DESIGN AND CONSTRUCTION OF 20WATTS WIRELESS PUBLIC ADDRESS SYSTEM

BY

EMEH HENRY NNAEMEKA

EE/2008/293

DEPARTMENT OF ELECTRICAL/ELECTRONIC ENGINEERING

FACULTY OF ENGINEERING

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AUGUST, 2013.

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BEING A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/ELECTRONIC ENGINEERING

FACULTY OF ENGINEERING, CARITAS UNIVERSITY, AMORJI-NIKE, ENUGU.

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL/ELECTRONIC ENGINEERING.

AUGUST, 2013.

CERTIFICATION

This is to certify that this project "The Design and Construction of a 20Watt Wireless Public Address System" was carried out by EMEH HENRY.N. and submitted to the department of Electrical/Electronic Engineering, Faculty of Engineering, Caritas University, Amorji Nike Enugu. For the award of a Bachelor of Engineering (B.Eng.)

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Engr. Ejimofor C.O *Head of Department*	Date
________________________	________________________
External Examiner	Date

DEDICATION

I dedicate this project to God Almighty for his unlimited and inexhaustible mercies and love upon my life. I also want to use this singular medium to dedicate this work to my wonderful family.

ACKNOWLEGEMENT

I sincerely want to appreciate my distinguished parents Mr.& Mrs. G.C Emeh for their love and parental care, Dean of Engineering, Engr. Prof. S.N. Ojobor , my honourable Head of department , Engr Ejimofor C.O, for his fatherly teachings and training. I thank you for the knowledge you have imbibed in us. I pray that God will keep you strong for your family.

I want to appreciate my God father, Engr. E.C. Aneke for his tremendous contributions to this work and advice he gave me during the course of this work. God bless you Sir.

I won't forget my distinguished project coordinator Engr. P.N. Mbah for his support and guidance and special thanks and gratitude goes to all my lecturers Engr. Prof. G.C. Ochiagha, Engr. Ochi, Engr. M.O. Ezeh, Engr Okonkwo, Engr. Ozoani, Engr. Emesoba, Engr. Chijioke because they made me who I am today through their teachings and training to become an Engineer. God bless you all.

Finally, I appreciate all my course mates, all my friends who have in one way or the other contributed immensely to the construction of this project. May God bless us all.

ABSTRACT

It has become inevitable that there would be communication and due to the inherent limitation of the human voice, the public address system came to being. A public address or "*P.A SYSTEM*" is an electronic amplification system with a mixer ,amplifier and loudspeakers, used to reinforce a given sound , e.g a person making a speech, pre-recorded music ,or message and distributing the sound throughout a venue . The voice signal is passed through a microphone , which converts the sound energy to electrical energy, the energy electrical signal being transmitted is been received and amplified by the amplifier circuit. The amplifier's output is fed into the loudspeaker which converts the electrical energy back to the original form but amplified sound energy. This project is made up of the power supply unit, the pre-amplifier and power amplifier units, and the tone control unit. This system is capable of delivering 20W of electrical power into a 8 ohm load(loudspeaker).

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Fig 1: A picture of a modern wireless public address system

A public address system allows you to broadcast information to a large group of people, whether you are giving a speech or playing live or recorded music.

Public address systems typically consist of input sources, preamplifiers, control and monitoring equipment, and loudspeakers. Input sources refer to the microphones that provides a sound input for the system. These input sources are fed into the preamplifiers. The pre amplified signals are then passed into the audio power amplifiers.

These amplifiers will amplify the audio signals to an adequate speaker line level. In view of the above, one can now say that the public address system is an electronic amplification system used for communication in public areas.

Microphone is a device that converts sound waves into electrical waves. Some times colloquially called a micro mike is an acoustic-to-electric transducer or sensor that converts sound into an electrical signal. Microphones are used in many applications such as telephones, hearing aids, live and recorded audio engineering, in radio and television broadcasting and in computers for recording voice, and for non-acoustic purposes such as ultrasonic checking. The sensitive transducer element of a microphone is called its element. Since a wireless microphone is used in this project; a wireless microphone is one in which communication is not limited by a cable.

A transmitter is extremely important equipment and is housed in the broadcasting station. Its purpose is to produce radio waves for transmission into space. The important components of a transmitter are microphone, audio amplifiers, oscillator and modulator.

It usually sends its signal using a small FM radio transmitter to a nearby receiver connected to the sound system, but it can also use infrared light if the transmitter and receiver are within sign of each other. The transmitter are responsible for taking in the signal from the microphone, modulating it, and transmitting it to the receiver using radio waves.

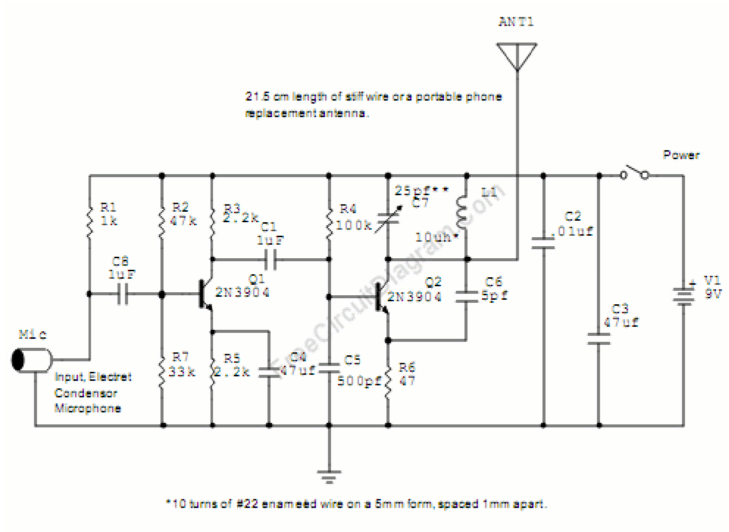


Fig2:A transmitter circuit

The first transistor (Q1) is the pre-amplifier for the microphone, and you can omit this circuit if you don't want to transmit the sound picked up by the mic, for example you can connect your mp3 player directly to C1. The core of this FM transmitter circuit is Q2, a modified Culprits oscillator that the frequency is determined by L1, C4, C6, and the transistor's internal base-emitter capacitance. The antenna use 1/16 wave length to compromise between the efficiency and the size. If you want the microphone to be less sensitive, we can replace the R1 by a higher resistor, such as 10k or 22k, and this might overcome the feedback problem if you use this wireless microphone FM transmitter for a public address system

The receiver captures the radio waves sent out by the transmitter, demodulates the signal, amplifies it to an appropriate level, and sends it out to the audio mixer. A receiver is an electronic circuit that receives its input from an antenna, uses electronic filters to separate a wanted radio signal from all other signals picked up by this antenna, amplifies it to a level suitable for further processing, and finally converts through demodulation and decoding the signal into a form usable for the consumer, such as sound, and digital data, etc.

Amplifier or simply amp is any device that changes, usually increases, the amplitude of a signal. The “signal” is usually voltage or current. Amplifier is a device for increasing the power of a signal. It does this by taking energy from a power supply and controlling the output to match the input signal shape but with larger amplitude. Routing the low-frequency parts of the signal to an amplifier can substantially improve the clarity of the overall sound reproduction.

In this project, the audio amplifier used is capable of delivering 20watts continuously. The term “power amplifier” is a relative term with respect to the amount of power delivered to the load and/or sourced by the supply circuit.

In general a power amplifier is designated as the last amplifier in a transmission chain (the output stage) and is the amplifier stage that typically requires most attention to power efficiency. Power amplifiers have also become lighter, smaller, more powerful and more efficient due to increasing use of Class A amplifiers, which offer significant weight and space savings as well as increased efficiency.

Power amplifier circuits (output stages) are classified as A, B, AB and C for analog designs, and class D and E for switching designs, based upon the conduction angle or angle of flow, Θ, of the input signal through the output amplifying device, that is, the portion of the input signal cycle during which the amplifying device conducts. The image of the conduction angle is derived from amplifying a sinusoidal signal. (If the device is always on, $\Theta = 360^o$.) In this project a class A amplifier is used because it offers low signal distortion.

Loudspeaker is an electro-acoustical transducer that converts an electrical signal to sound. A transducer that turns an electrical signal into sound waves is the functional opposite of a microphone.

