DESIGN AND IMPLEMENTATION OF A WIRELESS MUSIC PLAYER

BY

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SEPTEMBER, 2016

DECLARATION

I Okeowo Oluseyi Temitope hereby declare that this project work is entirely my own work and has not been submitted to any other university or higher education institution, or for any other academic award in this university. Where use has been made of the work of other people, it has been fully acknowledged and fully referenced

....

OKEOWO OLUSEYI TEMITOPE DATE

(EEE/11/0395)

CERTIFICATION

This is to certify that the design and construction of this wireless music player was carried out by OKEOWO, OLUSEYI TEMITOPE of the department of Electrical and Electronics Engineering, Federal university, Oye-Ekiti, Nigeria.

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ACKNOWLEDGEMENT

My profound gratitude and appreciation goes to Engr.Dr. A.M.Zungeru, assisted by Mr.Kenneth Njokuocha, for his encouragement, supervision and care that saw this project through its conclusive expectation. Indeed He is proudly a Father, a brother and a Friend. Following this are all the lecturers in the department starting from the H.O. D, A/prof. A.O Akinsanmi, Prof.Y.A Adediran, Engr. Dr.Oricha, Engr G.K Ijemaru, Engr.Adebusuyi, EngrObikoya,Engr. Adefarati, Engr.Ezea, Engr. Oluwole,Engr. Ofusori, Engr. A.K Babarinde, Engr.Olusuyi, Mr.Omoleye, Mr. Ajibola and MrEmmanuelEffiong that impacted skills, knowledge and leadership qualities into my life, I say thank you.

Words are not enough to express my sincere gratitude to my mum, Mrs. Bolanle Okeowo. I cannot appreciate you enough. I am forever indebted to you ma. You have been my backbone thus far in this journey. Thank you for your love, financial support, kindness, support and prayers.

I sincerely appreciate the moral support of my Dad, Mr. Okeowo. You are the best sir. A big thanks goes to my uncle, Mr. OgunleAdedoyin, for his moral and financial support. To my siblings, OkeowoAdetola, SarumiAderinsola, SarumiAdenike, Ogunle Praise, OgunleFavour, blessing and goodness, thanks for being there for me. I love you so much.

I am also indebted to all members of the Redeemed Christian Fellowship, an Arm of Christ the Redeemers Ministries, Ikole chapter, where I served as the pioneering president for three years. Thanks for your assistance and understanding during the period of the design and implementation of this project. You are my first family of faith on earth.

To all those who have been of great help to me but cannot be mentioned because of space, forgive me, you are always in my heart. I thank you all.

Finally, to my entire colleaguesin the department of Electrical and Electronics Engineering and other departments in the Federal university Oye Ekiti (FUOYE), a big thanks to you all.

DEDICATION

This project is dedicated to Almighty, the master of the universe, whom out of His abundant mercy has given me the rare privilege to reach this level of my academic pursuit

ABSTRACT

This project report presents the design and implementation of a wireless music player. This wireless music player allows the user to listen to compressed digital audio streamed over a wireless link. The Receiver thus can be placed in any corner of the house with radial distance of four meters and high quality music can be enjoyed without hassles of long connecting wires. In implementing the entire wireless music player, two sets of circuits, a transmitter circuit for transmitting the music signal from the source input and a receiver circuit for receiving the transmitted music signal and for playing it in the attached speaker were designed. The construction was carried out using analog components and integrated on two circuit boards. The design of the receiving end is split into two portions, the analog frequency modulation (FM) front end and the digital demodulator. The job of the front end is to step down the radio frequency (RF) signal to a frequency that is low enough to sample with an analog to digital converter. It can be used for playing high quality music wirelessly from a Television Set (TV) set, digital versatile disk (DVD) player, IPod, Cell phone or from any music system. The entire project was designed, constructed and tested in the electronics laboratory of FUOYE and met with design specifications.

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ABBREVIATIONS

FM= Frequency Modulation

AM = Amplitude Modulation

C= the speed of light = 300,000km/s or 3.0×10^{8}m/s

F= frequency

VLF = Very low frequency

MF = Medium Frequency

LF = low frequency

VHF= Very high Frequency

UHF = Ultra high frequency

SHF = supper high frequency

EHF = Extremely high frequency

A_V = voltage Gain

Rr = Radiation resistance

Pt = Transmitted power

Z_{out} = Output impedance

Z_{in} = Input Impedance

L = Self inductance of the coil (H)

C= capacitance of the condenser (F)

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Voice or information that is going to be transferred is termed as information signal. If the distance between communication parties is too large, direct voice communication is impossible. The method of message sender is needed, and the function of message sender is just to carry the information to the desired destination. Thus the message sender can be said to be a carrier. The carrier merely sends the information and needs not to be intelligent. The information signal is sometimes called the intelligence signal.

