DESIGN AND CONSTRUCTION OF A WIRELESS PUBLIC ADDRESS SYSTEM

BY

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ATTESTATION

I, MAILAFIA ISAAC, declare that this work was done by me and has never been presented elsewhere for the award of a degree also hereby relinquish the copy right to the Federal University of Technology Minna.

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ABSTRACT

The project has demonstrated the benefits accruable from the advancement in communication technology. A wireless PA system was constructed as indicated in the design objectives. The transmitter propagates frequency modulation signal in the range **88-108MHZ.** The receiver which uses a super heterodyne monolithic integrated circuits receives any frequency modulation that falls in the above range.

The audio amplifier delivers a peak current of **4A** and a power output of **44Watts.** The maximum output is limited by the supply voltage of $V_{CC} = 22V$ and a maximum current $I_O = 4A$. This output parameters are obtainable when the supply voltage is kept at **220-240V** which will require a minimum load of **3-6Ω** across the amplifier's output.

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CHAPTER ONE

GENERAL INTRODUCTION

The term public address (PA) system refers to an electronic means of communicating to a lar audience. It has added to the advantage of modern communication system which has enhanc communication in social, political, academic and religious gathering. It is now possible for a speaker address the gathering of one million people with little or no effort. This has been made possible throu the use of transmitters, receivers and audio amplifiers. Basically, a P_A system comprises: A micropho which is couple to a transmitter. The transmitter could be link directly to the receiver via a transmitti cable or through the free space by electromagnetic wave radiation; A receiver whose frequency reception is align with that of the transmitter; An audio amplifier with loud speakers which is connect to the output of a receiver.

PA devices can be employ in the following areas: Amplification of music; Lecture delivering; Publ addressing of large crowd; Transfer of sound energy from one place to another through cable or fr space. Transmission is made possible by first converting a low frequency audio signal to a hig frequency signal through a process known as modulation [1]. Modulation is employ for transmission f the following reasons: Reduction of antenna size to a practicable and realizable size and lengt Reduction of noise and interference; Channel assignment and Multiplexing [2].

The following modulation could be adopted to transmit audio signals:

i. Amplitude modulation;
ii. Frequency modulation/phase modulation;
iii. Pulse code modulation (for digital transmission);
iv. Pulse width modulation (for digital transmission).

This project focuses on frequency modulation; more emphasis will be given to it.

BLOCK DIAGRAM OF A PUBLIC ADDRESS SYSTEM

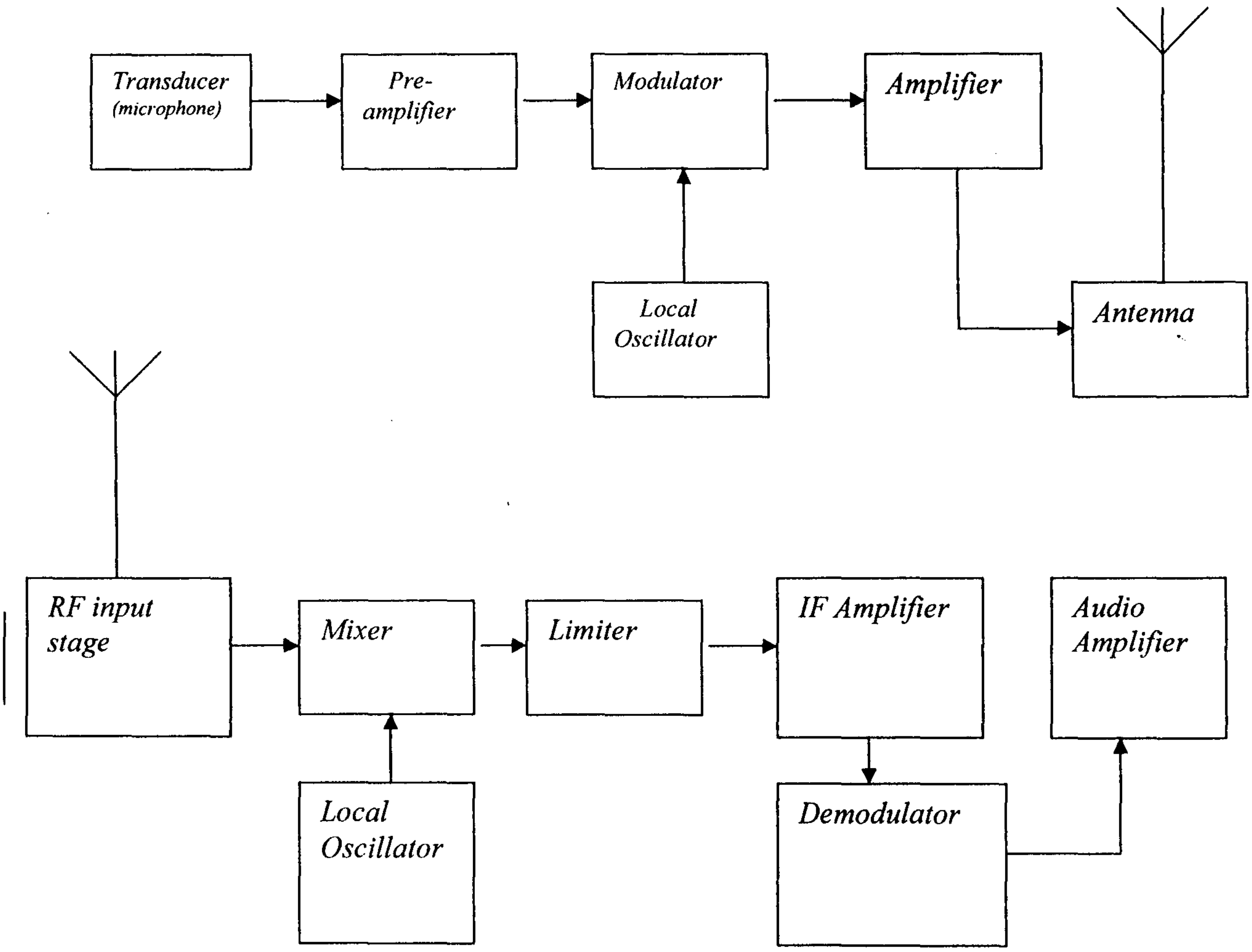

Fig 1.1 The block diagram of the wireless PA system.

1.1.0 AIM AND OBJECTIVES

To design and construct a wireless frequency modulation public address system which could be use to: Address a large crowd with less effort; Deliver lectures to students; Bring the beauty and advancement of radio communication systems down to the homes.

1.1.1 CHALLENGE

This project was born out of the need to come up with a more effective means of public address system to compliment the existing means of communication in our growing population.

1.1.2 1.1.3 PROJECT LAYOUT

There are five chapters which made up the sections of this project.

CHATER ONE: contains the general introduction and background information.

CHAPTER TWO: carries the design analysis for the various stages of the project.

CHAPTER THREE: explains how the project was constructed and the precautions taken.

CHAPTER FOUR: carries testing, measurement and result.

CHAPTER FIVE: carries the conclusion and recommendations for further improvement on the project.

COST ESTIMATION, REFERENCES AND APPENDICES are given after chapter five.

CHAPTER TWO

2.0.0 LITERATURE REVIEW

Public address system operates on the principle of radio communication system. This is so since a PA system involves transmission and reception through the manipulation of certain parameters such as frequency, amplitude and phase of a carrier signal by an impressing audio modulating signal. These are the basis of all communication system which all forms of electronic communication emanated from. In 1887 Heinrich Hertz detected radio waves by causing a spark to leap across a gap that generated electromagnetic waves. This was later replicated when the first oscillator and resonator were built in 1893.In 1894 Oliver Lorge in Britain, Alexander Papoo in Russia, Edward Brandly in France used a glass tube with metal fillings that will cohere under electromagnetic radiation when the tube was tapped, the fillings would collapse to break the circuit. This further lead to the detection of Radio waves. Gugliel Marconi used a spark transmitter with antenna from his home town in Bologna-Italy, in December 1894. He formed his first wireless telegraph and signal company in Britain in 1897 at the age of 23 and the world's first radio factory on Hall Street in December 1898.

In 1905, Reginald Fessenden of Canada invented a continuous wave voice transmitter using a high frequency wave alternator invented by Charles Steamed in 1903. He used it to make a voice broadcast over north Atlantic Christmas eve in 1906. His broadcast was heard by wireless operators of banana boat of the united fruit company that developed crystal receivers for its ships.

Harold D. Arnold developed the amplifying vacuum tube in 1913 that made possible the first coast to coast telephony and the first trans-Atlantic radio communication in 1915. Edwin Armstrong patented the regenerative circuit in 1913 that fed a radio signal through audio tube 20,000 times per second to cause stronger oscillations in the tube that generated radio waves.

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1933. In 1912 when he was 22 he discovered how Lee De Forest radio tube works and redesigned it by taking the electromagnetic waves that comes from a radio transmission and feeding the signal back through the tube again and each time the output power was increase by 20,000 times per second. He called the phenomenon as regeneration.

This was the most important advancement in the young history of radio communication because when the feed-back was increase beyond a certain critical level the tube gave up oscillations that created its own radio waves. He succeeded in making De Forest tube to function as both transmitter and receiver. The tube did not only amplify signals but also generated them as well and this advance made the difference [3]. Today, immense contribution has been made in the development of radio communication. It now comprises both wireless and non-wireless communication system which has led to space exploration via communication satellite.

2.1.0 RADIO WAVES TRANSMISSION AND RECEPTION

Since every modern communication system uses radio transmission and reception except those communication devices which exploits infra-red rays, it is important that we briefly explain how radio communication works.

Earlier before, the term radio refers to 'wireless' communication which now denotes an entire Industry. The radio we see today is the heart of every wireless device today. Cellular phones, television, wireless LANs uses radio waves to get from one point to another. Every kind of radio transmission uses some form of variation of full Amplitude modulation or full Frequency modulation [4].

