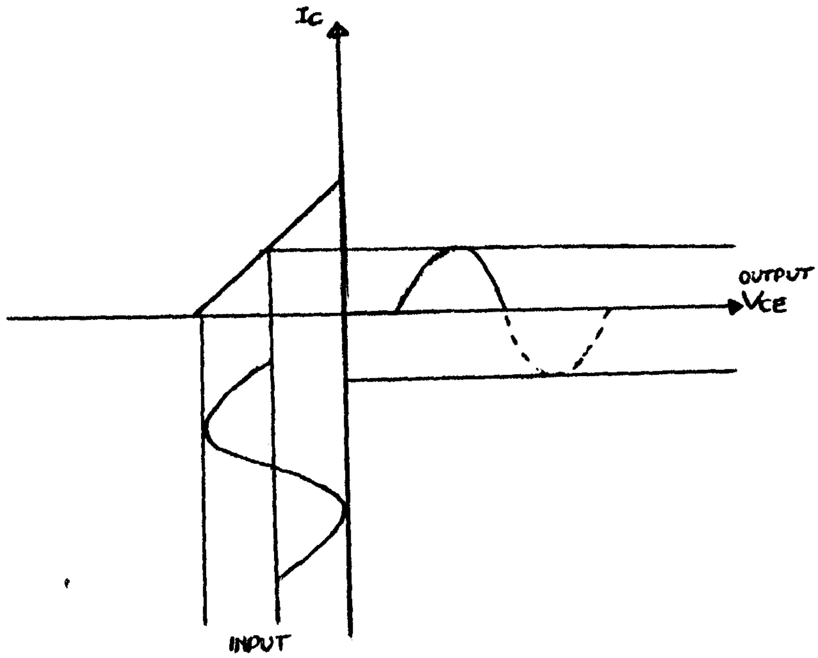


Fig. 1.4 Class B amplifier.

CLASS [AB] AMPLIFIER

This amplifier is the one in which a compromise is reached between low distortion of class A and high efficiency of class B. It is basically a class B amplifier that employs two identical transistors that are configured in push-pull.

A COMPLEMENTARY SYMMETRY push-pull class B amplifier is an improvement of push-pull. Two power transistors of the same type with closely matched parameters but oppositely-doped are employed. One is NPN while the other is PNP.

DESIGN AND CONSTRUCTION OF A 20WATT AUDIO AMPLIFIER

BY:

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

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IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.Eng.) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING.

SEPTEMBER 2003.

DECLARATION

I, AJEWOLE TITUS O. of the Department of Electrical and Computer Engineering, Federal University of Technology, Minna, hereby declare that this project is an original concept, wholly and solely carried out by me.

AJEWOLE TITUS O.
Student

....
Signature and Date

CERTIFICATION

This is to certify that this project titled: DESIGN AND CONSTRUCTION OF A 20 W AUDIO AMPLIFIER was carried out by AJEWOLE TITUS O. under the supervision of Engr. M.D. ABDULLAHI and submitted to the Department of Electrical and Computer Engineering, Federal University of Technology, Minna.

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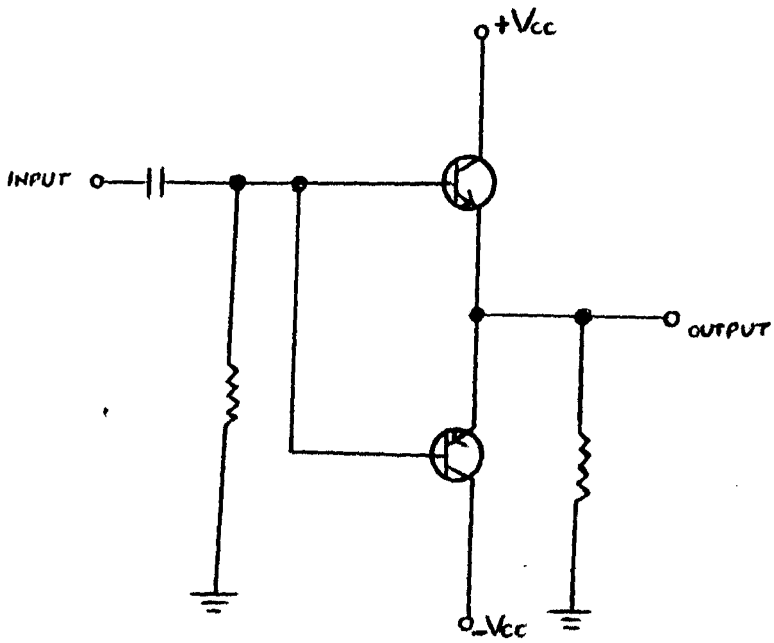


fig. 1.5 Push-Pull COMPLEMENTARY SYMMETRY amplifier

1.4 PROJECT OUTLINE

High quality is aimed at, in the design of this amplifier. That is, undesired by-products of audio signal processing are kept at an absolute minima. These impairments manifest as noise, hum or distortion and they are common phenomena whenever an audio signal is processed through electronic circuit.