Since a conventional speaker is constructed much like a dynamic microphone, (with a diaphragm, coil and magnet), speakers can actually work "in reverse" as microphones. The speaker pushes a medium in accord with the pulsations of an electrical signal, thus causing sound waves to propagate to where they can then be received by the ear. The loudspeaker used in this project is a load of 8 Ohms.

1.2 AIMS AND OBJECTIVES

Public speaking is the process of speaking to a group of people in a structured, deliberate manner intended to inform, influence, or entertain the audience. In public speaking, as in any form of communication, there are five basic elements, often expressed as “who is saying what to whom using what medium with what effects?”(W.Kleitz;2005 pg134).

The major objective of this project is to design and construct a public address system with relatively unique operational characteristics that is capable of delivering 20 watts of electrical power into an 8 Ohms load (loudspeaker). This will be achieved with adequate tone controls and mixer stages so as to enable communication or reproduction of speech and recorded music in buildings and institutions.

1.3 JUSTIFICATION

Over the ages, science and technology has been developing with new inventions in various fields; including the increase in modifications on existing technology all gearing towards improving effectiveness and reliability of equipment and achieving to a great degree miniaturization and optimal cost.

This project is backed by my interest in the area of electronics and communication, and having been groomed to a great extent with introductions into the various fields of electrical and electronics engineering, with the knowledge in principles of telecommunications, telecommunication engineering,

basic electronics and lab practice. I chose to combine basic electronics and lab practice. I chose to combine all these ideas in embarking on this project to develop a special system that utilizes all the above stated knowledge in one system; "***the public address system***".

This system makes use of radio communication system, it utilizes radio frequency to achieve all its set objectives, like data communication in the operation of wireless communication between the transmitter and the receiver.

This system is intended to provide a fast and reliable means of communication in small venues such as school auditoriums, churches, and small bars.

1.4 SCOPE OF THE PROJECT

This system is for public address; it has an estimated power rating of 20watts. For power supplies, it uses a 220/12Vac transformer for the receiver, amplifier and loudspeaker units. It has a power On/Off button with volume control.

1.5 SYSTEM BLOCK DIAGRAM

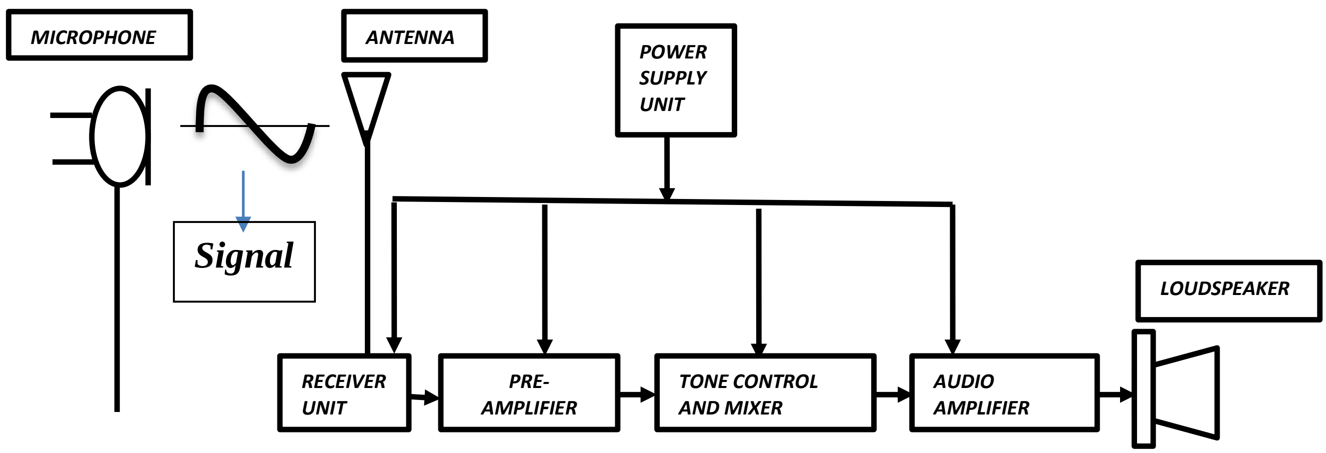


Fig 3: Block diagram of a public address system

The system is made up of the transmitter which is incorporated in the microphone; and the receiver unit, the tone control and mixer unit, the audio amplifier unit and the loudspeaker.

1.6 PROJECT WORK ORGANISATION

The various stages involved in the development of this project have been properly put into six chapters to enhance comprehensive and concise reading. In this project thesis, the project is organized sequentially as follows:

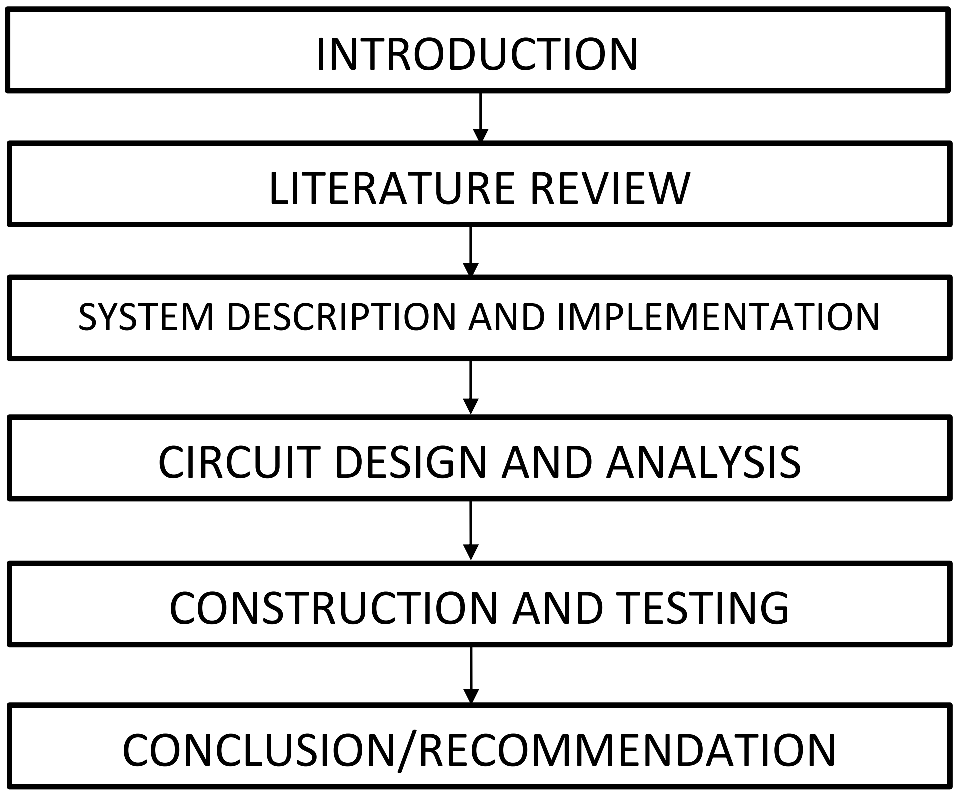


Table 1 : Project work organization

CHAPTER TWO

LITERATURE REVIEW

Communication has been an age long process in which information is passed from generation to generation. The idea of public address system was borne out of the necessity to reach out to a large audience in churches, lecture halls, etc. It would have been impossible to transmit and receive without the use of radio waves and radio receivers (C.G. Montoro and M.C Schneider. 2007). The practical applications of the wireless communication and remote control technology were implemented by Nikola Tesla. The world's first radio receiver (thunderstorm register) was designed by Alexander Stepanovich Popov, and it was first seen at the All-Russia exhibition in 1896. He was the first to demonstrate the practical application of electromagnetic (radio) waves

2.1 ANCIENT MEDIUM OF INFORMATION TRANSMISSION

In the ancient days information is passed across using drums, wooden gongs and gongs to call on people's attention before passing on the information, a rimmed cattle horn was also used to serve as a microphone (Ezeorah Chidiebere; 2009).

2.2 MODERN DAY MEDIUM APPROACH

Recently it has been witnessed that the advent of a durable, wider coverage and more reliable means that could be seen as announcement. It is called a PUBLIC ADDRESS SYSTEM. This system consists of a microphone as the input medium and an amplifier with the speaker as the output medium. These early public address systems made good use of transducers and communication cables. The condenser microphone which is a transducer that converts sound or noise into electrical quantity due to the change in resistance which enables the conversion of sound into electrical signal (Ogundeji;1982, Ogunrem;1997).