In Telecommunications, the mechanism of putting the information signal into a carrier for it to be transmitted farther is called modulation. Since the characteristic of the carrier signal is being altered by the information signal, the carrier is also a modulated signal. Therefore, the information signal, intelligence signal, and modulating signal represent the same thing. For the carrier to carry information, at least one of the carrier signals characteristics (amplitude, phase or frequency) must be modified. Frequency modulation is a method of modifying the frequency of carrier signal so that the receiver can obtain the desired transmitted information.

Frequency modulation (FM) is one of the angle modulation techniques. This modulation technique is so common nowadays that it can be found in any kind of commercial radios. Several projects and researches have been carried out on this topic since its introduction. Due to the rapid development of integrated circuit, Most FM transmitters and receivers nowadays are constructed and designed using modulator and demodulator chips. The use of ganged inductors and capacitors can also be found in modern radio set. Frequency modulation has several advantages over the system of amplitude modulation (AM) used in the alternate form of radio broadcasting. The most important of these advantages is that an FM system has greater freedom from interference and static Various electrical disturbances ,such as those caused by thunderstorms and car ignition systems, create amplitude modulated radio signal that are received as noise by AM receivers. A well-designed FM receiver is not sensitive to such disturbances when it tuned to an FM signal of sufficient strength. Also the signal to noise ratio in an FM system is much higher than that of an AM system. FM broadcasting stations can be operated in the very high frequency bands at which AM interference is frequently severe, commercial FM radio stations are assigned frequencies between 88 and 108 MHz and will be the intended frequency range of transmission.

Communication system engineers attempt to design communication system that transmits information at a higher rate with a higher performance, using the minimum amount of transmitted power and band width [1]. The purpose of any communication system is to transmit information signals from a source located at one point in space to the user/destination located at another point. The originating input is frequently referred to as the source, whereas the terminating /end is frequently referred to as the sink. If the message is understandable, then the information has been converted from the source to the destination. Mostly, the message produced by the source is not electrical in nature. But to carry them over an electrical system the message must be converted to an electrical signal in the same manner at receiver. The electrical signal must be reconverted into an appropriate form. A transducer performs these functions. Thus, an input transducer used to convert the message generated by the source in to time varying electrical signal called the message signal.

Basically, communication consists of three major parts. Transmitter, Channel and the Receiver, as shown in figure 1.1

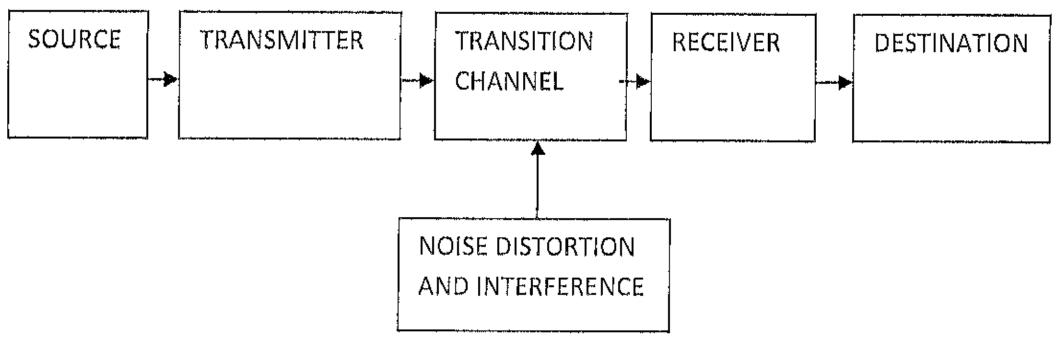

Figure1.1 Block diagram of a communication system

1.2 STATEMENT OF THE PROBLEM

The problem statement is broken up into two separate sections; one that defines the general problem area and another that describes the proposed approach to the solution.

1.2.1 General Problem Statement

Asimple and affordabledevice that will receive an input signal and broadcast on the FM band is not easy to come by. Thesimple and affordable is to receive its signal input from the headphone jack of a digital audio player and its power input from the 12V DC for the receiving end and 9V DC for the transmitting end. The device should be easily tunable to transmit on any desired frequency in the FM band (88-108 MHz). The minimum transmission distance is expected to be atleast 12 feet which is not easily accessible.