2.1.1 RADIO WAVES

This are part of a general class of waves known as electromagnetic waves. This implies that they are electrical and magnetic energy that travels through space. At certain frequencies they behave as radio waves. When their frequencies are much higher we refer to them as infra-red light and when their frequencies gets more higher they form the visible spectrum known as ultra violet light and x-rays.

2.1.2 MODULATION

This refers to the process of superimposing a relatively low frequency signal on a high frequency signal for long distance transmission. A device that performs this operation is known as a modulator. Modulation is very paramount in transmission since the process becomes very cumbersome if transmission is attempted without pre-conversion of the desire signal to a relatively high signal frequency on a carrier. This is achieved by superimposing a signal of low frequency on a very high frequency band. If a signal should be transmitted directly then the length of the antenna required for the transmission will be 1/4 of the signal wavelength [2].

Thus for an audio signal of frequency 3000HZ, the require antenna length can be determine as follows:

From $V = f\lambda$ (general wave equation).

Where: $V \rightarrow$ velocity of signal = $3x10^8 ms^{-1}$

$f \rightarrow$ frequency of the signal =3000HZ

$\lambda \rightarrow$ wavelenght of the signal

now, $\lambda = V/f = 3X10^8/3000 = 100Km$

since the antenna length must be ¼ of the wavelength then the require antenna length will be 1/4 x 100,000 = 25Km. this implies that the antenna length which we need to transmit this signal of frequency 3000HZ must be 25Km which is not a practical dimension. Supposing the signal is modulated using a carrier signal of frequency 100MHZ, then the wavelength of the signal will be:

$3x10^8/100MHZ = 3.0$meter.

This means that the antenna length will be 1/4x3.0 = 0.75cm

Thus, modulation helps to reduce the length of an antenna needed for any transmission to a practical dimension.

.1.3 AMPLITUDE MODULATION

'his kind of modulation involves varying the amplitude parameter of a carrier signal by the continuous ariation or fluctuation in the corresponding amplitude of a modulating signal. The maximum isturbance of the carrier signal from its resting point depends on the amplitude of the modulating gnal. If we change the amplitude, or strength, of the signal in a way that correspond to the variation of ıe signal information we are sending, then we will be using amplitude modulation, or AM [5]. The ırliest means of radio communications was by Morse code, and the code key would turn the transmitter n and off [6]. The amplitude went from nothing to full power whenever the key was pressed, a basic ›rm of AM. Modern AM transmitters vary the signal level smoothly in direct proportion to the sound ıey are transmitting. Positive peaks of the sound produce maximum radio energy, and negative peaks of ıe sound produce minimum energy. The main disadvantage of AM is that most natural and man-made ıdio noise is AM in nature, and AM receivers have no means of rejecting that noise. Also, weak signals e more quite than strong ones because of their lower amplitude, which requires the receiver to have rcuits that should compensate for the signal level differences.

he modulated envelope is formed by the imposition of the modulating signal over the un-modulated gnal known as the carrier wave. Amplitude modulation as the term implies only alters the amplitudinal vel of the carrier when the continuous modulating signal is impressed on it. Fluctuation occurs during nplitude modulation and this causes the carrier amplitude to vary in proportion with that of the odulating signal. The rate at which this occurs depends on the frequency of the modulating signal.

1.4 PHASE MODULATION

ıis kind of modulation involves the alteration of the carrier phase angle with respect to the fluctuation the modulating signal amplitude. Phase modulation is similar to frequency modulation which we shall ace more emphasis on . Frequency modulation varies the frequency of the carrier without tempering th the Amplitude of the carrier signal while phase modulation affects the phase of the carrier signal thout affecting the amplitude of the carrier too [7].

2.1.5 FREQUENCY MODULATION

This involves changing the frequency of a carrier wave by the continuous fluctuation of a modulating signal amplitude. The amount of change on the frequency of the carrier depends on the modulating signal amplitude while the rate of change of the carrier signal is dependent on the frequency of the modulating signal. This is illustrated in Fig. 2.1 bellow.

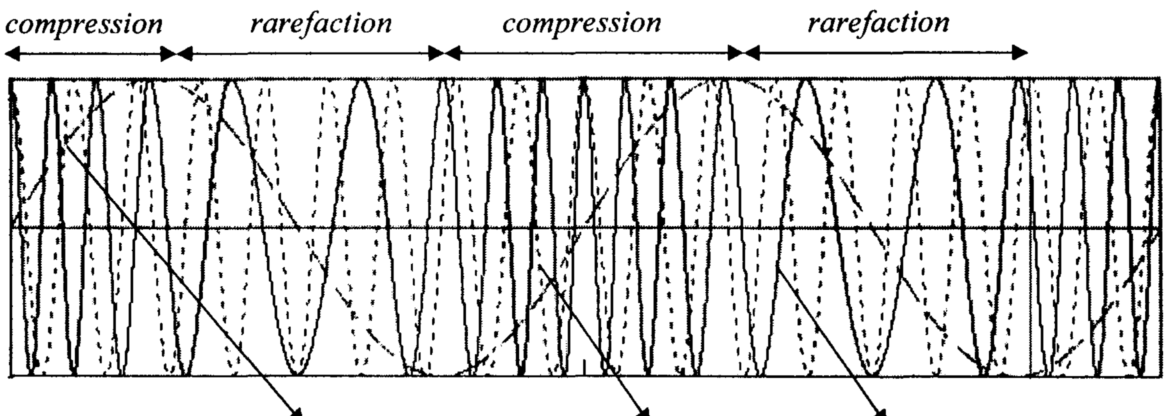


Fig. 2.2 showing:[a]. modulating signal, [b]. carrier signal, [c]. modulated signal

The degree of frequency deviation is a function of the amplitude of the modulating signal. The amplitude determine the loudness of the signal. Therefore, the higher the amplitude of the modulating signal the greater the frequency deviation of the carrier frequency and vice versa. In an attempt to overcome the problem of noise, a man named Edwin H. Armstrong invented a system that would overcome the difficulties of amplitude noise. Instead of modulating the strength (or amplitude) of the transmitted signal or carrier, he modulated the frequency. Though many engineers at that time said that FM was not practical, Armstrong proved them wrong, and today FM is the mainstay of the broadcast radio services [8]. In a frequency modulated system, the frequency of the carrier is varied according to the modulating signal. For example, positive peaks would produce a higher frequency, while negative peaks would produce a lower frequency. At the receiving end, a limiting circuit removes all amplitude variations from the signal, and a discriminator circuit converts the frequency variations back to the original signal. In this way, the effects of amplitude noise are minimized. Since the recovered audio is dependent only on the frequency, and not the strength, no compensation for different signal levels is required, as is the case with AM receivers.

2.1.6 FREQUENCY DEVIATION

This refers to the variation of frequency from its original state when a modulating signal is impressed on it . The frequency of an FM transmitter without a signal input is known as its resting or center frequency (f_0). This is the allotted frequency for which the transmitter is allow to broadcast. When a signal is impressed on the carrier it causes its frequency to deviate up and down from its resting value f_o. This up and down or fluctuation of the carrier frequency is refer to as frequency deviation Δf which is given as:

$\Delta f = \beta fm$, Where: $\Delta f \rightarrow$ frequency deviation, $\beta \rightarrow$ modulation index,

$fm \rightarrow$ modulating frequency.

At the receiving end of the transmitted signal a limiting circuit removes all amplitude variation from the signal and a discriminator converts all frequency variation back to the original signal. In this way the effect of noise are minimized since the recovered audio signal is dependent only on the frequency and not strength. No compensation for different frequency signal is require as in the case of AM receivers. Information can rarely be transmitted without being processed. For electromagnetic waves to be use, the audio signal must first be converted to electrical signals. This conversion is accomplished using transducers. After the conversion of the audio signal the resulting electrical signal is use to modulate a carrier signal.

2.1.7 ADVANTAGES OF MODULATION

Modulation presents the following advantages which has made signal transmission from one place to another possible: First, it reduces the wavelength of the signal to be transmitted for effective transmission. Secondly, it reduces the antenna length which is needed to transmit the desire signal to a practical dimension. Thirdly, it allows simultaneous use of channel for different signals-this is known as multiplexing. In this technique, each signal is assign a different carrier frequency in the same channel.

Beside that, it reduces noise and interference which can suppress the quality of the audio signal if not check. It also helps the design Engineer to overcome equipment limitation. This means that the complexity of the equipment require is reduce when the desire signal is modulated on the carrier signal.

2.1.8 FM MATHEMATICAL EXPRESSION

An FM signal has two components which are:

i. the carrier signal and

ii. the modulating signal

The carrier signal is made up of a single frequency sinousoids which varies with time like a sine wave. It is given as: $V(t) = Vo\sin(2\prod ft + \Phi)$ 2.1

where: $V(t) \rightarrow$ voltage of the carrier signal as a function of time

$Vo \rightarrow$ Amplitude of signal as a function of time

$f \rightarrow$ Frequency of oscillation expressed in Hertz

$\Phi \rightarrow$ Phase angle of signal representing the starting point of the cycle.

FM modulation uses the information signal Vm(t) to vary the carrier signal frequency within some small range about its original value. The mathematical expression for the three signals are:

$Vm(t)=V\cos in(2\prod fc + \Phi)t \rightarrow$ modulating signal 2.2

$Vc(t)=Vco\sin(2\prod fc + \Phi) \rightarrow$ carrier signal 2.3

$Vfm(t)=Vco\sin(2\prod(fc + (\Delta f/Vmo)Vm(t))t + \Phi) \rightarrow$ modulated signal................2.4

The new term Δf denotes the peak frequency deviation. The carrier frequencies

$fc + (\Delta f/Vmo)t$ varies between the extremes of : $fc - \Delta f$ and $fc + \Delta f$

Δf is the farthest deviation from the original frequency that the FM can have [13].