This electrical signal is then transmitted to the amplifier section through a transmission cable which is parallel or coaxial. A suitable amplifier circuit is built at the loudspeaker section to amplify the signal from the transmission cable and finally the speaker is a transducer that can equally convert this signal (electrical) back to sound energy. The above explanation is the operation of early public address system and how it was invented.

2.2.1 Problems Associated with earlier systems

- Risk of open circuit occurrence in the communication cable as a result of the environment.
- There are complex circuitry due to the absence of integrated circuit chips for higher reliability and easier trouble shooting.
- Discomfort while handling the microphone due to the cable connecting it to the speaker.
- The range of movement is usually restricted by the length of the wire.

2.2.2 Working Principles of the Modern Systems

Recent public address system were now designed to overcome the above shortcomings. To tackle the problem of complex circuit and additional cooling circuit, integrated circuit have been invented which contains most of these complex circuits with the correct biasing element which have been tested and used in signal amplification, demodulation etc(K.M James; 2001).

Also instead of using the transmission cable a more reliable link, the radio frequency is now employed.

The working principle of this modern public address system is described below; the transducer microphone converts the speech into electrical quantity through change in resistance, this electrical signal is amplified and then used to modulate an electromagnetic carrier wave generated by an oscillator , this modulated signal is then sent into out as radio frequency through the antenna.(W.Kleitz;2005.). The radio frequency is then picked up by the antenna and thus it will require a radio receiver to interpret the signal and obtain the intelligence been conveyed. When the receiver is equipped with a suitable audio amplifier at the output, a speaker can be used at the output to achieve the required performance of a public address system.

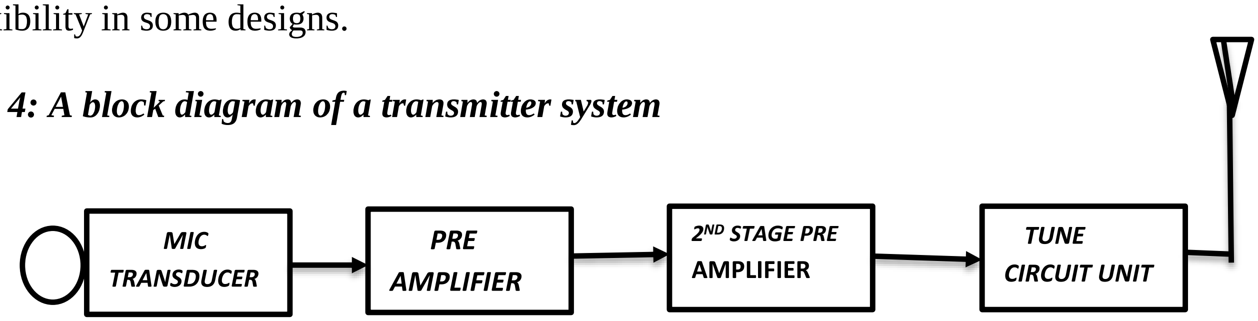
2.3 PUBLIC ADDRESS SYSTEM

This system basically transmits; receives and amplifies voice signal. However, since wireless microphone systems depend upon certain general principles of radio, there is need for modulation of the transmitted signal. And demodulation or reception of the transmitted signal. The systems involved are the transmitter and receiver systems. Modulation is the process of varying one waveform in relation to another waveform. In telecommunications, modulation is used to convey a message, or a musician may modulate the tone from a musical instrument by varying its volume, timing and pitch . Often a high-frequency sinusoid waveform is used as carrier signal to convey a lower frequency signal. The three key parameters of a sine wave are its amplitude (“volume”), its phase (“timing”) and its frequency (“pitch”), all of which can be modified in accordance with a low frequency information signal to obtain the modulated signal. Frequency modulation is the modulation type used in this project.

2.3.1 THE TRANSMITTER SYSTEM

The first part of the typical transmitter is the input circuitry. This section makes the proper electrical match between the input source and the rest of the transmitter. It must handle the expected range of input levels and present the correct impedance to the source (N.R.Malik;1995). Gain controls and impedance switches allow greater flexibility in some designs.

Fig 4: A block diagram of a transmitter system



In certain cases, the input circuitry also provides electrical power to the source (for condenser microphone elements).

"The first process is a special equalization called pre-emphasis, which is designed to minimize the apparent level of high frequency noise (hiss) that is unavoidably added during the transmission"[4].

The "emphasis" is a specifically tailored boost of the high frequencies. When this is coupled with an equal (but opposite) "de-emphasis" in the receiver, the effect is to reduce high frequency noise by up to 10dB. The second process is called "compensate for the limited dynamic range of radio transmission"(Ezeorah Chidiebere 2009).

2.3.2 THE RECEIVER SYSTEM

Since the transmitter sends out electrical energy in form of electromagnetic waves into space; the receiver's antenna intercepts these electromagnetic waves with the aid of a tuning system. These waves are directed into the receiver's circuit to give the audio signal back at the receiving end. The first section of receiver circuitry is the "front end". Its function is to provide a first stage of radio frequency (RF) filtering to prevent unwanted radio signals from causing interference in subsequent stages.

It should effectively reject signals that are substantially above or below the operating frequency of the receiver. For a single frequency receiver the front end can be fairly narrow.

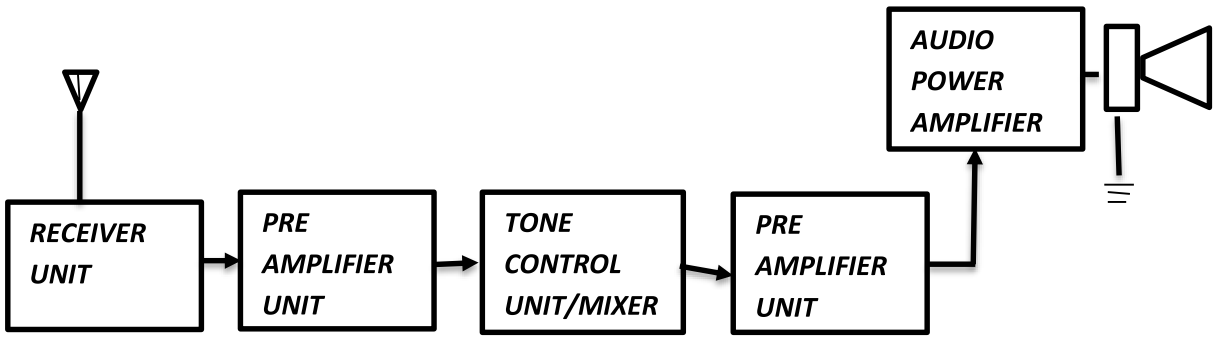


Fig 5: A block diagram of a receiver system

2.3.3 ANTENNA

In addition to the circuitry contained inside transmitters and receivers, one critical circuitry element is often located outside the unit; the antenna. In fact, the design and implementation of antennas is at least as important as the devices to which they are attached. Although there are certain practical differences between transmitting and receiving antennas, there are some considerations that apply to both. In particular, the size of antennas is directly proportional to wavelength (and inversely proportional to frequency) (L.Beranek; 1954). Lower radio frequencies require larger antennas, while higher frequencies use smaller antennas. Another characteristic of antennas is their relative efficiency at converting electrical power into radiated power and vice versa. An increase of 6 dB in radiated power, or increases of 6 dB in received signal strength can correspond to a 50% increase in range. Likewise, a loss of 6 dB in signal may result in 50% decreased in range. Though these are best (and worst) case predictions, the trend is clear. Greater antenna efficiency can give greater range.

2.3.3.1 FUNCTIONS OF ANTENNA

The function of an antenna is to act as the interface between the internal circuitry of the transmitter (or receiver) and the external radio signal. In the case of the transmitter, it must radiate the desired strength and in the desired direction.

2.3.4 THE TONE CONTROL AND MIXER STAGE

Audio mixer is an electronic device for combining (also called “mixing”), routing, and changing the level, timbre and/or dynamics of audio signals. A mixer can mix analog or digital signals, depending on the type of mixer. The modified signals (voltages or digital samples) are summed to produce the combined output signals with preamp controls. Digital mixers can be designed to be quieter than most analog mixers, as digital mixers often incorporate very low threshold noise gates to stop inactive mix bus background hiss from summing with active signals(V.Atti et al; 2007). The mixer, in a radio receiver, is a circuit that combines these signals in a process called "heterodyning."