1.2.2 General Solution Approach

The proposed solution to this problem is a wireless music player. In implementing the entire wireless music player, we actually need to make two sets of circuits, a transmitter circuit for transmitting the music signal from the source input as discussed in 1.2.1 and a receiver circuit for receiving the transmitted music signal and for playing it in the attached speaker. This wireless music player shall be capable of obtaining power from a 220 VAC for the receiver and a 9volt battery for the transmitter. The FM transmitter will modulate the signal, send it through an amplifier, and finally through an internal antenna.

1.3 SCOPE OF THE STUDY

This wireless music player allows the user to listen to compressed digital audio streamed over a wireless link. It can be used for playing high quality music wirelessly from a TV set, DVD player, IPod, Cell phone or from any music system. A transmitter circuit for transmitting the music signal from the source input and a receiver circuit for receiving the transmitted music signal and for playing it in the attached speaker. In implementing the entire wireless music player, we actually need to make two sets of circuits. The Speaker thus can be place in any corner of the house with radial distance of 12feet and high quality music can be enjoyed without hassles of long connecting wires.

1.4 AIM AND OBJECTIVES

The primary purpose of this project is to design and implement an affordable wireless music player and to understand the operation of basic wireless telecommunication.

The following objectives shall be achieved in the design of the device. These objectives were defined from the project problem statement.

1. To design a device that will receive an input signal and broadcast it on the FM band. The device will receive a stereo audio signal through a wired connection. The device will transmit the signal using the standard FM radio band.
2. To design a device that will receive its signal input from the output jack of a digital audio player. The device will have one stereo input jack. This will accept signals of various amplitudes. Varying outputs from the digital audio player will be connected using a cable.
3. To design a device that will receive its power input from a 220VAC and a 9VDC battery. A cable will be provided for each of these two sources. The 220VAC for the FM receiver and 9VDC for the FM transmitter.
4. To design a device that willbe capable of transmitting within a range encountered during normal use. The transmission range of the device should be large enough to support normal use. Normal use is within 1 average sized residential room.
5. To design a device that willpower on and off manually. While connected, the device should be capable of detecting the input signal. The device shall turn on and off automatically based on the absence of this signal.
6. To construct and implement designed wireless music player for the FUOYE engineering Faculty.

1.5 SIGNIFICANCE OF THE STUDY

The wireless music player is intended to make personal music players more accessible to listen to through home and FM receiver stereos. It does so in a cost efficient and highly functional design. The intended user for this product is anyone owning digital audio players. This is not exclusive to age, size, sex, or handicap. It does assume the amount of operating knowledge associated with digital audio player. The transmitter may be used for all varieties of personal music players. The wireless music player may be used in a variety of environments including varying temperatures, humidity, seismic conditions, and electromagnetic noise and may be used at all hours of the day. The input audio signal will consist of standard music with a frequency range of 20 Hz to 20 kHz. The device design will implement solid state electronics. The user will have access to a steady power source able to supply the rated voltage and frequency (if AC) within a 10 percent tolerance.

1.6 PROJECT OUTLINE

This project is broken down into five(5) chapters as follows: Chapter two contains the literature review and theoretical background that aids the construction of the project. Chapter three entails system design and analysis of the wireless music player; Chapter four comprises of Results and testing of the project. Chapter five gives the conclusion and recommendations for further study on the project.

CHAPTER 2

LITERATURE REVIEW AND TECHNICAL BACKGROUND

2.1 LITERATURE REVIEW

The wireless era was started by two European scientists, James Clerk Maxwell and Heinrich Rudolf Hertz. In 1784, Maxwell presented the Maxwell's equations by combining the works of Lorentz, Faraday, Ampere and Gauss. He predicted the propagation of electromagnet waves in free space at the speed of light. His theory was accepted 20 years later, after Hertz validated electromagnetic wave (wireless) propagation. Hertz demonstrated RF generation, propagation and reception in the laboratory. His work then continues by Guglielmo Marconi after 2 decades. He then acquires a method for transmitting and receiving information. Marconi started to commercialize the use of electromagnet wave propagation for wireless telegraphs and allowed the transfer of information from one continent to another without physical connection. Since the cellular mobile phone system was introduced in the early 1980's, the wireless industry has gone several generations of revolutionary changes. Other examples for this application are in remote sensing, broadcast, smart automobile and highways and so on[2].