This thesis outlines the procedures involved in the design, construction and testing of the amplifier. Chapter one provides an introduction to the amplifier The aims and objectives; literature review and the project outline are also featured in this chapter.

Chapter two contains the steps involved in the system's design. It includes the block diagram of the complete amplifier system, as well as its operating principle. It shows the breakdown of each design step of the decoupling network, speech filter, the tone control, the pre-amplifier stage, as well as the output stage. It also includes the design of the power supply unit.

In the third chapter, the construction and testing of the amplifier is discussed.

Chapter four contains the conclusion and recommendation for future upgrading of the project.

CHAPTER TWO

2.0 SYSTEM DESIGN

The design approach that was adopted in this project work is the Top-Down design methodology. The design process is broken into simpler modules and the stages are organized in a logical order for simplicity of analysis and synthesis.

Fig 2.1 below shows the block diagram of each stage of complete system.

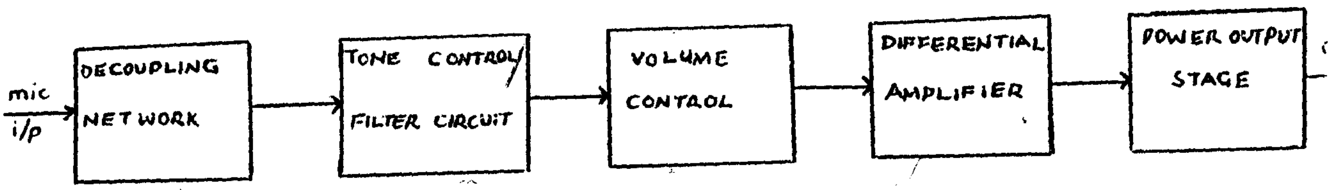


Fig 2.1 block diagram of the complete system.

2.1 OPERATING PRINCIPLES OF THE AMPLIFIER

The microphone converts the sound wave to electrical energy in the form of voltage at a very low level. The decoupling network serves to remove humming from the input signal while the next stage functions as noise filter as well as tone control. This stage is basically a band-pass network.

For necessary volume variation, a volume control stage is incorporated and the next stage to that is the differential amplifier stage. This stage provides the necessary signal pre-amplification to raise the low level signal from the microphone to a higher-level power, enough to drive the power stage. Differential amplifier is employed here because of its high throughput in term of hum shielding. Feedback can also be easily effected with it.

Power output stage, which is the last stage, delivers the expected 20watts to an 8ohms loudspeaker. The two output transistors involved are connected to work in complement. There is also a third transistor that serves as driver for the first two. This driver is needed because the power input required for the output transistors is so large that supplementary is needed. For the output, the driver through their base electrodes feeds the two transistors with input signal in parallel. A positive signal makes the NPN transistor activated and so positive voltage is produced across the load R_L. When the input signal is negative, the PNP transistor is energized and produces a negative voltage across R_L. The schematic diagram of the power amplifier is given in fig 2.2 below.