This process produces two "new" signals; the first new signal is at a frequency and the local oscillator frequency, while the second is at a frequency which is the difference between the received signal. Digital circuitry is more resistant to outside interference from radio transmitters such as walkie-talkies and cell phones. A major requirement is to minimize audio feedback.

2.3.5 THE AUDIO AMPLIFIER

It is a two port device that accepts an externally applied signal, called input and generates a signal called output such that output gain x input, where gain is suitably proportionality constant. An amplifier receives its input from a source up stream and delivers its output to a load downstream. The most common type of amplifier is the voltage amplifier whose input Vi and output Vo are voltages. The essential role of this active element is to magnify an input signal to yield a significantly larger output signal. The amount of magnification (the "forward gain") is determined by the external circuit design as well as the active device.

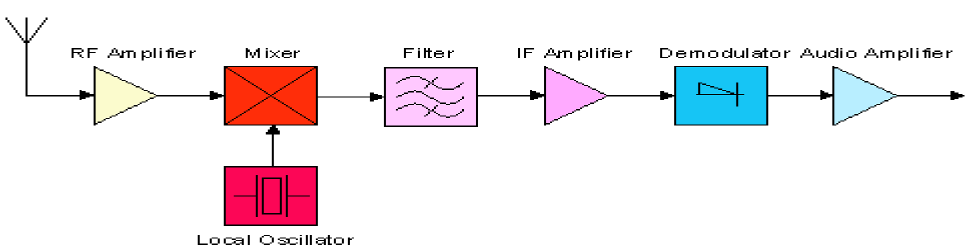


Fig 6: A block diagram of an audio amplifier

2.3.6 THE LOUDSPEAKER

The loudspeaker is the device used for conversion of electrical signal to sound wave.

2.4 MODULATION

This can be referred to as a process of combining an audio frequency signal with a radio frequency carrier. Modulation is the process of varying one waveform in relation to another waveform. In telecommunications, modulation is used to convey a message, or a musician may modulate the tone from a musical instrument by varying its volume, timing and pitch. Often a high-frequency sinusoid waveform is used as carrier signal to convey a lower frequency signal.

The three key parameters of a sine wave are its amplitude ("volume"), its phase ("timing") and its frequency ("pitch"), all of which can be modified in accordance with a low frequency information signal to obtain the modulated signal. A device that performs modulation is known as a modulator. It is of three types namely; amplitude, frequency and phase modulation. Frequency modulation will be discussed since it's the type of modulation used in this project.

2.4.1 FREQUENCY MODULATION(FM)

When the frequency of carrier wave is changed in accordance with the intensity of the signal, it is called frequency modulation. It conveys information over a carrier wave by varying its frequency. In analog applications, the instantaneous frequency of the carrier is directly proportional to the instantaneous value of the input signal.

An important concept in the understanding of FM is that of frequency deviation. The amount of frequency deviation a signal experiences is a measure of the change in transmitter output frequency form the rest frequency of the transmitter. The rest frequency of a transmitter is defined as the output frequency with no modulating signal applied. For a transmitter with linear modulation characteristics, the frequency deviation of the carrier is directly proportional to the amplitude of the applied modulating signal. Thus, a transmitter is said to have modulation sensitivity, represented by a constant, **kf**, of so many **kHz/V, Kf = frequency deviation/V = kf kHz/V.**

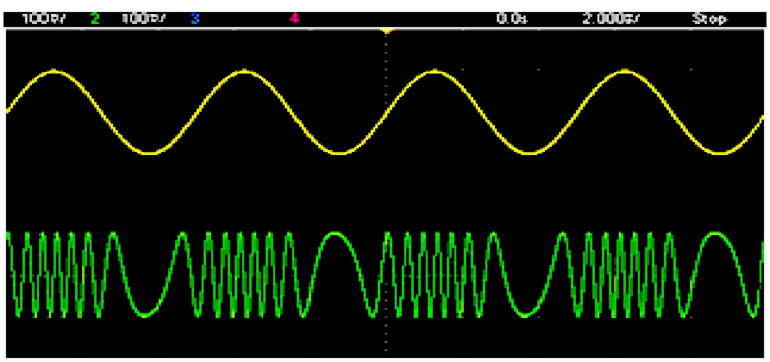


Fig 7: A typical FM shown with the modulating signal

CHAPTER THREE

SYSTEM DESCRIPTION AND IMPLEMENTATION

In the design of this project, some existing designs were extensively studied and modified. These different designs were tested and modified using the breadboard.

3.1 TRANSISTOR POWER AMPLIFIER

Power amplifiers boost a signal level and provide current to drive a loudspeaker. All output transducers require amplification of the signal by an amplifier, including loudspeakers.

The essential role of this active element is to magnify an input signal to yield a significantly larger output signal. The amount of magnification (the "forward gain") is determined by the external circuit design as well as the active device. Many common active devices in transistor amplifiers are bipolar junction transistors (BJTs) and metal oxide semiconductor field-effect transistor (MOSFETs).

3.2 MOSFET POWER AMPLIFIER.

The metal-oxide-semiconductor field-effect transistor (MOSFET) is a device used to amplify or switch electronic signals. The voltage rating of the transistor is a function of the doping and thickness of the N-epitaxial layer, while the current rating is a function of the channel width (the wider the channel, the higher the current). In a planar structure, the current and breakdown voltage ratings are both a function of the channel dimensions (respectively width and length of the channel), resulting in inefficient use of the "silicon estate". With the vertical structure, the component area is roughly proportional to the current it can sustain, and the component thickness (actually the N-epitaxial layer thickness) is proportional to the breakdown voltage.

It is worth noting that power MOSFETs with lateral structure are mainly used in high-end audio amplifiers. Their advantage is a better behavior in the saturated region (corresponding to the linear region of a bipolar transistor) than the vertical MOSFETs. Vertical MOSFETs are designed for switching applications. A MOSFET operates with the lowest resistance when fully-on and thus has the lowest power dissipation when in that condition, except when fully off.

The MOSFET includes a channel of n-type or p-type semiconductor material. Usually the semiconductor of choice is silicon; unfortunately, many semiconductors with better electrical properties than silicon, such as gallium arsenide, do not form good semiconductor-to-insulator interfaces and thus are not suitable for MOSFETs.

When a voltage is applied between the gate and source terminals, the electric field generated penetrates through the oxide and creates a so-called "inversion layer" or channel at the semiconductor-insulator interface. The inversion channel is of the same type P-type or N-type as the source and drain, so it provides a channel through which current can pass. Varying the voltage between the gate and body modulates the conductivity of this layer and makes it possible to control the current flow between drain the source.

MOSFET power amplifiers are classified into;

N-channel enhancement mode

P-Channel enhancement mode

N- Channel depletion mode

P- Channel depletion mode

3.3 BIPOLAR JUNCTION TRANSISTOR.

Since it was invented, the transistor from the transfer resistor has been used widely in amplifier and electronics circuit. A bipolar transistor consists of a three-layer “sandwich” of doped (extrinsic) semiconductor materials, either P-N-P or N-P-N. Each layer forming the transistor has a specific name, and each layer is provided with a wire contact for connection to a circuit.