2.1.9 FM SPECTRUM

Frequency modulation spectrum represents the relative amount of different frequency components in any signal. It is like the display on graphic equalizer in a stereo which display the relative amount of bass, treble and mid-range audio signal. This is illustrated illustrated in fig 2.3 bellow:

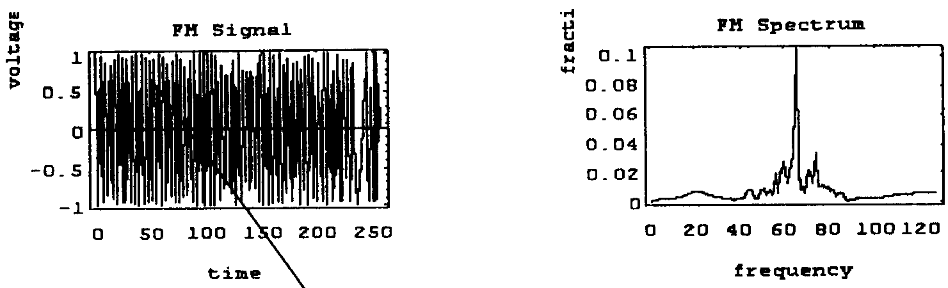


fig. 2.3 A frequency spectrum within a specified band width

2.2.0 FM RADIO

FM radio uses frequency modulation. The frequency band is about 88-108MGHz.The information signal is music which falls in the audio spectrum. Audio spectrum ranges from 20-20,000HZ but FM limits the upper frequency to 15000HZ-since most people cannot hear it there is little lost in fidelity. FM radio is broadcast in stereo-meaning two channels of information. However, in practice three signals are generated prior to applying the modulation.

i. The Left plus Right signal in the range of 50-15000Hz.

ii. a 19000Hz pilot carrier

iii. The Left minus Right signal center on a 38KHz pilot carrier- which is suppressed and ranges from 22-53KHz.

2.2.1 FM PERFORMANCE

The band-width of a frequency modulating signal can be predicted through the following relation $\mathbf{BW=2(\beta+1)f_m}$ where β is the modulating index and f_m is the maximum modulating frequency used. The band-width of an FM signal has a more complicated dependency than in amplitude modulation. Band-width of an AM signal depends only on the maximum modulating frequency. In FM signals both modulation index and modulating frequency affects the band width. As the information is made stronger the band-width also grows.

2.2.2 EFFICIENCY

The efficiency of a signal is power in the side band as a fraction of the total power of the signal. Because of the considerable side bands produced in FM signals the efficiency is generally high. The efficiency of an FM signal can be improved by making the modulation index larger unlike in amplitude modulation where this becomes a disadvantage.

2.2.3 NOISE

FM systems are better at rejecting noise than AM systems. Noise is generally spread across the spectrum-an example is the white noise which has a wide spectrum. The amplitude of noise varies randomly at this frequencies. The change in amplitude can actually modulate the signal and can be picked up by the AM system. As a result AM systems are very sensitive to random noise and needs special filters to eliminate them.

FM signals are inherently immune to random noise- this is one of its advantages over other types of modulation. For noise to interfere with an FM signal it will have to modulate the frequency [9]. Since it is distributed uniformly in frequency and varies mostly in amplitude there is no interference picked up by the FM receiver. Therefore, FM signal is “static free”- this refers to its immunity to random noise.

2.2.4 FM TRANSMITTER

The transmitter which was designed on this project operates within the frequency range of 88-108MGHz. It comprises the following:

i. a transducer/microphone

ii. a pre-amplifier

iii. a modulator/oscillator

iv. an amplifier and a transmitting antenna

v. a 9V DC supply.

2.2.5 DESCRIPTION OF OPERATION

The transducer is coupled directly to the pre-amplifier**½358.** The output of the OP-AMP is fed back to the input to prevent fading of the audio signal. The output of the pre-amplifier is fed into the low-pass filters and high pass filters. The variable resistor VR_1 which determined the modulation depth **(f= 1/2∏RC)** is connected to the 100k resistor which serves as the input to the first stage of the amplifier and oscillator. The Varactor diode VD_1 is reverse biased and generates oscillations along with the LC oscillator. The oscillations are then fed into the amplifier C9014. This amplifier will then step up the amplitude of the signal. The amplified signal is fed into the second stage of the amplifier through the 100pF capacitor. Due to the attenuation of the signal generated by the first oscillator the amplified output across C9014 is fed back into the LC oscillator via the 5pF capacitor to sustain the oscillations generated. At the second stage of amplification, the oscillations which represent the modulated signal is amplified and transmitted into space through the linear antenna. The power source of the transmitter is taken directly from the 9V battery. The RFC and electrolytic capacitors smoothens the input voltage to prevent noise from interfering with the signal. The circuit diagram is shown in Fig.2.4 bellow:

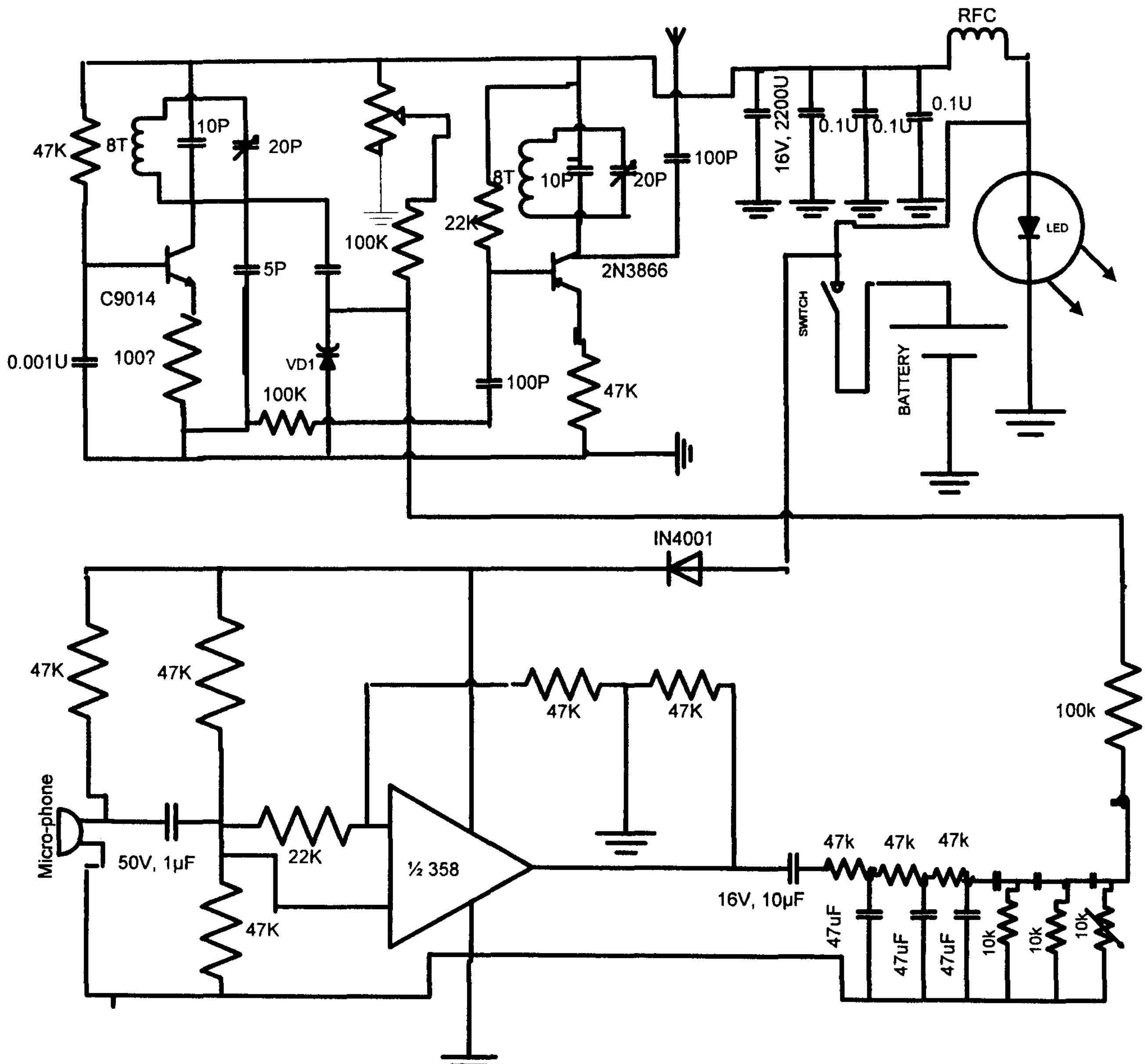


Fig. 3.4 A varactor Diode FM transmission circuit

The constant voltage source 7905 maintains an output voltage of 5V across the primary oscillator to avoid pop noise or distortion when the voltage from the battery source drop bellow 9V.

2.2.6 BASIC OPERATION

The microphone takes its input voltage from the 9V source. Sound pressure impressed upon the diaphragm of the microphone causes the current flowing through its carbon granules to vary as the varying pressure on the diaphragm. The resulting alternating current which represent the audio signal is fed into the OP-AMP. This amplifies the signal and transfers it to the low pass and high pass filter through the electrolytic capacitor 16V, 10**µf**.The Low Pass Filters (LPF) ensures that frequencies bellow the audio range are cut-off. This help to eliminate background noise. The High Pass Filters (HPF) ensures that frequencies above the audio range are block. Therefore, the LPF and HPF functions as limiters. The oscillations generated by the primary oscillations represent the carrier signal. The audio signal is impress on the carrier signal which modulates its frequency parameter. The modulated signal is couple to the secondary oscillator which serves as a repeater through the 100pF capacitor. The oscillations are regenerated and amplified accordingly and the resulting modulated signal is transmitted into space via the linear antenna. The 100pF capacitor isolates the antenna from having a direct link with the circuit to avoid noise and interference when the antenna touches a metallic casing or when it is approach by a passer-by. The 20pF capacitor at both oscillators must be preset to the same value so that the signals generated by the oscillators will be in phase.

2.2.7 OSCILLATORS

An oscillator is a combination of active and passive components that generate sinusoidal signal with constant wavelength and amplitude [2]. This means that the parameters of the signal remain constant. Oscillations are use to generate carrier signals which are needed for modulation. Three sections that are basic to all oscillatory circuits are: Frequency determining unit; Feed-back path and the Amplifier unit. These sections are shown in the transmitter circuit diagram in Fig 2.5 above.