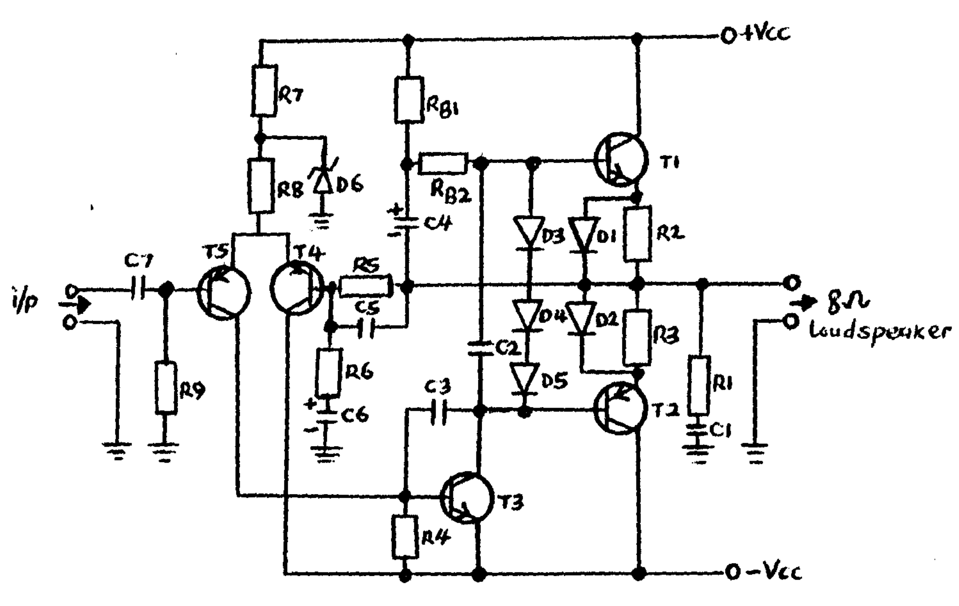
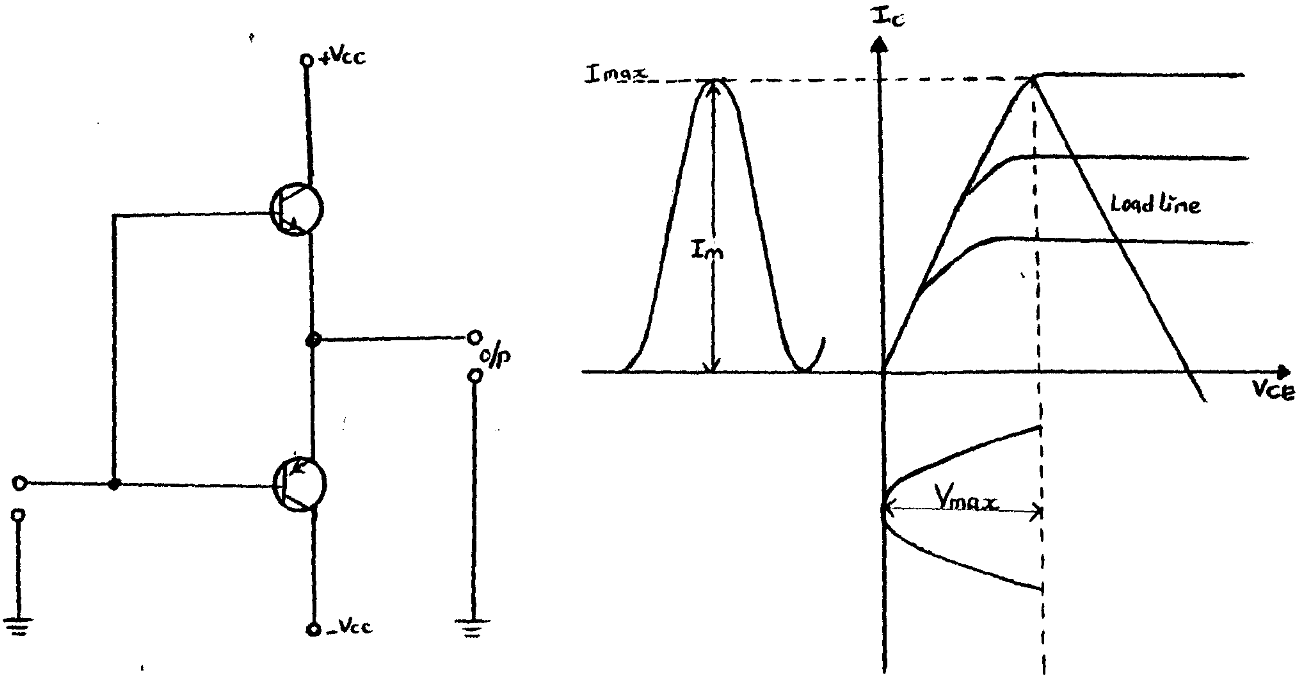


Fig. 2.2 The schematic circuit diagram of the power amplifier.

2.2 DESIGN OF THE POWER OUTPUT STAGE

The matched pair of transistor s employed in this stage is connected in complementary emitter follower. Emitter follower provide negative feedback, thus high stability is obtained. Good impedance matching is also obtained due to its low output impedance.



(a) (b)

Fig2.3

From the above, fig 2.3(a) shows the output stage and (b) shows the graphical representation.

$P_L=(Im/\sqrt{2})\ x(Vm/\sqrt{2})=(ImVm)/2$

$V^2/2R_L=(V_{cc}-V_{min})^2/2R_L$

The average current in that half cycle rectified waveform

$I_{av}=I_m/\pi=Vm/\pi R_L$

The supplied power is obtained by

$P_{dc}=(2V_mV_{cc})/\pi R_L$

With a supply of $\pm V_{cc}$ collector efficiency is

$\int = P_L/P_{dc} = (V_m^2/2R_L) \text{ X } (\pi R_L/2VmVcc) = (\pi Vm/4Vcc)$

Thus efficiency is proportional to Vm and maximum efficiency occurs at maximum signal level (i.e. Vm=Vcc)

$\int max = \pi/4 = 78.5\%$

and $P_L(max)=(I_mV_{cc})/2=V_{cc}^2/2R_L$

The power dissipated per each transistor is given by

$P_C=0.5[\ Pdc-P_L]$

$=0.5[\ 2V_mV_{cc}/\pi R_L-V^2_m/2R_L]$

$=(V_mV_{cc})/\pi R_L-(V_m^2/4R_L)$

For class B the quiescent collector dissipation is zero. To find the maximum power dissipation $dP_c/dV_m=0$

$dP_c/dV_m=V_{CC}/\pi R_L-2Vm/4R_L=0$

$Vm=2Vcc/\pi$

$Pc(max)= 2V_{CC}^2/\pi^2R_L-4V_{CC}^2/\pi^2 4R_L=V_{CC}^2/\pi^2R_L$ (per transistor)

Now for the design, fig 2.2shows then power output stage when the amplifier discharges 20watts maximum.