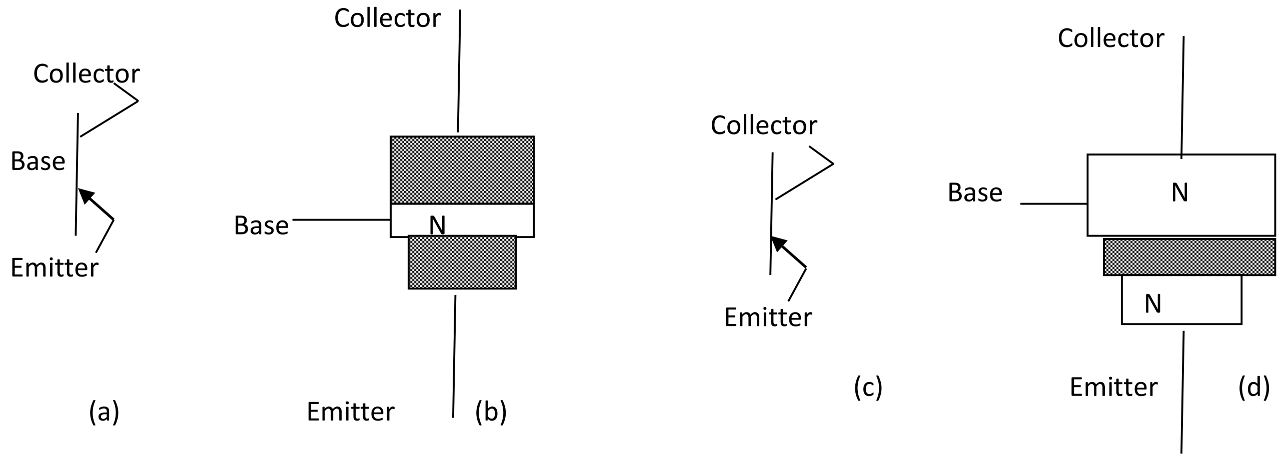


Fig 8: The symbols of PNP and NPN transistors

Bipolar transistors work as current-controlled current regulators. In other words transistors restrict the amount of current passed according to a smaller, controlling current. The main current that is controlled goes from collector to emitter or from emitter to collector, depending on the type of transistor it is (PNP or NPN, respectively). The small current that controls the main current goes from base to emitter, or from emitter to base, once again depending on the kind of transistor it is (PNP or NPN, respectively). Transistor parts are as follows;

- The emitter: is analogous to the cathode of a valve. It is more heavily doped than any of the other regions because its main function is to supply majority charge carriers (either electrons or holes).
- The base: it is the controlling elements. It is the middle section of the transistor. A current at the base controls the current through the transistor.

- The collector basically collects the emitted electrons. Somewhat analogous to the plate of vale. In most cases, collector region of transistors is made physically larger than the emitter region because it has to dissipate much greater power.

3.4 OPERATIONAL AMPLIFIERS

An operational amplifier is a circuit that can perform such mathematical operations as addition, subtraction, integration and differentiation. An operational amplifier, abbreviated as op-amp, is basically a multi-stage, very high gain (typically 2,00,000), direct-coupled, negative feedback amplifier that uses voltage-shunt feedback to provide a stabilized voltage gain. An op-amp has high input impedance (exceeding 100kΩ) and low output impedance (< 100Ω) and has capability of amplifying signals having frequency ranging from zero Hz to 1 MHz i.e op-amp can be used to amplify DC as well as AC input signals. It is an extremely efficient and versatile device. LM320 was used in the cause of this project.

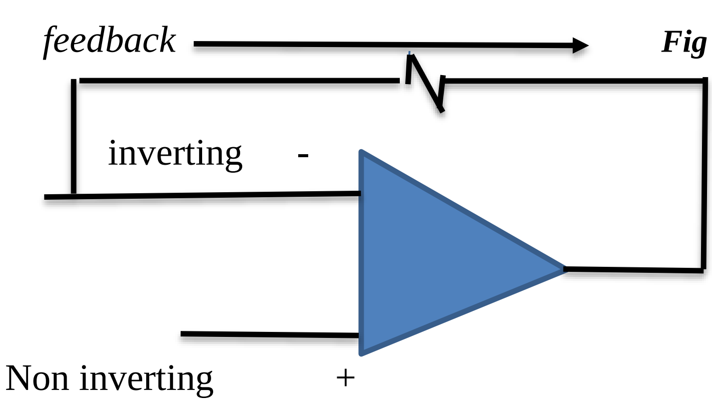


Fig 9: A symbol of an Op-Amp

3.4.1 CLASS A AMPLIFIER.

The output signal varies for a full 360^o of the cycle. In other words, the output current flows at all times during a cycle of the input wave form. The peak valve of the signal wave form should at all times be less than the bias voltage or current, otherwise the output wave form will be distorted. Class A operation of an amplifier offers low signal distortion. Class A amplifier was used in this project.

3.5 IMPLEMENTATION METHOD.

Once the radio signal is sent from the microphone, it is received by the antenna. It subsequently induces a current and voltage in the antenna. This signal is then passed through the receiver where the demodulation is done it demodulates the audio signal. The preamplifier formulates the difference and sum the signal between the oscillatory and incoming radio signal. The signal then travels to the audio amplifier. This amplifier's gain is controlled by the automatic gain control of the audio amplifier. Next, the (filtered) received signal and the local oscillator output are input to the "mixer" section.

The mixer, in a radio receiver, is a circuit that combines these signals in a process called "heterodyning."

This process produces two “new” signals: the first new signal is at a frequency which is the sum of the received signal frequency and the local oscillator frequency, while the second is at a frequency which is the difference between

the received signal frequency and the local oscillator frequency. Both the sum and the difference signals contain the audio information carried by the received signal. The sum and difference signals are then sent to a series of filter stages that are all tuned to the frequency of the difference signal. This frequency is the “intermediate frequency” (IF), so-called because it is lower than the received radio frequency but still higher than the final audio frequency.

The IF signal is finally input to the “detector” stage which “demodulates” or extracts the audio signal by one of several methods. One standard technique is known as “quadrature.” When two signals are out of phase with each other by exactly 90 degrees they are said to be in quadrature. When such signals are multiplied together and low-pass filtered the resulting output signal consists only of frequency variations of the original input signal.

The demodulated audio signal undergoes complementary signal processing to complete the dynamic range recovery and noise reduction action begun in the transmitter. For conventional compander systems, a 1:2 expansion is applied, followed by a high-frequency de-emphasis.

CHAPTER FOUR

CIRCUIT DESIGN AND ANALYSIS.

Design specifications. The design specifications used in this project work are enumerated below.

- The power supply unit
- The receiver principle
- The transmitter principle
- Input amplifier
- Nature of the mixer and tone control.

4.1 POWER SUPPLY UNIT DESIGN

The transformer primary voltage is 220V, which is directly from the main supply. The rectifier circuit used in this project makes use of the bridge rectifier shown below which uses four rectifier diodes, the IN4001. The rectified signal is then passed through a smoothening capacitor to remove the ripples which results to a steadier signal output. A voltage regulator is connected at the output to give a constant value of 30V. For the capacitor used for smoothening, a ripple factor of 0.1 was used. The formular is given below;

Power = V^2 x I = 20Watts

Cp = 1/2$\sqrt{3}$RxFxY where Y represents ripple factor, F= frequency (usually 2 x supply freq = 100khz)

R = resistance = V/I = 12/60mA

= 200Ω . : Cp = 1/2$\sqrt{3}$x 200x 100x 0.2 = 721.7µF but due to availability 1000uF 50V was used. Regulator

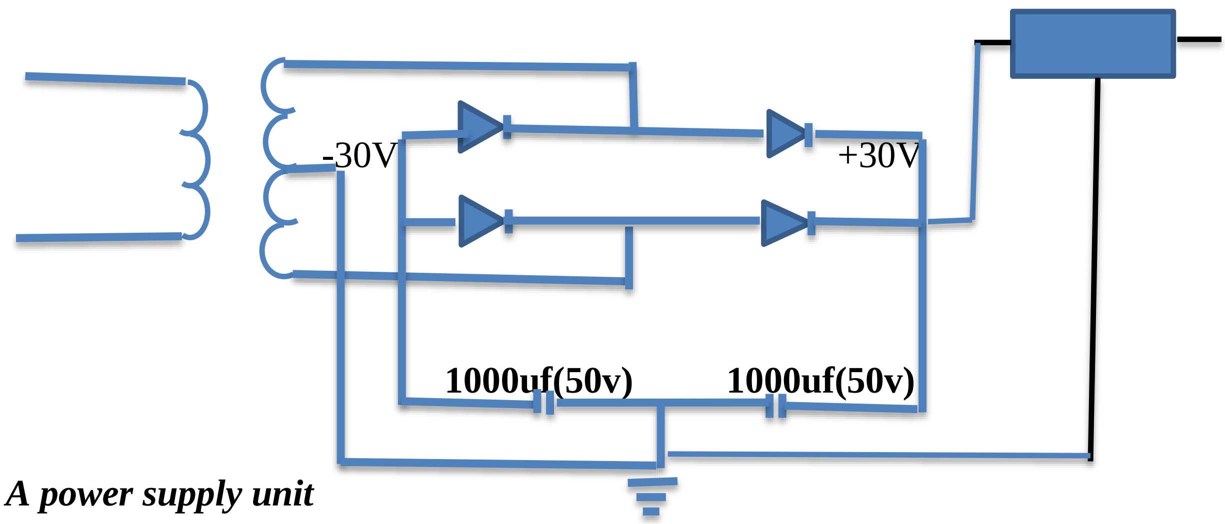


Fig 10: A power supply unit

4.2 TRANSMITTER DESIGN

The transmitter is designed to use a 9V battery which can be easily replaced. This transmitter circuit uses a 9V(+Vcc). The radius of reception is within 100meters with a power output of 0.03mW

In designing with the above transistor characteristics given that +Vcc is 9V and V_{CE} = 0.6V

Choosing to design for a voltage gain of 200,according to the rule of thumb in designing of class A amplifier which specifies that $V_E = 0.5xV_{CE}$

Then,

$V_E = I_E$ x R_E, $R_E = V_E/R_E$

But since R_E was not used in this project the above formular can be neglected.