2.2.8 RADIO FREQUENCY AMPLIFIER

The first stage for amplification of the audio signal in the transmitter uses an operational Amplifier. The intelligence which is fed into the microphone is transfer to the OP-AMP through its inverting input terminal. C1 is a coupling capacitor while R1 and R2 are bias resistors which enhance the normal operation of the OP-AMP. R5and R6 forms the feed-back loop to the non- inverting input terminal. The output of the OP-AMP which is taken across pin 6 is couple into the low pass filter and high pass filter circuit which serves as a limiter-eliminating frequencies bellow and above audio range. R11 and R12 forms the modulation depth adjustment which is determine from the relation:

$$f = 1/2\prod RC.$$

2.2.9 FM RECIEVER

A super heterodyne receiver was adopted for the reception of the signals transmitted by the transmitter. It has the advantage of providing enough gain to boost the weak signals. Super het. receivers operates on the principle of conversion of all incoming radio frequency frequency signals into intermediate frequencies (IF). This IF is kept fixed thereby helping the amplifier circuit to operate with maximum stability of selectivity and sensitivity [10].

A monolithic integrated circuit TDA7000 was adopted to perform this function. The IC has an FLL (frequency lock loop) system with an intermediate frequency of 70KHZ. The intermediate frequency selectivity is obtain by the active R-C filters. The only function which needs alignment is the resonant circuit for the oscillator which select the reception frequency. Spurious reception is avoided by means of a mute circuit which also eliminates too noisy input signals. Special precaution were taken to meet the radiation requirements. The TDA7000 monolithic IC comprises the following sections:

i. the RF input stage

ii. the mixer stage

iii. a local oscillator

iv. an IF amplifier / limiter

v. a phase modulator

vi. a mute detector and

viii. a mute switch.

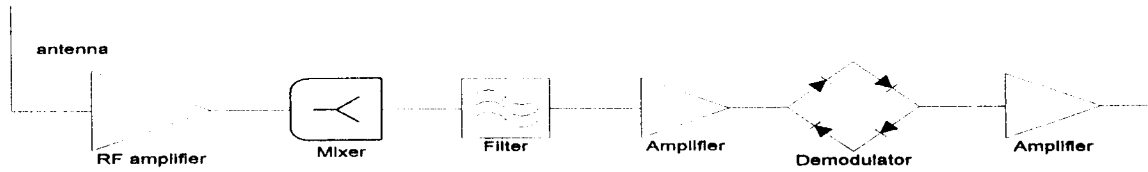
In super heterodyne receivers, all signals frequencies are converted to a constant lower frequency before detection. In medium wave receivers the frequency is 455KHz while for FM and VHF it is usually 10.7MHZ. Super heterodyne receivers mixed a signal from a local oscillator in the receiver with the incoming signals. The user tunes the radio by adjusting the set of oscillator's frequency. In the mixer stage of a receiver the local oscillator signal is multiply with the incoming signal producing beat frequencies at both the sum of the two input frequencies. The signal at the difference frequency is pass on by tuned circuits. It is then amplify and demodulated to recover the original audio signal. Superhet receivers have the advantage of overcoming most limitation of other receiver designs. For instance tune radio receiver suffer from poor selectivity since filters with high Q-factors have wide band-width at radio frequencies. Regenerative and super-regenerative offer better sensitivity but suffers from stability and selectivity problems.

Draw backs of super heterodyne receivers:

i. cost of mixer and local oscillator stage.

ii. vulnerability to interference from signals other than the desire ones which falls within the IF range.

The diagram below shows the basic elements of a single conversion superhet receiver. In practice not every design will have all these elements, nor does this convey the complexity of other designs, but the essential elements of a local oscillator and a mixer followed by a filter and IF amplifier are common to all superhet circuits. Cost-optimized designs may use one active device for both local oscillator and mixer-this is sometimes called a "converter" stage. Fig. 2.6 bellow is a good example of a pentagrid converter.



The circuit diagram of the super heterodyne receiver showing its external connection to passive and active components is shown in Fig. 2.7 bellow:

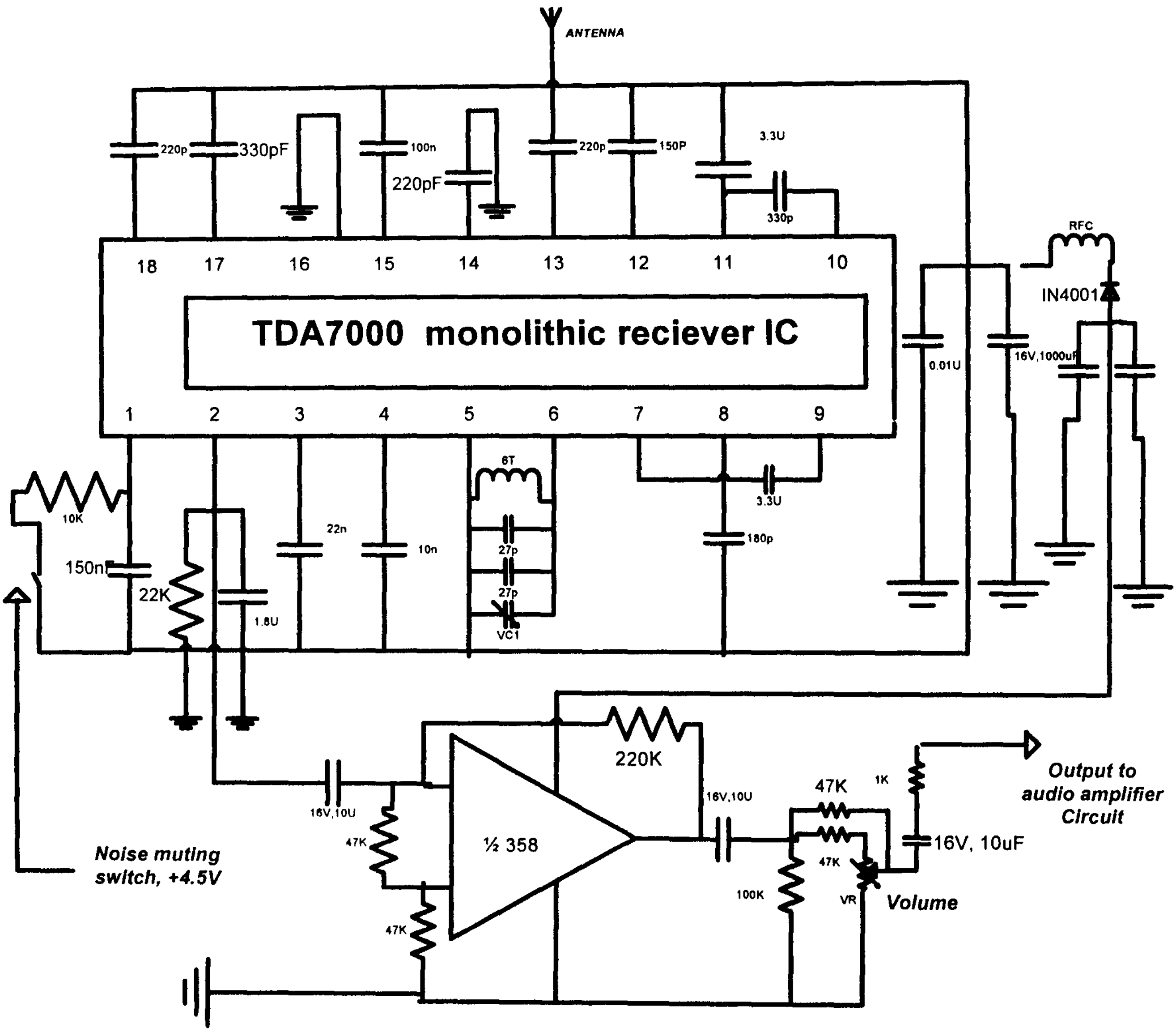


Fig.2.7 Circuit diagram of a TDA 7000 Frequency Modulation Receiver (all ground connection should terminate at pin 16)

2.3.0 AUDIO AMPLIFIER

An amplifier increases the strength of a weak signal. It is employ in the design of electronic gadget such as: radios, television set and radar equipments. It operates on the principle of amplification of signals applied across its input terminals.

All amplifiers operate basically for the same purpose though their mode of operation may differ. Most amplifies uses small current fed into them through their base terminals to control the flow of large current/voltage. In an amplifier, the efficiency is the ratio of the output signal power to the ratio of the input signal power require to produce the output. This is expressed as: $eff=(P_{out/Pin})100\%$.

Fig. 2.10 bellow shows the amplifier circuit diagram that was used to realized the signal amplifier.