$P_Lmax=V_{CC}^2/2R_L$

$20=V_{CC}^2/2 \text{ x}8$

$V_{CC}=\sqrt{(2 \text{ x } 8 \text{ x } 20)}$

$=17$

$\approx 15V$

The maximum power that each transistor T_1 and T_2 is to handle

$P_c max = V_{CC}^2/\pi^2 R_L$

$= 15^2/(3.142^2 \times 8) = 2.849W$ (per transistor)

The maximum collector current for each transistor T_1 and T_2

$I^2 max\ R_L = P_L(max)$

$Ic(max) = \sqrt{P_L(max)/R_L}$

$\sqrt{20/8} \quad = 1.5811A$(per transistor)

Based on the above values, the transistor s were chosen having power and current ratings far greater than the calculated values for safety of operations. Thus, TIP120 and TIP125 were chosen using data book.

For the base current of each transistor

$I_C = h_{FE}\ I_B$

$I_B = I_C/h_{FE}$

The h_{FE} for both T_1 and T_2 is 1000

$I_B = 1.5811/1000$

$= 0.00158$ [redacted]A

$\therefore I_{B1} = I_{B2} = 1.58mA$

Total biasing current for both transistors is

$I_{BT} = I_{B1} + I_{B2}$

1.58 +1.58

3.16mA

R_{B2} was chosen to be 1 kΩ as biasing resistor for both transistors. Voltage across resistor R_{B2}

$V_{RB2}=I_{BT}\ xR_{B2}$

3.16mA x1000

3.15 V

The voltage across R_{B1} is obtained by

$V_{RB1}=V_{CC}-V_{CC}/2-V_{RB2}-2V_{BE}$

Since both T_1 andT_2 are silicon made, $V_{BE}=0.6$

$\therefore V_{RB1}=15-7.5-3.16-12$

$=3.14V$

But, I_{BT} flows through R_{B1} also

$\therefore R_{B1}=V_{R2}/I_{BT}=3.14/0.00316$

$993.67\Omega \approx 1K\Omega$

In order that the complementary pair $T_1$and T_2 is correctly biased diodes D_3 –D_5, forward biased by source voltage is used to link the base of the transistors.

For the driver network, the operating point currently flowing through the collector of transistor T_3 is I_{C3} and approximately equal to the current through the base of transistor T_2, and current flowing through the diodes. This is approximately twice the current flowing through the base of T_2.

$I_{C3} \approx I_{BT} = 3.16mA$

Voltage at the collector of T_3 at operating point

$V_{C3}=V_{CC}-0.6$

$=14.4$

Since T_3 is also a silicon transistor (V_{BE}=0.6), henceT_3 must handle at least ($I_{C3}V_{C3}$) W, which is equal to 0.0455W.So transistor T_3 was chosen to handle at least four times the power calculated. With data book BD139 was chosen

2.3 THE DIFFERETIAL AMPLIFIER STAGE DESIGN

The differential amplifier consists of two basic CE amplifiers having their emitters directly coupled to each other. It may be operated either in single ended or double-ended mode. Fig 2.4 below shows how a differential amplifier can be used to accept two inputs by means of $t_1$and ground and also t_2 and ground. It can provide two separate outputs by means of t_3 and ground and t_4 and ground. It can also provide a single output between t_3 and t_4 that is, differential output.

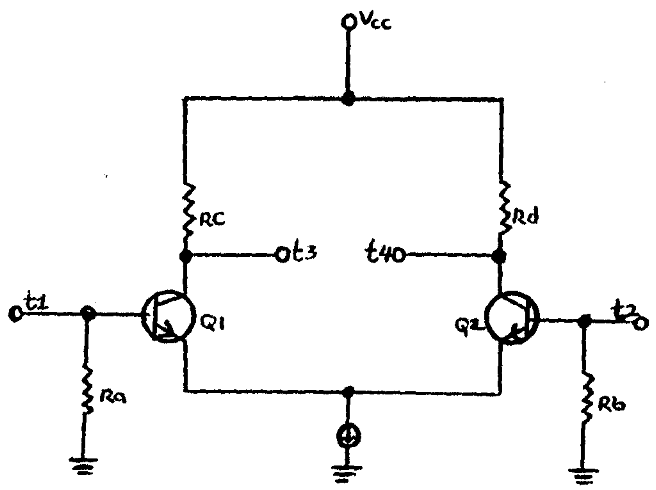


Fig2.4 differential amplifier

A balance differential amplifier in which Q_1 and Q_2 are identical and their associated component are matched. In that case, each amplifier stage produces the same voltage gain.