Also from the circuit Vc = Vcc – V_{CE} – V_E, = 9 – 0.6 – 0.3 = 8.1V

Since Vc = Ic x Rc , Rc = 8.1 = Ic x Rc , Rc = 8.1/0.2mA = 21kΩ

Thus a 22kΩ resistor was used.

Hfe = Ic /I_B , I_B = Ic / hfe = 0.2mA/200 = 1µA

For the base biasing;

R1 + R2 = Vcc / I_B = 9/1 x 10^{-6} = 12mΩ

V1 = R2 x Vcc/R1 + R2 = R2 x 9/37000

V2 = V_{BE} + V_E, = 0.65 + 0.3 = 0.95 = R2 x 9/37000

.: from the relation R1 + R2 = 37000, R1 = 150000Ω = 150KΩ

The lowest frequency to be handled is used to calculate the value of capacitor to establish effective coupling. Now from the range of frequency which the audio amplifier will be handling that is the audio frequency band, the lowest frequency is 30Hz which is used to determine the C_E.

The capacitive reactance , $Xc = 1/10 \times R_E$, $= 1/10 \times 1500 = 150\Omega$

$Xc = 1/2\pi fC_E$, $1/2\pi \times 30 \times 150 = 35\mu F$

4.3 AMPLIFIER CIRCUIT DESIGN

This amplifier was designed to produce an output power of 20W to an 8Ω loudspeaker this is done so as to enable the receiver to serve the function of a public address system. The audio amplifier is powered by 12V dc from the rectified 22Vac supply. The amplifier makes use of TA2822A as the operational amplifier for the amplification.

Vin = 50mV pk – pk at 3.4kHz

Quiscent point = Vcc/2 = 12/2 = 6V

Required power output = 20W

The input power to the TA2822 = 2W

.: the derived gain in dB = 20log20/2 =20dB

To bias the transistor properly, we have

V_E = 1v and Vc = 6V(trying to bias to get the Q-point)

$V_{CEQ} = Vc – V_E$ i.e $V_{CEQ} = 6 – 1 = 5v$

$V_{CEQ} + V_E = Vcc – Ic_Q Rc$

$Ic_Q Rc = Vcc – (V_{CEQ} + V_E)$

So $Ic_Q Rc = 12 – (5 + 1) = 6V$

.: $Ic_Q Rc = 6v$

Assuming R1 to be 150k, R2 is given by R2/R1 + 1= gain , .: R2 = 47k **Ω**

Max TA2003 output current , Io = 3A

Output current is given by $Vo^2/R = 20W$

Vo = √20 x 8 = 12.6V , where Vo = 12.6 , R = 8 **Ω**(speaker resistance)

But current across R2 - R1 branch is given by Vo/R2 + R1

12.6/150 + 150 = 0.042A

Expected current at the speaker terminals, is given by $P = I^2R$ 20W

I = √20/8 = 1.58A

A resistor is required to shunt the excess current to the speaker.

Iex = (3.5A – 1.58A) = 1.92A

R3 is chosen to be 22k to reduce the offset current below 0.1A

12.6/100 = 0.126A.

Capacitors were used to protect IC from A.C and D.C short circuits, values were suggested by IC data sheet.

4.4 RECEIVER PRINCIPLES.

The receiver consists of an aerial and demodulator with the help of the tuned circuit, this helps in picking up the required signal. A typical tuned circuit consists of a coil and variable capacitor which are connected in parallel. These are connected to the aerial and earth. The coil constitutes an inductor and is called aerial coil; the variable capacitor is commonly referred to as the tuning capacitor. It is able to receive the radio wave through the crystal set which consists of tank circuit which is capacitor and inductor connected in parallel. The heart of this circuit is based on TA2003 which is monotolitic IC. It is an FM IFT(FM Intermediate frequency tuning) and AM IFT(AM intermediate frequency tuning) with operating range from 1.8 to 7ohms and can withstand 25^{o}c as the operating temperature.

The tuning starts from the variable capacitor that adjust the capacitance formed along the resonance coils at a resonance frequency transmitting channels are tuned. The Vcc is connected to Pin 14,which supplies voltage to the IC. Ground is connected to pin 9, at pin 11 the output is taken and at pin 4 and 7, I made up a circuit for the local oscillator(LO) using LTP455B.This allows the circuit to tune clearly having it mixed with the Radio frequency at the mixer within the IC.

The LTP455B enables the radio system to demodulate at 455kHz.

The receiver was connected to the amplifier and the IC used is TA2822(Power Operational amplifier)

4.5 DEMODULATION

Demodulation or detection is the process of recovering AF signals from the modulated carrier wave. When the radio frequency modulated waves, radiated out from the antenna, after travelling through space, strike the receiving aerials, they induce weak RF power in them. If these high frequency currents and voltages are passed through loudspeakers they produce no effect on them because the device will be unable to respond to such high frequency due to large inertial of their vibrating disc. These RF power produce no effect on the audience since they are beyond the audible frequency. FM detection involves three stages viz;

- Rectification of the modulating signal

- Conversion of frequency changes produced by modulating signal into corresponding amplitude changes.
- Elimination of the RF component of the modulated wave.