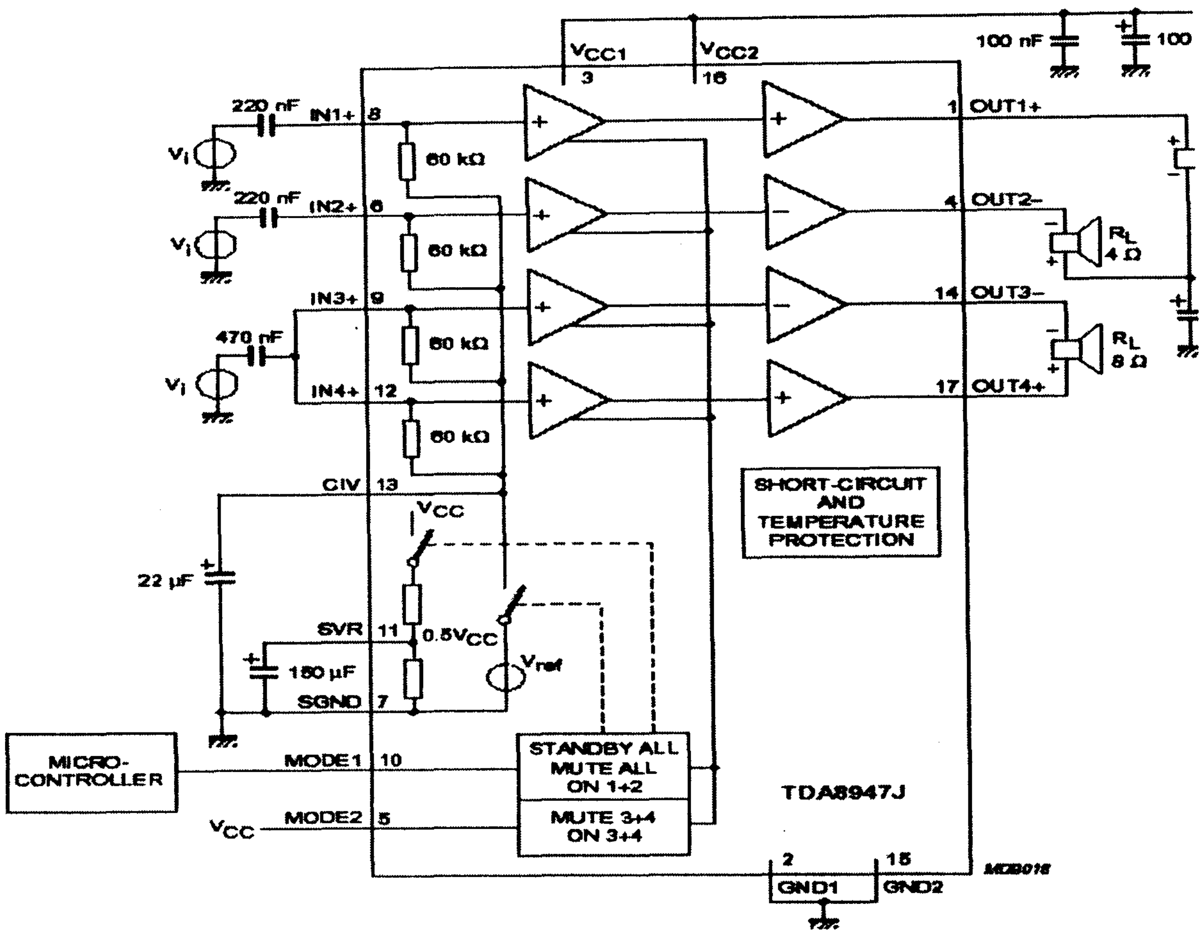


Fig. 2.8

2.3.1 ANTENNAS

An antenna is a transducer design to transmit or receive radio signals which are in form of electromagnetic waves and vice versa. Antennas are use in system such as radio and television broadcasting, point to point radio communication, wireless LAN, Radar and space exploration.

Antennas usually work in air or under water or even through soil and rocks at certain frequencies for short distances. They can take the form of physical arrangement of conductors that generate radiating electromagnetic field in response to an applied alternating voltage and the associating electric current or can be place in an electromagnetic field so that the field will induce an alternating current in the antenna and voltage between its terminals.

Antennas were first use by Heinrich Hertz in 1894 to prove the existence of electromagnetic waves predicted by the theory of James Clerk Maxwell.

2.3.2 OVERVIEW OF THE ANTENNA USED

Antennas have practical uses for the transmission and reception of radio signals which can theoretically travels over great distances at the speed of light. These signals can travel through non conducting walls though there may be a slight reduction in their intensity as they pass through obstacles. Natural rocks can be very reflective to radio waves.

The type of antenna adopted for this project is the Haitian dipole type. It radiates and receives from all horizontal direction. However, one limitation presents a set back for this antenna which is the inability of the antenna to radiate and receive in the vertical direction which it points. The vertical direction is refer to as the antenna blind cone or null region. Two fundamental types of antenna with respect to three dimensional planes include:

i. Omni directional antenna – which radiates equally in all direction

ii. Directional antenna – which radiates in one direction

Antennas usually radiates some energy in all direction in free space but special arrangement or construction of antenna's conductors results in a substantial transmission of energy in the prefer direction.

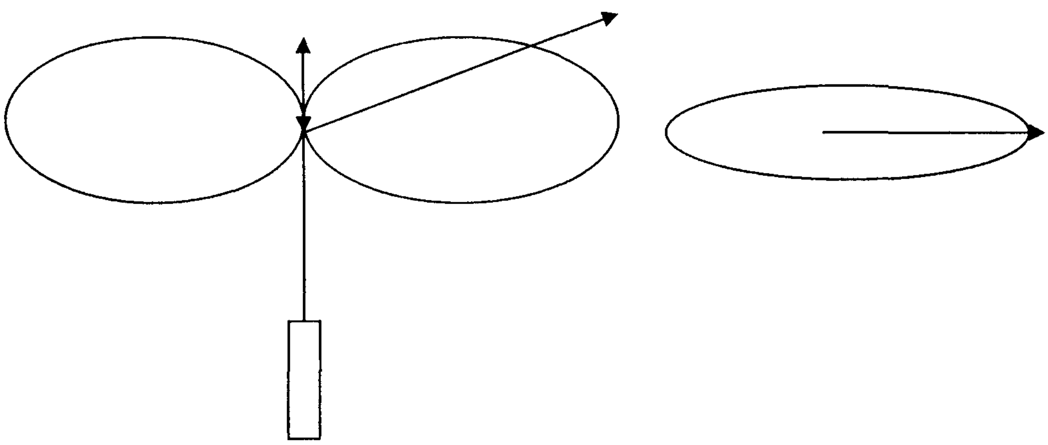
2.3.3 ANTENNAS PARAMETERS

These are the critical parameters that affect the performance of the antenna and can be adjusted during design process. They include: gain, band width, impedance, radiation pattern, polarization and efficiency. The Haitian dipole antenna adopted for this project is a simple wire whose current distribution is assume uniform. The current induces into the surrounding air produces its own associated electric field. This set up a propagation of electromagnetic field away from the antenna. Two fields are always associated with the propagation of energy from the dipole. This are:

i. The induction field which occupies the near field region known as Frosnel zone. It is inversely proportional to the distance of the antenna.

ii. Radiation field which occupies the far field region known as Fraunhofier region which is also inversely proportional to the distance of the antenna.

The magnitude of electric field intensity is given by: $\mathbf{E_m = |E_Q| = 60\Pi LI/\lambda d}$. The radiation pattern which is defined by COSΦ means that at right angle there is maximum radiation [17]. In the direction of the antenna the radiation diminishes to zero as shown in Fig. 2.11 bellow.



Radiation in the vertical plane *b.* *Radiation in horizontal plane*

The power of radiation into space by the antenna is given by $\mathbf{P=80\Pi^2(1/\lambda)^2}$ **Watts**

The radiation resistance $\mathbf{R_r=P/I^2= 80\Pi^2(1/\lambda)^2}$**.**

Fig. 2.9 Radiation pattern of linear antenna

CHAPTER THREE

3.1.0 DESIGN AND CONSTRUCTION

This project has been built on different Vero Boards which offers firm connection to the components. Bread Boards could not be used to test the working of the circuit since a firm grip is always require for radio frequency circuit to minimize inductances which can cause signal attenuation and perturbation. The wireless public address system comprises three principal components as emphasized earlier. The components include: a low power FM transmitter; a Frequency Modulation super heterodyne monophonic receiver and a 60 Watts audio power amplifier. The design requirements are:

i. The design of a wireless FM-based public address system,

ii. The transmitted audio signal should be received by any FM receiver;

iii. The received audio signal should be amplified high enough for normal audible range.

To achieve the first requirement, a low power short range FM transmitter was designed operating within a frequency modulation band of 88-108MGHz. The second requirement was achieved by designing an FM receiver capable of intercepting FM transmissions within the above frequency range. The third requirement was met by employing a high power integrated circuit capable of delivering 60Watts output across loud speakers.

3.1.1 POWER AMPLIFIER

The power amplifier was built using the TDA8947 audio IC which is packaged in a single in-line staggered package, the IC runs off a maximum of 28V DC and can source an output power of 1-25Watt into 4 ohm load. The IC comprises four separate amplifiers, two are phase inverted and two are non-inverted. It has an internally fixed gain of 26dB (single-ended configuration), or (32dB bridge-tied load configuration).

3.1.2 POWEWR SUPPLY

The power supply was designed using a 22V, 4A transformer connected to the bridge rectifier as shown in Fig. 3.1 bellow:

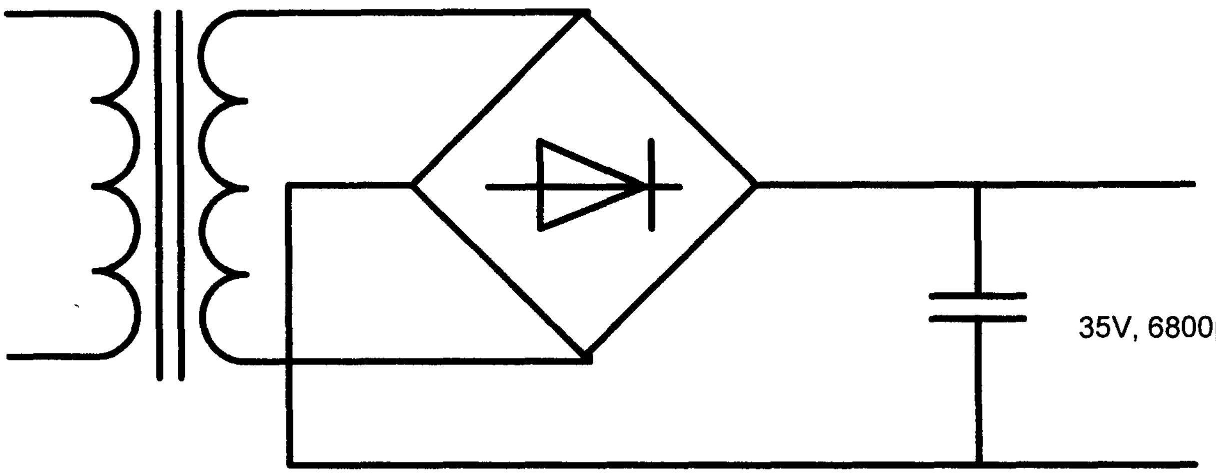


Fig. 3.1 AC Rectifier Circuit

The peak output of the rectifier is given b.3y the expression: $\mathbf{V_{peak} = (V_{rms} \sqrt{2}1.4)V}$........................i.