$A = r_0 / r_e$ where r_0=Rc or Rd

$r_e = 25mV/I_E$

The output voltage between terminals T_3 and T_4 is

$Vo\ (t_3 - t_4) = A(v_1 - v_2)$, where A =voltage gain of each transistor.

A differential amplifier was preferred in this design because it gives higher gain than two cascade stages of ordinary direct coupling. It also eliminates the use frequency dependent coupling and bypass capacitors. It provides very uniform amplification of signal from DC to very high frequency.

For the design of this special amplifier stage, resistor R_7 and zener diode Z_1 were chosen to keep the voltage above resistor R_8 at 12V in order to prevent humming from the supply. R_7 was chosen to be 470Ω. The voltage across the R_7 must be

$V_{R7} = 15-12$

$= 3V$

Therefore the current flowing through R_7 will be

$I_{R7} = V_{R7}/470\Omega = 3/470$

$= 0.006382978A$

$= 6.38mA$

For a current of at least 1.07mA to flow in each of transistor T_4 and T_5, then the current to flow in resistor R_8 will be

$I_{R8} = 2x1.07mA$

$= 2.14mA$

$R_8 = 12V/I_{R8} = 12/2.14mA$

$= 5607.5\Omega$

$\approx 5600\Omega = 5.6k\Omega$

Current through the zener diode will be

$$Iz = 6.38mA - 2.14mA$$

$$= 4.24mA$$

Therefore the zener diode Z_1 was chosen to be of 12v, 500mW.For each of T_4 and T_5;

$$Ic \approx I_E$$

$$\therefore Ic \approx 1mA$$

For this, taken resistor R_4 to be 1kΩ, then the power delivered by each transistor T_4 and T_5 is

$$P = I^2{}_C x R$$

$$= 1^2 mA x 1000$$

$$= 1mW$$

Transistors T_4 and T_5were chosen using data book as BC 161-16.

2.4 THE VOLUME CONTROL

It is often necessary to provide a manual means for setting or adjusting the gain of an audio amplifier. A variable resistor serves a good purpose in this respect. The main concern here is the placement of the variable resistance in a transistor circuit for this purpose, as there is no isolation between the stages, therefore the choice of location for the control requires a great deal of study. In deciding upon the location attention was paid to the followings:

i. The volume control should usually provide for complete alternation of the signal,

ii. DC biasing must not be upset by the adjustment of the control.

iii. Overall frequency response should not suffer as a result of changed impedance level

iv. The load on a stage should not be shifted by the adjustment of the control because of distortion considerations.

v. Location of the control must not be too near the circuit input for the signal/ noise ratio may be adversely affected. Neither should it be too near the output lest the prior stages be overloaded.

vi. Direct current through the control will contribute to circuit noise.

In nearly all installations, a compromise results, as circumvention of all the limitations poised by the items listed is impossible. So the volume control was chosen to be a 50k pot. and placed between the tone control circuit and the pre-amplifier (differential amplifier) to prevent impedance mismatching.

2.5 THE TONE-CONTROL CIRCUIT

The tone control is basically a band pass filter. This circuit is incorporated to serve the purpose of tone controlling as well as noise filtering. As a tone control, the frequency response of the amplifier is varied. This means that high-frequency (treble) or low-frequency (bass) are amplified to a higher or a lesser degree.

As a noise filter, the circuit has a lower cut-off and higher cut-off frequencies. Any signal frequency e.g. noise that does not fall within this frequency bandwidth is filtered away. The number of passive components is few, only capacitors C_9 and C_{10} are needed for the frequency control.

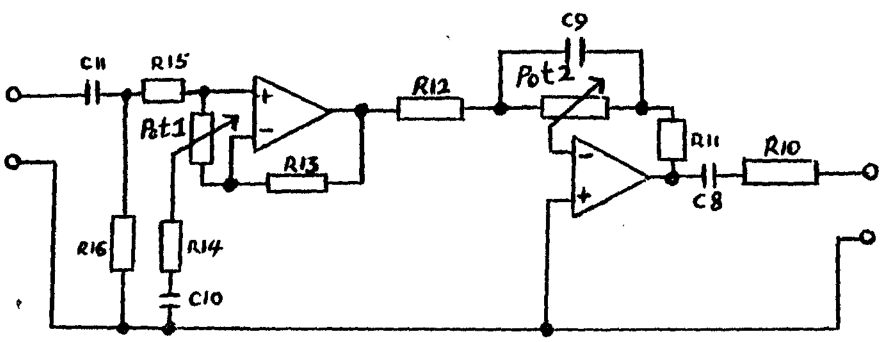


Fig. 2.5 The tone control circuit.