4.6 TRANSMITTER CIRCUITRY

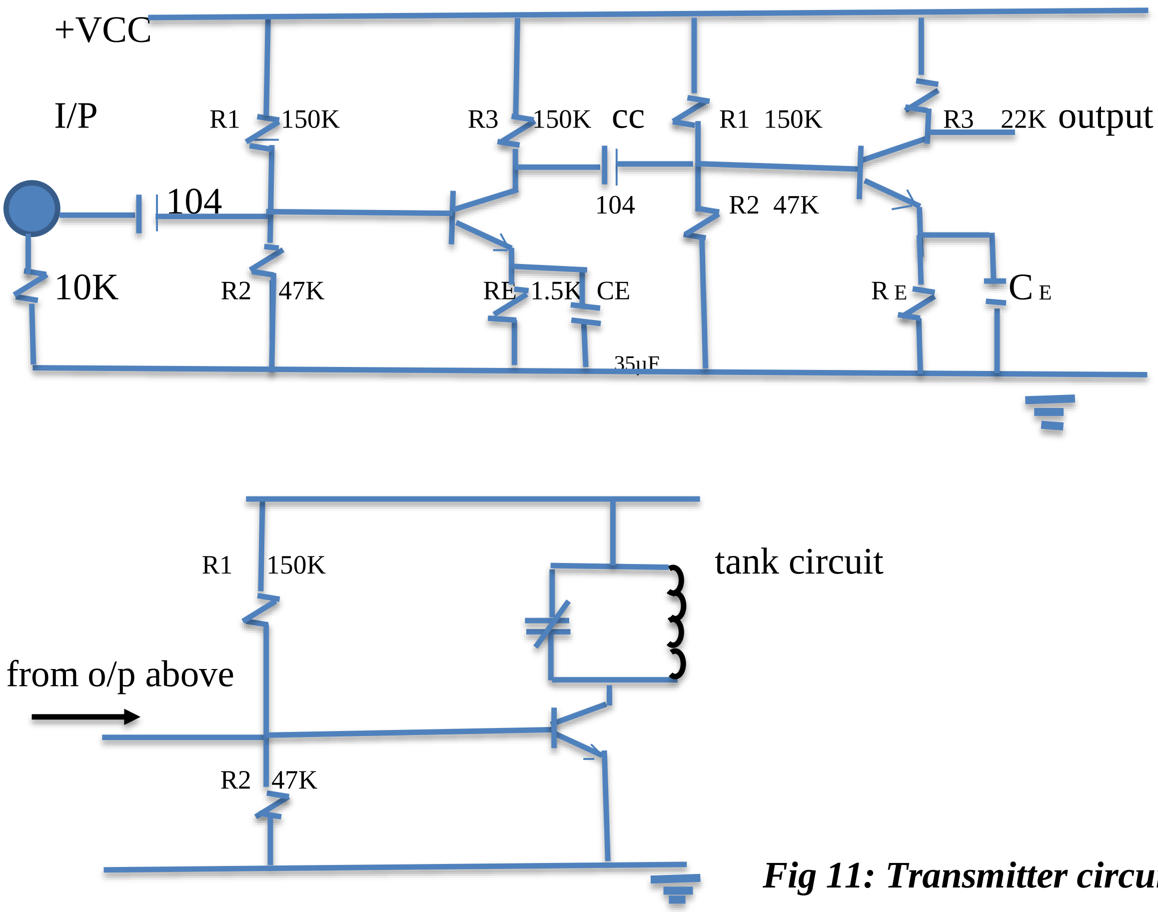


Fig 11: Transmitter circuitry

Tank circuit: This was used to generate the radio wave which is also a culprit design. This circuit generates radio wave by charging and discharging the capacitor. The capacitor charges through the coil at first half cycle and discharges through the coil in another half cycle forming a damping resonance frequency.

With the addition of this circuitry to the amplifier we can be to generate a radio signal. The frequency of the signal is dependent on the time varying of the tank circuit.

For this project we are operating at a medium wave band (96.9 FM) and this is the transmitter used for my wireless public address system

4.7 THE INPUT STAGE.

The input stage is known as the preamplifier. In this design the amplifier is classified into two sections viz: IC input stage and discrete component. These are coupled together for maximum gain. The preamp is fed from the power supply unit with voltage drop of +12v and -12v via. 1.5 kΩ resistors. I fed into the mixing circuit. The boost capacitor bypasses VR2 at frequency use between 50Hz and 400Hz.

4.8 MIXING STAGE

When all the Input Signals Comes in at the same, the mixer which is a summing amplifier mix all the signals together to produce a refined signal before it is fed to the audio amplifier. The circuit schematic is shown below.

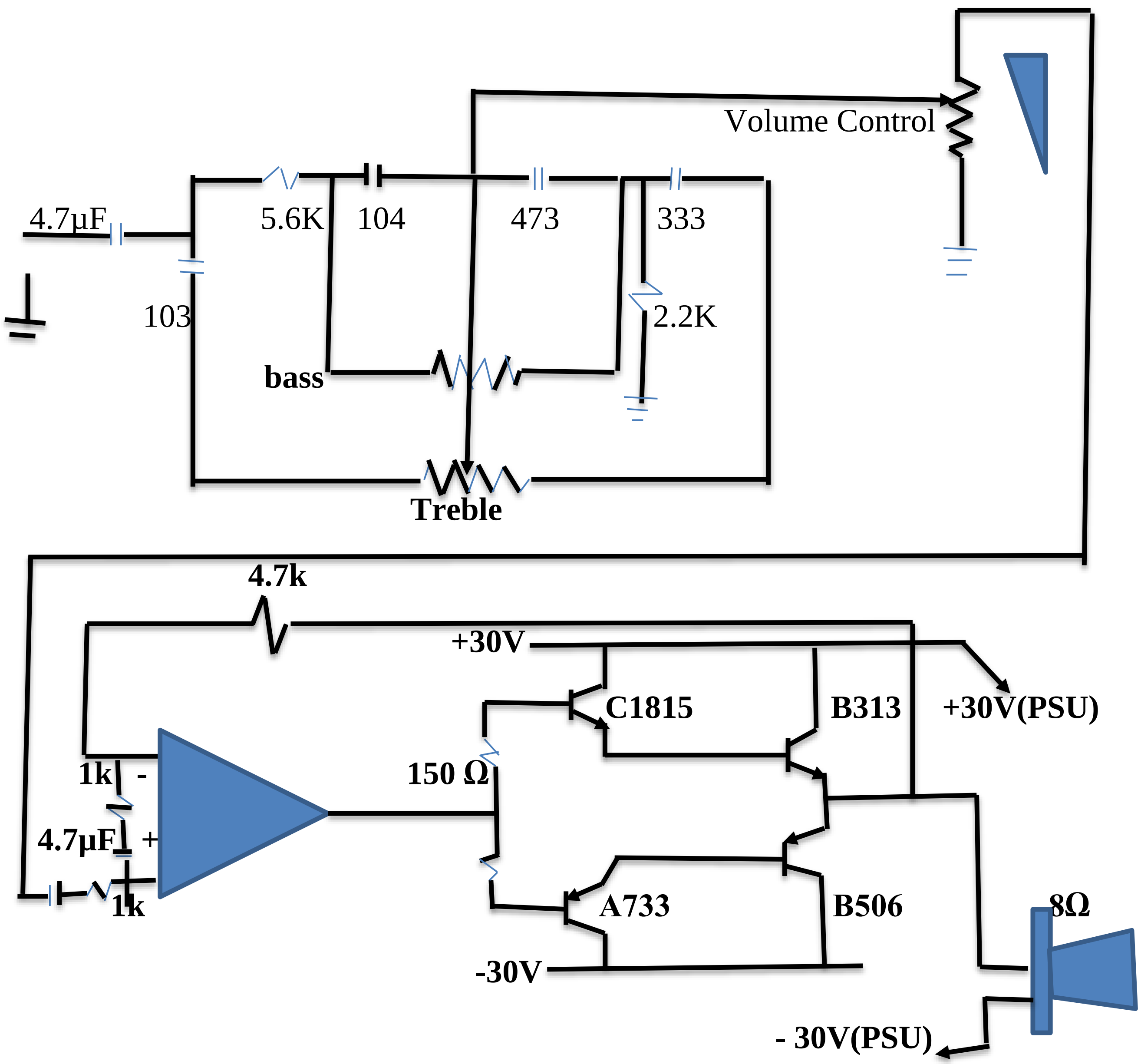


Fig. 12: Tone control circuitry connected to the amplifier.

4.9 AUDIO POWER AMPLIFIER.

The amplifier has a differential input stage with negative feedback used to stabilize the amplifier. The circuit at the output eliminates interference from any transmitter as it forms a short circuit to ground at frequencies above 10MHz the efficiency of this amplifier is based on the radio of power output to the speaker versus input power from the battery audio power amplifier design involves three stages;

- The input stage: the input stage of the amplifier must be able to supply the base current of the driver stage. Since third stage must be biased, a margin between 2 and 5 was applied: to determine the upper and lower values of the bias resistor in which the lower value was preferred for it is appropriate for this design.
- The driver stage must be able to supply enough current to the output power MOSFET, the driver must also be able to charge and discharge the gate source capacitance quickly enough to allow us to get the needed power at the highest frequencies of interest.
- The output stage: the effective load impedance and the available voltage and current of the amplifier determines the power output. The amplifier has two sides, side A and B, each of the sides produces an output power of 10W each and total output power of 20W.

CHAPTER FIVE

CONSTRUCTION AND TESTING

The components were initially mounted on breadboard as stated earlier and tested; some of the mistakes were corrected before finally transferred onto the vero board for permanent soldering.

5.1 THE POWER SUPPLY.

Since the power supply is the hub of the circuit, it made use of high current rating diodes. The diodes were adequately soldered on the vero board to avoid short circuit and excessive heating, which may lead to dry joint problems. The construction was also protected by a fuse.

5.2 THE OUTPUT POWER AMPLIFIER.

During the construction of this stage, special attention was given to the positive rails and they were located at appreciable distance from each other to avoid accidental contact (short circuit); the third power terminal which is the ground was such that it formed a mesh around the circuit. This was to avoid problems due to floating ground effect, which can also be eliminated by adequate earthing. Therefore high performance and better reliability was achieved.

5.3 DISSIPATION OF EXCESSIVE HEAT.

Due to the presence of some components, which generate heat, such as power transistors. There is need for heat dissipation so as to avoid damage to the system which can also reduce the system's reliability and efficiency. Heat dissipation in this project was effected by incorporating heat sink in the circuit which will reduce the temperature of the entire system.