For a $\mathbf{22V_{rms}}$, secondary voltage will be: V_{peak}=**(22√2-1.4)V =29.7V**

Where: √2 = **rms** to peak factor, **1.4** = forward voltage drop in two diodes of the bridge rectifier

$V_{DC} = V_{peak} / (1 + 1/\mathbf{4FRC})$......................ii.

F = mains frequency = **50HZ, R** = Load resistance, **C** = Total capacitance across the power supply circuit. The relation for determining the value of C is given by:

Q = CV = It......................................iii.

CV = It..iv.

CΔV = tΔI → C = tΔI /ΔV....................V

ΔV = Maximum allowable ripple, **t = 1/2F = 1/2 X** mains frequency-for a bridge rectifier.

ΔI = current change on load.

C = tΔI /ΔV. We see that C is proportional to **1** / ΔV and is also proportional to **ΔI**. This implies that a large value of C will yield a small value of ΔV and the **I_{max}-I_{min}** is a calculation of the capacitance (during normal operation at rated output load, ΔV is to be kept bellow **2V** and ΔV at **4A** this implies maximum current minus minimum current).

C = (1/2X50X4)/2 F..............................vi

C = 0.01X4/2 = 0.02F. C = 20,000uF

3.1.3 POWER AMPLIFIER CONFIGURATION

The power audio IC has four separate amplifiers each with a gain of 26dB (AV = 20) when operated in the single ended mode. When two separate amplifiers are used to drive a common load, the gain factor is **32dB.** Three speakers were used to radiate the lower, mid-range and treble portion of the audio spectrum. Since different amplifiers were used, the audio frequency was split into three bands:

F < 200HZ; F > 200HZ; and **F > 5kHz.**

The filter network where a low pass filter strips off the high frequency content of the of the input voltage to drive a 30Watt minimum amplifier was constructed as shown in Fig. 3.2.

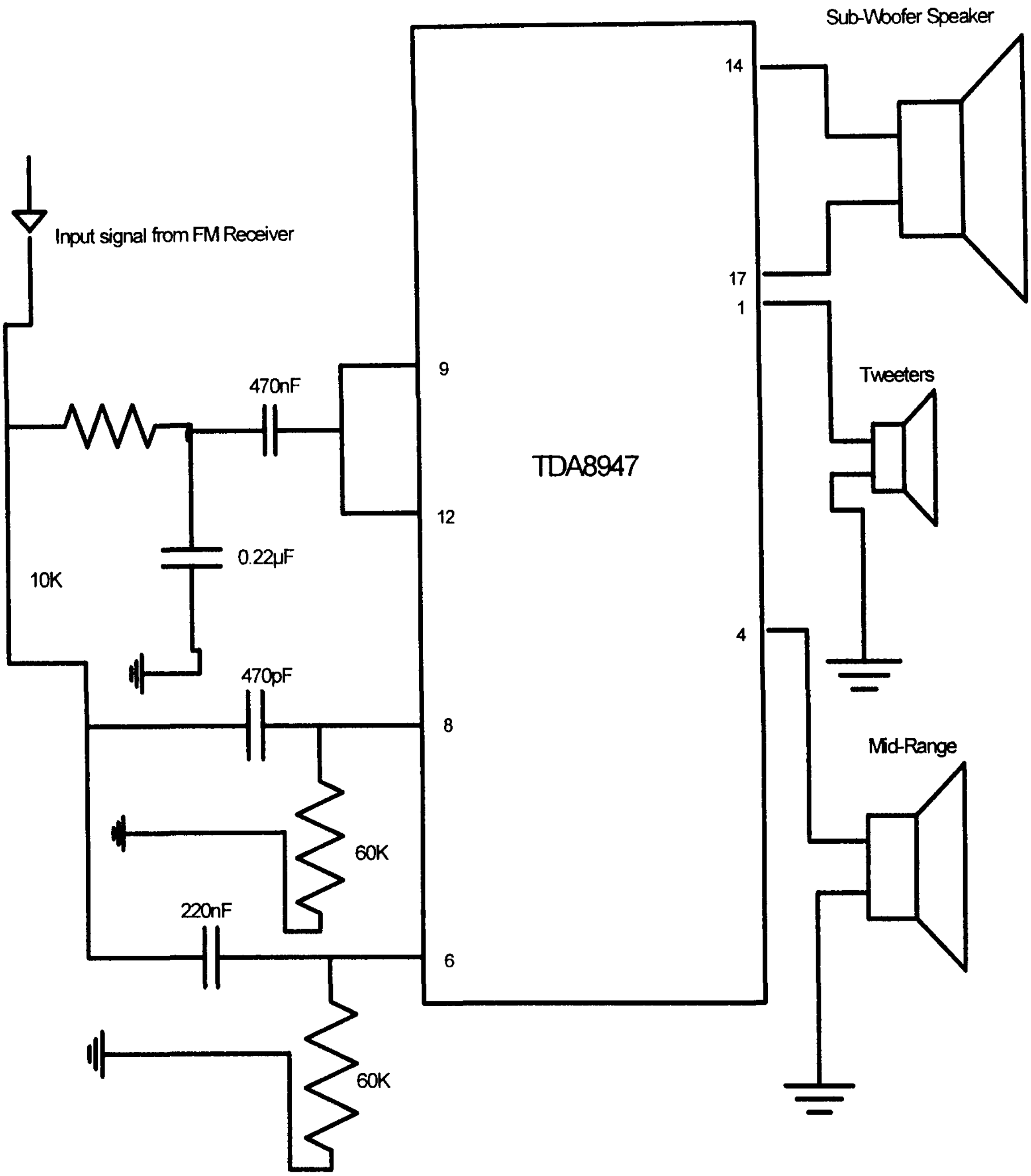


Fig. 3.6 Pin connection of the Power Amplifier to the loud speakers

The 60K resistors are the input resistances of the amplifier. The low pass filter driving the sub-woofer amplifier has a cut-off frequency of 200HZ which was determine from the relation:

$F = 1/2\pi RC$..............................vi.

Selecting R as 10K, and making C the subject of the formula gives the capacitance value from the relation: **$C = 1/2\pi FR = 1/(\pi \times 200 \times 10{,}000) = 7.95775 \times 10^{-8}F$, $C \sim 80\mu F$.**

A high pass filter was employed to pass only frequencies above **15kHz** to a **15watt** amplifier that powers the high frequency radiator. The expression used for deriving the values of the filter components was given in equation vi where C can be express as:

C = 1 / 2∏FR................................vii.

R is the internal input resistance of the amplifier with a specified value of **60K** from the manufacturer's data sheet. Taking **C** as **5kHz,** the value of **C** can be determine as follows:

C=1 / (5000 X 2∏ X 60,000) = 530pF.

A **470pF** capacitance was used to reduced the frequency overlap that would be produced by the filter network driving the mid-range unit. The mid-range radiator was driven by a high pass filter with a cut-off frequency of **200Hz**. The filter components were selected using **R** = **60K, F** = **200HZ**, yielding a capacitance value of **13uF** from equation vii above. A **12uF** was used. No low pass filter used after the high pass filter to increase the energy content of the reproduced audio signal.

3.1.4 9V POWER SOURCE

A **9V** regulated power source was provided for the FM receiver subsystem. This was generated using a **7809,** 1-Ampere regulator connected to the rectified DC Voltage as shown in Fig. 3.3 bellow.

The **7809** regulator produced a regulated **9V DC** which powers the FM receiver. The **9V DC** was stabilized using a **25V, 1000uF** capacitance.

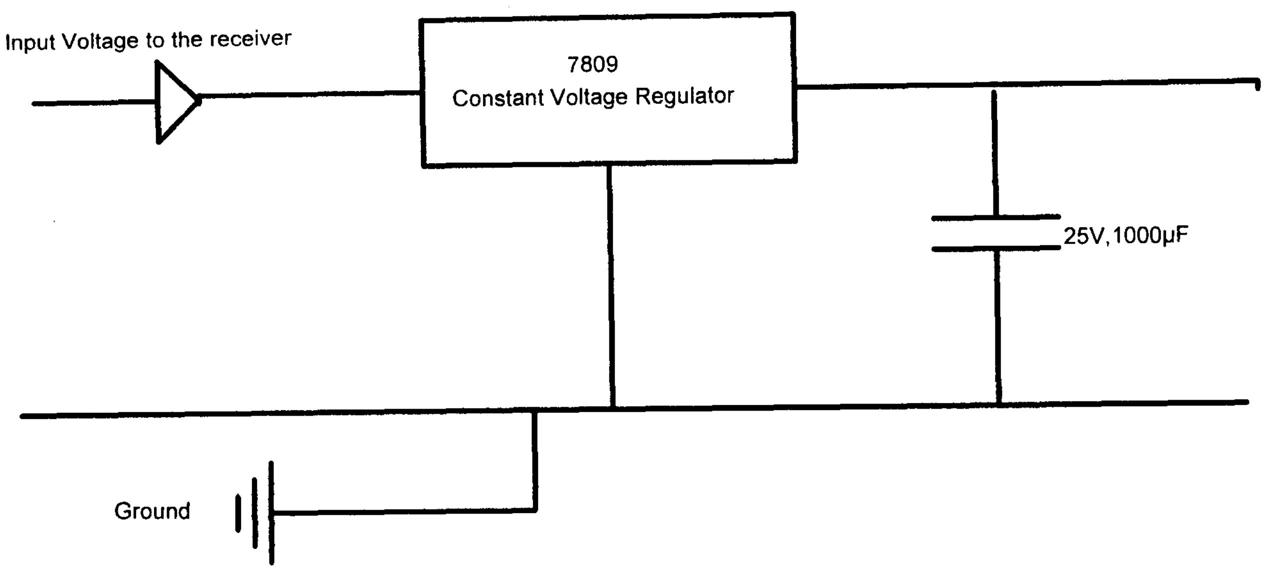


Fig.3.3 FM Receiver's power supply

3.1.5 THE RECIEVER

A **TDA7000** monolithic integrated circuit was employed for the design of the receiver. The **IC** has a frequency lock loop **(FLL)** with an intermediate frequency of **70KHZ.** The intermediate frequency selectivity is determined by the active RC-filters which were specified on the manufacturer's data sheet. The only function which needs alignment is the resonant circuit for the oscillator which selects the reception frequency. Spurious reception which introduces noise to the output of the receiver was avoided by means of a mute circuit. The IC is powered by a **9V** source from the amplifier's circuit as shown earlier. An antenna which is isolated by a **220pF** from the receiver circuit at pin 13 intercepts the radiated signal from the transmitter. The isolation capacitor also helps prevent noise when the antenna is approached by passer-by carrying charges. The output of the receiver across pin 2 as shown in Fig 2.7 is connected to the operational amplifier which raises the signal amplitude to a level that is sufficient to drive the audio amplifier. The input to the operational amplifier is filtered by a 16V, 10uF capacitor. The amplifier combines the positive and negative half of the audio signal and amplifies them across its output terminal across pin 6. The output signal is further by another 16V, 10uF capacitor which is usually employ for audio filtering.