2.6 POWER SUPPLY UNIT

A symmetrical +/-15V line powers this amplifier. The reason for this is that this enables the central (0V) potential to be earthed so that the amplifier can swing in either positive or negative directions.

The power supply designed here provides a regulated output voltage of +/-15V. Based on 4.5-watt transformer, the power unit can provide a current up to 140mA.

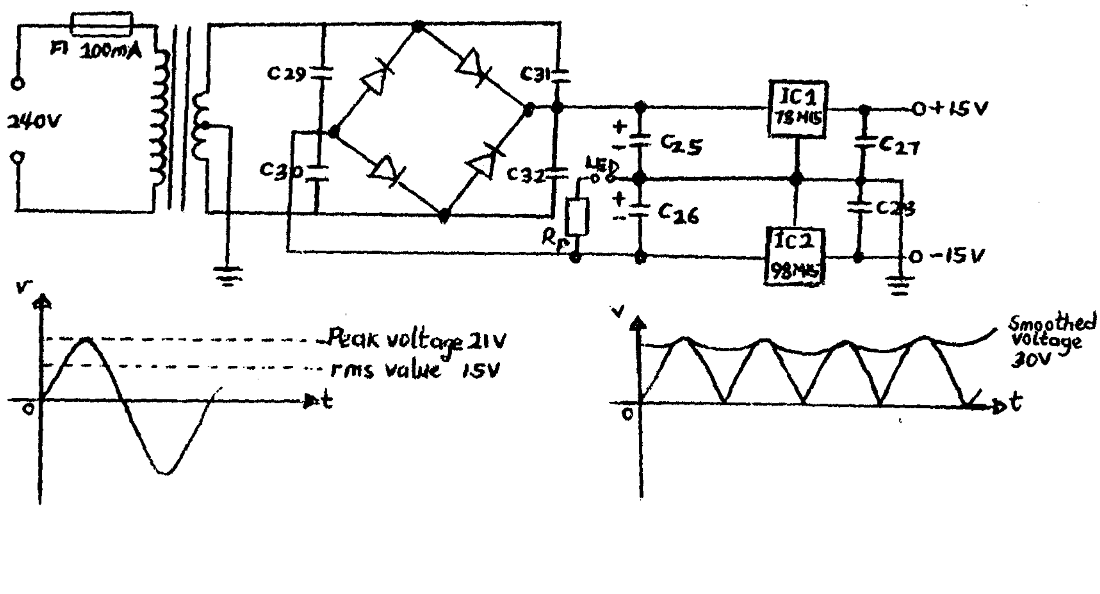


Fig. 2.6 The power supply unit.

The transformer employed is 240V/2x15V centretapped transformer is used for step-down. The secondary voltage is rectified by a 200 PIV 6A rated bridge rectifier, rectifies the voltage and two capacitors rated 2200/35V are used for smoothing. IC_1 78M15 stabilizes the voltage across C_{25} to +15V. This voltage is further smoothened by C_{27}. Also IC_2 98M15 stabilizes the voltage across C26 to −15V and further smoothened by C_{28}. Resistor Rp provides facility for connecting an off/on LED indicator.

CHAPTER THREE

3.0 DESCRIPTIONS, CONSTRUCTION AND TESTING

This chapter gives the details of description of the complete system as well as the construction procedure and finally the testing.