5.4 ENTIRE CIRCUIT TESTING.

The whole circuit was connected together and tested. Short circuiting problems were encountered which resulted in component burning. Adequate care was taken during replacement to avoid re-occurrence of the problem.

5.5 PERFORMANCE EVALUATION

The whole circuit was successfully tested, and it was observed that the system is functioning in optimal condition. Due to this fact, one can rate the project's performance at about 87%. This is simply because the circuit responds exactly as it should be except for few errors that were corrected before it was packaged.

5.6 CIRCUIT DIAGRAM.

The circuit diagram used for the implementation of this project is a very straightforward diagram. Its mode of operation can be comprehended by anyone who is interested in this project. When all the sub circuit diagrams being explained above are given, we have the complete mode of operation of the system. The circuit diagram is given below.

5.7 PACKAGING

Every quality and good product is often determined by how it is packaged. Packaging the circuit in a very convenient way in other to avoid damage to its components was the next step after the test has been carried out successfully. Therefore it was decided that a non conductive material will be used for this purpose. Due to this fact, a glass casing was preferred in the packaging. In choosing this medium, we considered the power rating of our system and the frequency characteristics such that the casing will not in any form cause interference.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

The constructed public address system can stand the test of time in its performance. It is very reliable, and the overall performance is excellent. The design specifications were met.

6.1 BILL OF ENGINEERING MEASUREMENT AND EVALUATION

The total expenses made at the cause of the design and implementation of this project is analyzed as follows;

S/N	ITEM	QUANTITY	UNIT PRICE	TOTAL AMT
1	Resistor	13	5	65
2.	Capacitor	6	15	90
3	Inductor	3	10	30
4	Transistor	8	50	400
5	Mic	1	100	100
6	Variable Resistor	3	80	240
7	Op amp(TA2822)	1	50	50
8	Speaker(8ohms)	1	150	150
9	Diode(IN4001)	6	35	210

10	Transformer(12v)	1	220	220
11	Antenna	2	350	700
12	Vero board	2	80	160
13	Glass(for packaging)	1ft	890	1780
14	Switch	2	30	60
15	Receiver IC(C9014)	1	2500	2500
16	Soldering Iron	1	2500	2500
17	Casing	-	10000	10000
18	Transportation	-	5560	5560
			Total	**24815**

Table 2: Bill of engineering measurement and evaluation(BEME)

6.2 PROBLEMS ENCOUNTERED AND SOLUTION

The major problem was audio feedback

The reception was poor at first and the component was scarce in the market.

6.3 AUDIO FEEDBACK

Also known as the Larsen effect after the Danish scientist, Soren Larsen, who first discovered its principles is a special kind of feedback which occurs when a sound loop exists between an audio input (for example, a microphone) and an audio output (for example, a loudspeaker). In this example, a signal received by the microphone is amplified and passed out of the loudspeaker the sound from the loudspeaker can then be received by the microphone again, amplified further, and then passed out through the loudspeaker again. The frequency of the resulting sound is determined by resonant frequencies in the microphone, amplifier, and loudspeaker. Most audio feedback results in a high-pitched squealing noise familiar to those who have listened to bands at house parties, and other locations where the sound setup is less than ideal-this usually occurs when live microphones are pointed in the general direction of the output speakers.

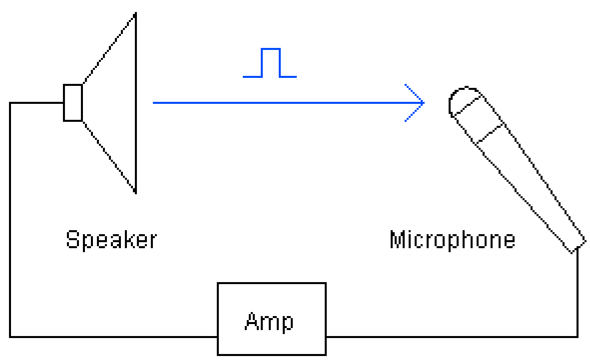


Fig.14 : ***public address system with acoustic feedback.***

6.3.1 AUDIO FEEDBACK PREVENTION

To keep the maximal loop gain under 1, the amount of sound energy that is fed back to the microphones has to be as small as possible. As sound pressure falls off with

1/r with respect to the distance in free space or up to a distance known as reverberation distance in closed spaces (and the energy density with 1r2), it is important to keep the microphones at a large enough distance from the speaker

systems. The loudspeakers and microphones should have non-uniform directivity and should stay out of the maximum sensitivity of each other, ideally at a direction of cancellation.

6.4 CONCLUSION

Conclusively the public address system successfully achieved the aim of transmitting and receiving voice signals over a distance. I learnt and researched more on the use of modulation and demodulation, the amplifier circuitry etc.

6.5 RECOMMENDATION

The only recommendation is that adequate time should be allotted for research; since the project is not only concerned with paperwork but construction and design.

This project is recommended for schools and in a situation where there is need to communicate with a good number of people.

Further improvements in this project is also recommended such as;

An infrared switching circuit can be equally be built in the receiver to enable it to be tuned on with a remote control as the case may be and many more with more enhanced modifications.

REFERENCES

Armstrong, E. H. (2008). *Hisotry of Electrochemistry, Electricity, and Electronics*. Eugenii Katz Homepage, Hebrew University of Jerusalem. http://www.geocities.com/neveyaakov/electro-science/armstrong.html. accessed on 10-05-2008.

Atti, L. (2007). *Audio Signal Processing and Coding*. U.S.A: John Wiley-Interescience.

Beranek, L. (1954). *Acoustics*. London: Mc-Graw Hill Books.

Boylestad, R., & Nashelsky, R. (1996). *Electronic Devices and Circuit Theory*, (7^{th} Edition). London: Prentice Hall College Division.

Dalton, W. M. (1975). *The Story of Radio*. London: Adam higher.

Dugan, F. (1993). *Electronic Communication*. New York, U.S.A: Delmer Learning.

Floyd, T. (2004). *Electronic Devices*. London: Pearson Educational Publications.

Franco, S. (1988). *Operational Amplifiers and Analog Integrated Circuits*. New York: Mc-Graw Hill Book Co.

Gibilisco, S. (2002). *Teach Yourself Electricity and Electronic*. New York: Mc-Graw Hill Professional.

Great, K. (1990). *Advanced Electronics Project*. New York: Mc-Graw Hill Book Co.

Horowitz, L., & Hill, W. (1989). *The Art of Electronics*. London: Cambridge University Press.

Hughes, E. (1996). *Electronic Technology*, (7^{th} Edition). England: Prentice Hall Harlow.

James, K. M. (2001). Room Reverberation effects in Hearing aid Feedback Cancellation. *Journal of the Acoustical Society of America*: pp. 367-378

Kleitz, W. (2005). *Digital Electronics: A Practical Approach*. London: Cambridge University Press.

Kouwenhoven, M. H. L. et al (2003). *Structured Electronic Design, Negative-Feedback Amplifiers*. Ghana: Kluwer Academic.

Malik, N. R. (1995). *Electronic Circuits: Analysis, Simulation, and Design*. Englewood Cliffs, New Jersey: Prentice Hall.

Montoro, C. G., & Schneider, M. C. (2007). *MOSFET Modeling for Circuit Analysis & Design*. London/Singapore: World Scientific.

Sessler, G. M., & West, J. E. (1962). Self-biased Condenser Microphone with High Capacitance. *Journal of the Acoustical Society of America*. Pp. 1787-1788

Spencer, R. R., & Ghausi, M. S. (2001). *Microelectronic Circuits*. Upper Saddle River, New Jersey: Pearson Education/Prentice.

WWW.Electronics4u.com

Theraja, B. L., & Theraja, A. K. (1998). *A Textbook of Electrical Technology*. New Delhi, India: S.Chand & Company.

APPENDIX

P.A.S ………………………… Public Address System

MOSFET………………………..Metal Oxide semi conductor field effect transistor.

BEME ………………………… Bill of Engineering measurement and Evaluation.

FM IFT ……………………… .. Frequency Modulation Intermediate frequency tuning.

AM IFT ………………… Amplitude Modulation Intermediate frequency tuning.

HZ ………………………….. Hertz

Vin …………………………..Input voltage

RF ………………………… Radio Frequency