3.1.6 FM VARACTOR DIODE TRANSMITTER

The transmitter was constructed on Vero-board to ensure a rigid connection of the circuit components. A varactor diode was used for oscillation generation to avoid perturbation due 'micro phonic'-a form of noise which arises due to vibration of the transmitter by the user. A constant voltage regulator **78605** was used to supply the primary oscillator with a constant **5V** to avoid distortion when the voltage level of the battery drops bellow **9V**. The low pass and high pass filter was included in the circuit to ensure that only frequencies within the audio range are selected. The modulation depth was included to enable the user adjust the modulation to a desire depth. The secondary oscillator serves the purpose of increasing the strength of the signal to minimize signal power loss due to attenuation. The transmitting antenna is isolated from the circuit by a **1000pF** to filter noise away from the output. The following diagrams shows how the circuits were connected on the Vero-boards:

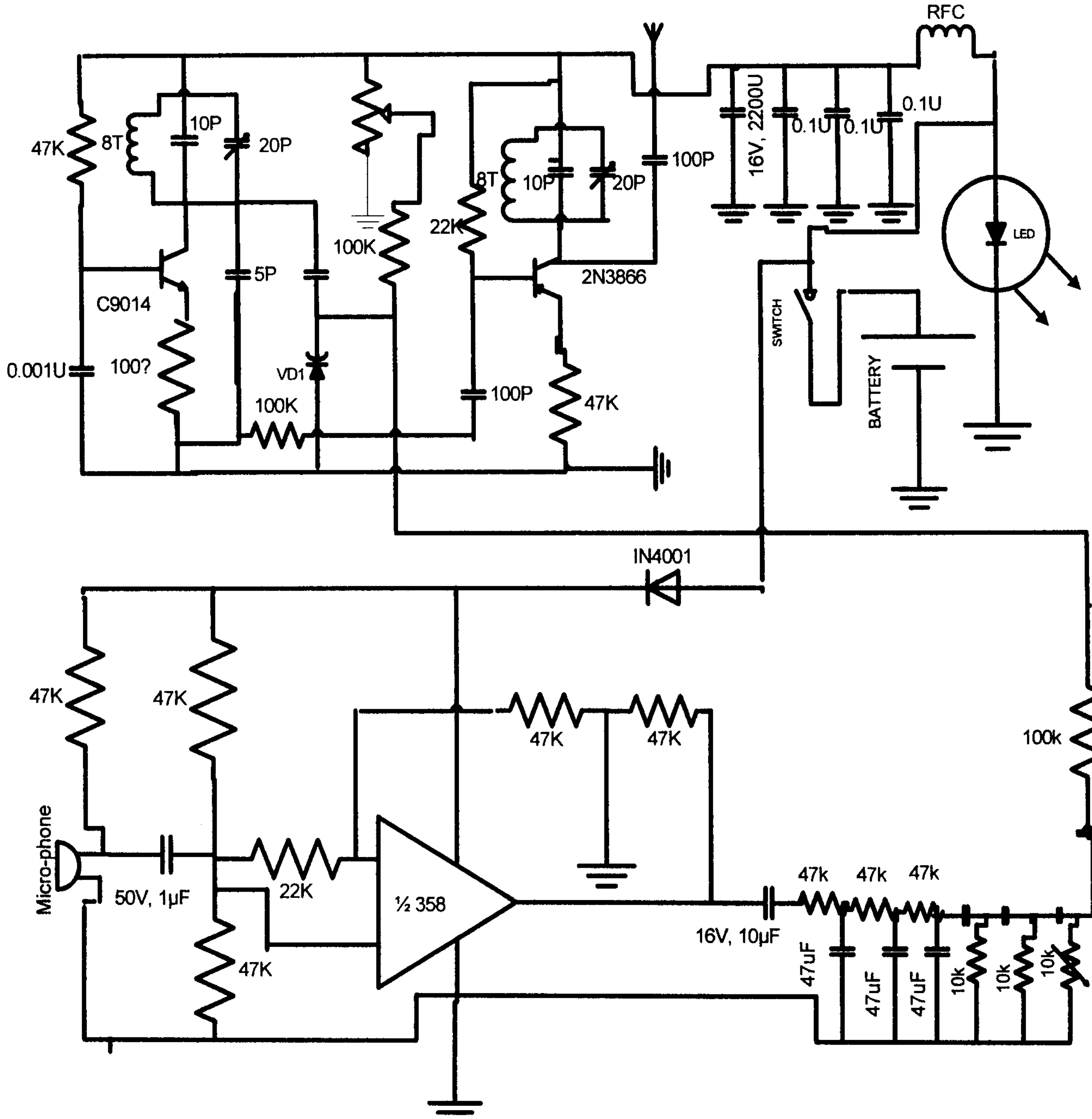


Fig. 3.4 A varactor Diode FM transmission circuit

1933. In 1912 when he was 22 he discovered how Lee De Forest radio tube works and redesigned it by taking the electromagnetic waves that comes from a radio transmission and feeding the signal back through the tube again and each time the output power was increase by 20,000 times per second. He called the phenomenon as regeneration.

This was the most important advancement in the young history of radio communication because when the feed-back was increase beyond a certain critical level the tube gave up oscillations that created its own radio waves. He succeeded in making De Forest tube to function as both transmitter and receiver. The tube did not only amplify signals but also generated them as well and this advance made the difference [3]. Today, immense contribution has been made in the development of radio communication. It now comprises both wireless and non-wireless communication system which has led to space exploration via communication satellite.

2.1.0 RADIO WAVES TRANSMISSION AND RECEPTION

Since every modern communication system uses radio transmission and reception except those communication devices which exploits infra-red rays, it is important that we briefly explain how radio communication works.

Earlier before, the term radio refers to 'wireless' communication which now denotes an entire Industry. The radio we see today is the heart of every wireless device today. Cellular phones, television, wireless LANs uses radio waves to get from one point to another. Every kind of radio transmission uses some form of variation of full Amplitude modulation or full Frequency modulation [4].

2.1.1 RADIO WAVES

This are part of a general class of waves known as electromagnetic waves. This implies that they are electrical and magnetic energy that travels through space. At certain frequencies they behave as radio waves. When their frequencies are much higher we refer to them as infra-red light and when their frequencies gets more higher they form the visible spectrum known as ultra violet light and x-rays.