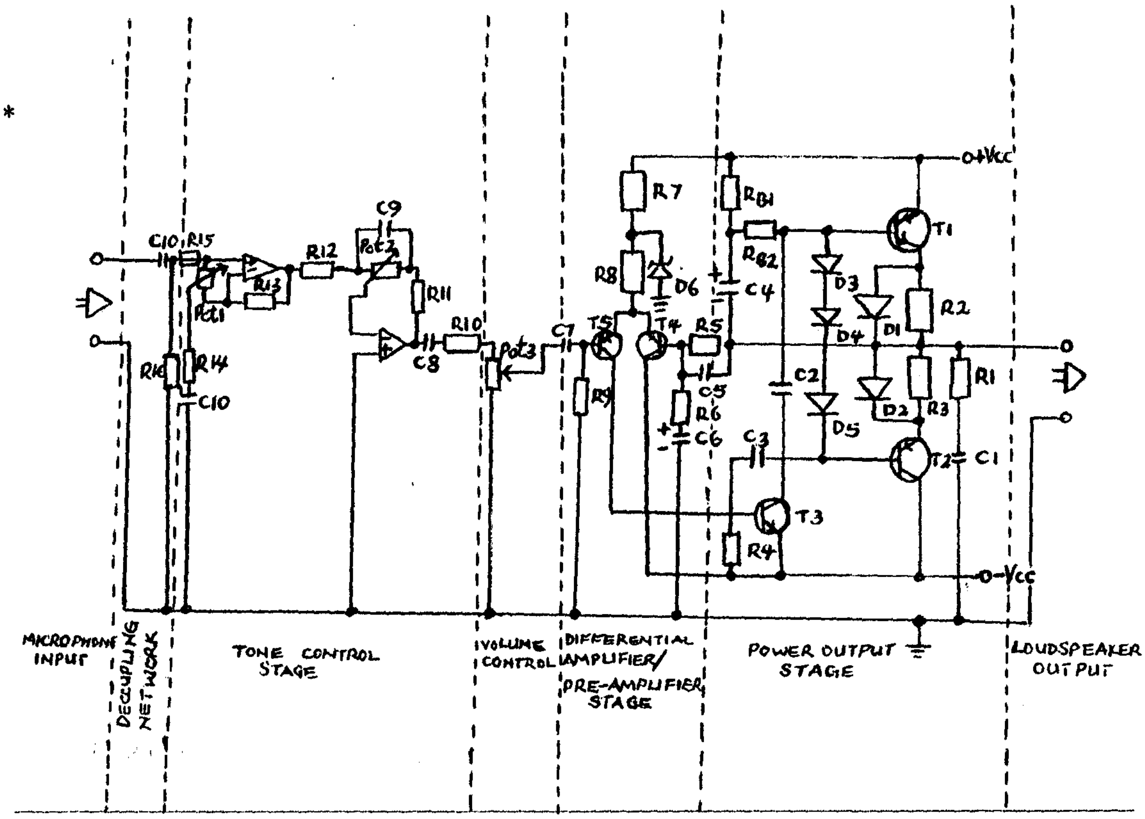


Fig 3.1 Circuit diagram of the complete audio amplifier

3.1 DESCRIPTION OF THE SYSTEM

The input into the amplifier is from a microphone, considerably the dynamic type. The input signal is decoupled by C_{11} and R_{16}. A decoupling network shields the circuit from humming that is associated with the input signal as a result of the wiring of the input transducer. The signal is then applied into op-amp A1 (TL084) that provides treble control. Capacitor C_{10} limits the control to high frequency. When Pot1 is fully anticlockwise R_{15} and C_{10} form a low-pass section at the inverting input of the op-amp. Resistor R_{14} provides the maximum attenuation in the highest frequency range.

When Pot1 is fully clockwise, $R_{13}$and C_{10} form low-pass in feedback loop that provides a completely different frequency response, so high frequency are lifted.

For bass-control, op-amp A2 (TL084) is in operation. Ignoring C_9 this stage becomes a standard inverting amplifier. When Pot2 is fully anticlockwise, it forms a series network with R_{12}.The amplification of the stage is then bellow unity. When Pot2 is fully clockwise, it forms a series network with resistor $R_{11}$and amplication is greater than unity. When wiper of Pot2 is anywhere between the extreme positions one part of pot's resistance is in series with R_{12} and the other part with R_{11}. Capacitor C_9 shot circuits Pot2 at midrange and treble frequencies that the pot acts on bass frequencies only. R_{10} and C_8 couples the signal to the volume control.

From the volume control the signal goes to the base of transistor T_1. $T_1$and T_2 forms a differential amplifier. Potential at base of T_2 is compared with input voltage (at the base of T_1). When the base voltage of T_2 is higher than T_1, $T_1$is on, since potential across base-emitter junction is about 700mV whereas that of $T_2$is lower (soT_2 cannot conduct). The base of T_3 is driven by T_1 so that T_3 and is on and connects the bases of T_4 and T_5 to ground: the output of the circuit then drops. Since the output is dropped across potential divider R_6 and R_5, it drives the base of T_2. Consequently, the base potential of T_2, which at the onset was slightly higher than that of T_1, drops until the base voltage of the two transistors of the differential amplifier is equal. This kind of operation is basically identical to that of an operational amplifier with feedback. This means that the circuit controls the output voltage so that the base potentials of T_1 and T_2 are ideptical. The ratio of resistors R_6 and R_5 determines the amplification of the circuit.

Diode D_6 and resistor R_7 hold the voltage the upper end of R_8 stable at about 12V to ensure that any hum on the supply lines is suppressed. Diodes D_3, D_4 and D_5 generates the requisite base bias voltage for the Darlington transistors. The value of emitter resistors R_2 and R_3 is relatively high, which makes setting the quiescent current unnecessary. To keep the dissipation in the emitter resistors low, diodes D_1 and D_2 ensures that the maximum voltage drop across them cannot exceed 700mV.

Network R_{B1},R_{B2} and C_4 are bootstrap circuits, which ensure that when, for instance, the base voltage of T_4 rises by 10V, the output voltage of the circuit, rises by the same amount. Capacitor C_4 raises the voltage at the junction of $R_{B1}$and R_{B2} by 10V The means that the potential at both ends of R_8 is lifted by the same amount, so that the drop across the resistor, and the current through it, remains unchanged irrespective of the out put.