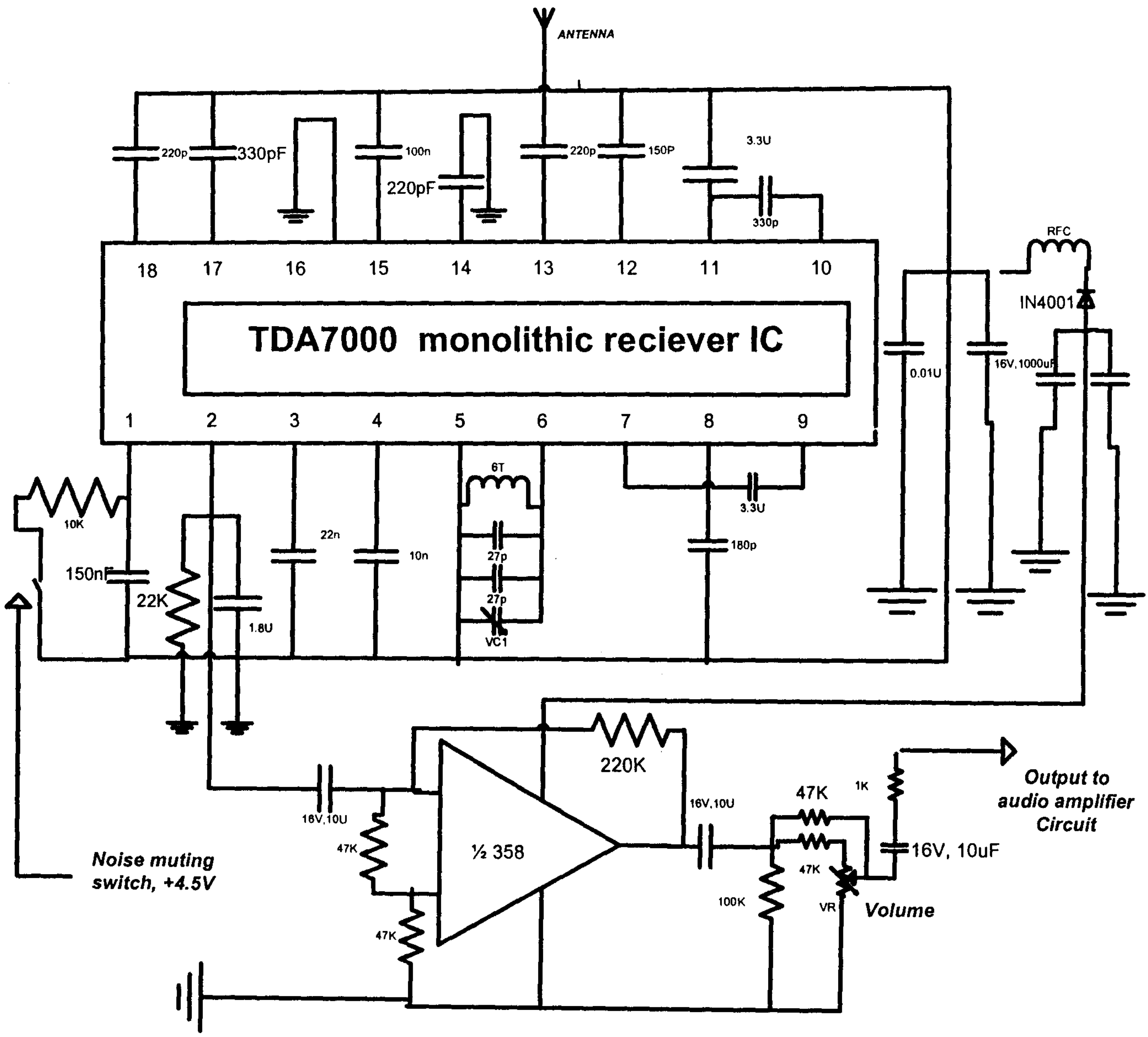


Fig.3.5 Circuit diagram of a TDA 7000 Frequency Modulation Receiver (all ground connection should terminate at pin 16)

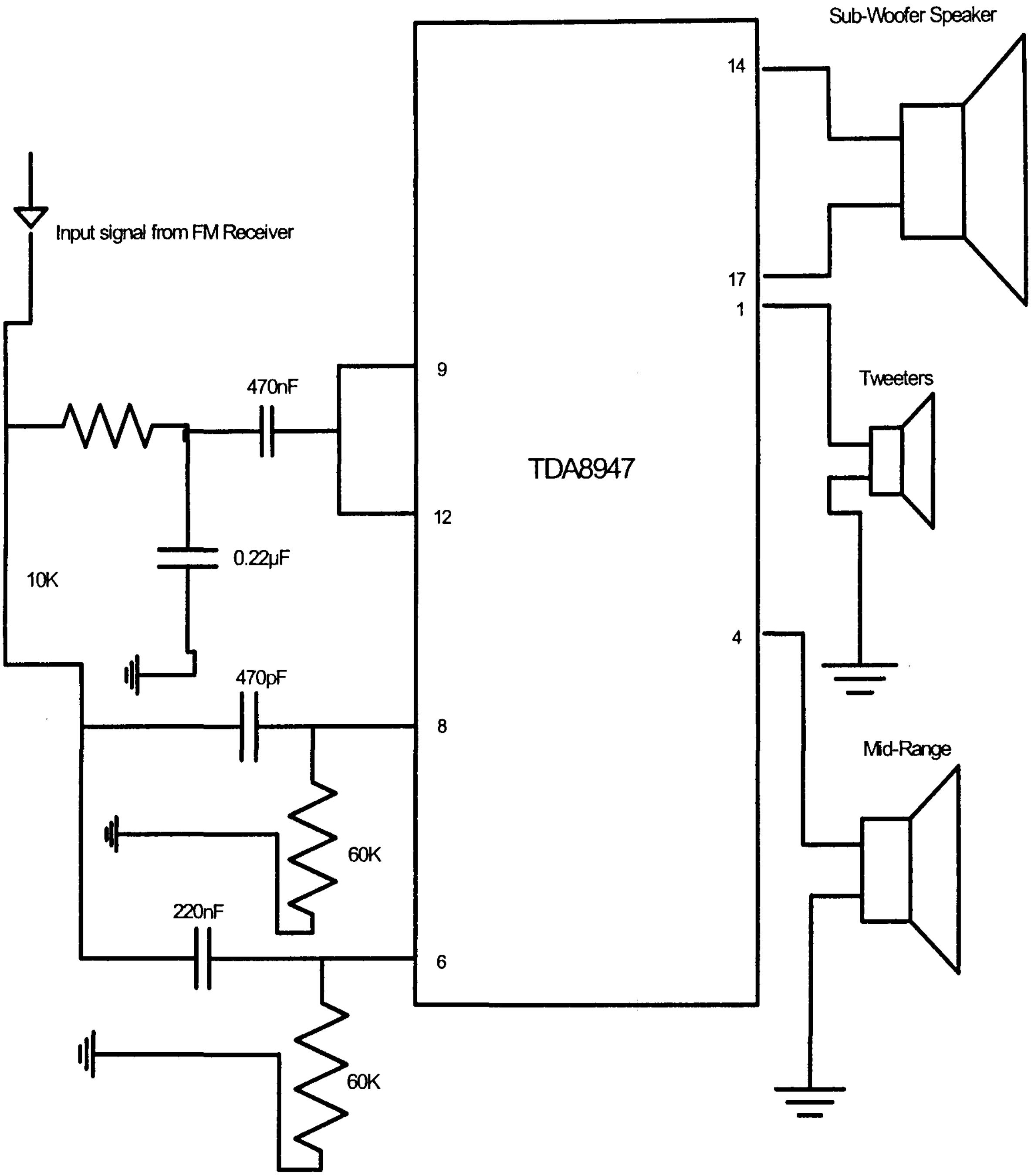


Fig. 3.6 Pin connection of the Power Amplifier to the loud speakers

CHAPTER FOUR

4.1.0 TESTING, MEASUREMENT AND RESULT

At the end of the constructions for this project it was found that the Amplifier transmits within the desire frequency range of **88-108 MHz**. This was determined using a radio receiver which was able to picked-up the FM radiations from the transmitter as specified in the design objectives. The receiver constructed is sensitive enough to detect weak radio signals even from a low power transmitter that is position over **200 meters** away. The receiver is capable of intercepting any signal that is broadcasted within the frequency band which lies in the range **88-108 MHz.**

The audio power amplifier was found to deliver a peak current output of **4A**. Its total power output was found to be **44 Watts** as indicated in the manufacturer's data sheet. The power output of the amplifier is a function of the input voltage and the current. The maximum output power is limited by the supply voltage (**V_{CC} = 22V**) and the maximum current **I_o = 4A.** For a supply voltage of **V_{cc} > 22V,** a minimum load of **3-6 ohms** is required.

From the manufacturers data sheet, the noise output voltage is measured at the output with a frequency range from **20Hz to 22kHz** with a source impedance **R_{source} = 0** at the input. Supply voltage ripple rejection is measured at the output with a source impedance **R_{source} = 0** at the input with a frequency range from **20Hz to 22kHz**. The ripple voltage is a sin wave with a frequency (F_{ripple}) and an amplitude of **300mV (r.m.s)** which is apply to the positive supply rail.

To ensure that a **22-26Volt** peak value is deliver to the amplifier by the step-down transformer, the supply voltage from the mains should be kept within **220-240Volts**. This will further enhance the efficiency of the amplifier by making it deliver a higher output across the loud speakers.

4.1.1 PRECAUTIONS TAKEN

During the construction of the circuits, it was ensure that all the components were firmly soldered to avoid noise due to partial contact of components at their connecting terminals. It was also ensure that components were not mounted wide apart from each other to avoid too much inductances along the conducting paths. Before testing the project it was ensured that there were no bridge connections or short-circuited paths which could have damage the components network on the Vero-boards. The audio amplifier and the loud speakers were enclosed in a wooden frame which was tightly fastened with screws to ensure that quality sound was produced from the speakers. The audio Amplifier was screwed to an heat sink. This was to ensure that too much heat dissipated in the IC during its operation was conducted away.

CHAPTER FIVE

5.1.0 CONCLUSION

This project has clearly demonstrated the beauty and advancement of modern communication system. With this advancement, less effort is require to address a large audience. Lecturers have also find it easier to deliver lectures to students without much stress. This was the main driving objective for the design and construction of this wireless public address system. This was achieved at the end of the construction having taken the necessary precautions into consideration which were imperative for the realization of this objectives as outlined above.

4.1.1 RECOMMENDATION

Further work on this project should incorporate a temperature and over current protection circuit. A micro-controller incorporated could also control the muting and temperature level of the amplifier automatically when programmed accordingly. Future work on this project should consider improving the sensitivity of the receiver by constructing a pre-amplifier at the reception antenna terminal. This will enable the receiver to detect very weak signals thereby increasing the maximum radius of reception of the transmitted signal.

COST OF CONSTRUCTON

1. TRANSMITTER

ITEMS	UNIT	COST IN NAIRA
47k	12	220
100k	4	160
27k	1	20
22k	1	20
10VR	1	50
10pF	2	40
20pF	2	40
47uF	3	60
0.001uF	1	20
0.1uF	3	60
5pF	1	20
16V, 2200uF	1	50

16V, 10uF	1	30
50V, 1uF	1	30
IN 4001	1	10
RFC	1	100
LED	1	10
½ 358 op amp	1	150
Microphone	1	100
VD1	1	300

2. RECEIVER

TDA7000	1	750
½ 358 op amp	1	150
220pF	2	60
330pF	2	60
150nF	1	30
180pF	1	30
3.3uF	2	40
0.01uF	1	10
1.8uF	1	10
27Pf	2	40
VC1	1	50
22uF	1	20
10uF	1	10
IN 4001	1	10
16V, 1000Uf	1	100
16V, 10uF	2	60
10K	1	10
22K	1	10
47K	1	20
VR	1	50
220K	1	30
100K	1	40

3. AMPLIFIER

TDA8947	1	500
10K	1	10
60K	2	40
470nF	1	30
0.22uF	1	10
470pF	1	30
220nF	1	30
8 ohms sub-woofer speaker	1	1500
4 ohms mid-range speakers	1	700
3 ohms tweeter speaker	1	200
7809 constant voltage source	1	100
25V, 1000	1	100

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