Capacitors C_1, C_2, C3, C_5 and resistor$R_1$are not part of the operation of the circuit: they serve merely to suppress any spurious oscillations

3.2 CONSTRUCTION

The construction of the design involved all the units. These were constructed on a 9.5 by 4.5inch Vero board. The materials used were soldering iron, soldering led, desoldering pump and connecting wires.

The power supply unit consists of center-tapped transformer, rectifier, filter capacitors and voltage regulators. All were constructed on vero board except the transformer. The regulators were constructed with heat sink.

The tone control consists of two ICs TL O84, IC sockets were used for these to prevent excessive heat. Transistors TIP 120 and TIP 125 were connected to heat sinks. All other circuit components; resistors, capacitors, volume controls were connected directly.

A lot of etching work was done and since etching solution was not available, blade was used for etching purpose.

The following points were considered when soldering:

(a) All connections were made shinning rather than dull

(b) Excess solder were removed

© It was made sure that the solder flowed as a smooth paddle rather than a round ball.

(d) All pieces of solder crossing the copper traces were broken with a soldering ion.

3.3 PROJECT CASING

The casing was constructed using both wood and mild steel sheet. The front and back views were made with metal sheet while other sides were wooden. Instruments used were drilling machine, sharing machine, hacksaw, hammer, measuring tape and screws.

3.4 TESTING AND RESULT

Each unit was tested at every stage and results were drawn. For the power unit, when power is delivered from the main unit, the LED lights. The secondary output of the transformer was 24V(12V-12V center-tapped). Output of the regulator was +/-15V, all these tested with digital machine.

The tone control was tested separately with signal from a signal generator also the amplifier. The output voltage of the amplifier without input signal is 0.003V.This compared favorably to the expects 0V.The output power, when tested is lower than the expected value. This can be attributed to the fluctuating power supply. Because at time this test was carried out, the supply was 175V instead of 240V.

CHAPTER FOUR

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSION

This project "Design and Construction of a 20watt Audio Amplifier" achieved its objective within a reasonable degree of efficiency. The output is fairly constant within the frequency range of 64Hz – 16KHz when tested with a signal from a signal generator. This agrees with the expectation.

This project might be thought to be a simple task considering its commonness, but practically it is not so when the unavailability and market price of many components is considered. Most of the components used had to be transported from far places and those that are readily available are too exorbitant in price.

However, within the limit of available components used and experimental error, the aim of the project was reasonably achieved.

4.2 RECOMMENDATIONS

For future work on this project, a Computer Aided Design may be employed. Using packages like Tina, Electronic Workbench or Spice for necessary simulation. Also a single IC chip called BA 54 06 can also produce the needed 20watt audio amplification.

This circuit can also be built as a 20W, 40W, 60W, 80W or 100W amplifier. The output power depend entirely on the value of R_6 and R_7, the type of transistor used for T_1 and T_2 and on the level of power supply voltage. The table below will help such future work.

Power Output	Power Supply	T_1	T_2	R_6	R_7
20W	+/-15V	TIP120	TIP125	390Ω	470Ω
40W	+/-20V	TIP 120	TIP125	270Ω	1.2KΩ
60W	+/-24.5V	TIP130	TIP135	220Ω	1.8KΩ
80W	+/-28V	TIP141	TIP146	180Ω	2.7KΩ
100W	+/-32V	TIP141	TIP146	180Ω	3.3KΩ

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THE TABLE OF COMPONENTS' VALUES.

TRANSISTORS:

Components	Values
T_1	TIP120(NPN)
T_2	TIP125(NPN)
T_3	BD139(NPN)
T_4,T_5	BC161- 16(PNP)

DIODES:

Components	Values
D_1,D_2,	IN4001
D_3,D_4,D_5	IN4148
D_6	Zener Diode 12V/500mW

RESISTORS:

Components	Values
R_{B1},R_{B2}	1K(0.5W)
R_1	1Ω
R_2,R_3	1.5Ω
R_4	1K
R_5	10K
R_6	390Ω
R_7	470Ω
R_8	5.6K
R_9	22K
R_{10}	470Ω
R_{11},R_{12}	1K
R_{13}	10K
R_{14}	1K
R_{15}	10K
R_{16}	100K
Pot1,Pot2	10k Linear
Pot3	50k log

CAPACITORS:

Components	Values
C_1	100nf
C_2	470nf
C_3	47pf
C_4	470uf/25V
C_5	150pf
C_6	220uf/16V
C_7,C_8	1uf
C_9	470nf
C_0	10nf
C_1	330nf
C_2,C_{26}	2200uf/35V
C_2,C_{82},C_{29},C_{30},C_{31},C_{32}	100nf