The first primitive radio transmitters (called Hertzianoscilllators) were built by German physicist Heinrich Hertz in 1887 during his pioneering investigations of radio waves. These radio waves were generated by a high voltage spark between two conductors. These spark-gap transmitters were used during the first three decades of radio (1887-1197), called the wireless telegraphy era. Short lived competing techniques came into use after the turn of the century, such as the

Alexanderson alternator and poulsen Arc transmitters. But all these early technologies were replaced by vacuum tube transmitters in 1920s, because they were expensive and produced continuous waves, which could be modulated to transmit audio (sound) using amplitude modulation (AM) and frequency modulation (FM). This made possible radio broadcasting, which began about1920. The development of radar before and during world war 2 was a great stimulus to the evolution of high frequency transmitters in the ultrahigh frequency (UHF) and microwave ranges, using new devices such as the magnetron and travelling wave tube. In recent years, the need to conserve crowded radio spectrum bandwidth has driven the development of new types of transmitters such as spread spectrum [3].

In the past radio receivers were designed with analog circuitry. This inherently has the same problems that all analog circuits have. That is, they are susceptible to temperature variations, electrical noise, component aging, and they are complicated and inflexible. Initially, as digital circuits and processors were developed, they were not useful for radio or any high frequency circuitry since they operated at low frequencies and their transistor density was not enough for the signal processing needed in receivers. However, with the exponential increase in transistor density, faster clock rates, and faster analog to digital(A/D) converters radio frequency receivers and possibly higher frequency receivers and transmitters are now suited for the digital domain [4].

Today, with transistor densities in the billions and clock rates in the GHz range, digital receivers are everywhere. Because of the advantages of digital communication systems, a concept of Software Defined Radio (SDR) has become popular in the literature. The ideal concept of SDR is to sample the RF signal with as little as possible analog manipulation. That is, ideally we would have an A/D converter at the output of an antenna and do all of the require signal processing in the digital domain. However, sufficiently fast A/D converters are not cheap enough yet, therefore we still require a front end to generate an intermediate frequency to sample. Once the signal is in the digital domain the designer has all the benefits of digital signal processing as described before, and the ease of configuration and reconfiguration [4].

At university of Malaysia, GohHanShin wrote a thesis on frequency modulation transmitter and receiver. He made emphasis on the various transmitter and receiver architectures [5]. There I discovered the reason why heterodyne is the architecture that was selected for most of the cellular handsets in the past, but asintegratedcircuit(IC) process and technology evolves, other approaches, such as homodyne, have also become a plausible solution to some of the design problems. In 2006 at Cornell University, James and his colleague, designed and implemented a wireless music player that reads uncompressed audio data from secured digital (SD) card in an immobile base station. A pair of Xbee transceiver modules was used to stream data and control signals between the base station and a portable module [6]. The battery powered module can be connected to speakers at any location within 30 feet of the base station. In year 2006 at university of Florida, Gainesville, FL, 32608, USA, BhavyaDayadesigned a super heterodyne FM receiver [7]. This design was performed with minor adjustment to remove interference to other FM radios. Spurious emission emitted from the receive antenna can directly affect other FM radios receivers. The design was adjusted to have a higher if frequency to avoid interference emission to occur in the FM radio pass band. Even though spurious emission resulted, most were too low to be detected by other systems. The components of the system were carefully chosen to ensure that the receiver doesn't affect other systems and good receiver performance resulted. Francis McSwiggandesigned and implemented a FM transmitter. The design chosen was miniature, low powered and tunable to different frequencies. The parts used are very common and the circuit is very easily constructed. The circuit was firsts build on Vero-board and worked rather well without applying any real effective RF techniques all that had to be adhered to was to keep the leads short and compact the circuitry as much as possible. Theprinted circuit board (PCB), as expected performed exceedingly well, but more of a better attempt had to be made in matching the antenna and shielding the RF section from the output as the PCB layout was a lot more efficient in radiating power out. Unwanted Electro-magnetic radiation had to be stopped from destructively interfering with the carrier modulation. To keep the design simple and easy to construct it was decided to just wrap household cling-film, electrically protecting the circuitry from the Aluminium foil that was used to electro-magnetically shield the RF stage. The effective range of the transmitter was 80 feet in a household environment and about 50 feet in a lab environment, which makes the transmitter ideal aiding Tourists hear a Tour Guide within a densely packed room. The Antenna co-axial extension lead helps in raising the antenna over people's heads and transmitting to theirFM receivers (otherwise the water content in the human body would bounce the electromagnetic waves). Because of the 14 hours of effective transmission given by the MP3 and the power consumption of the battery, the device could be used as a baby monitoring device within the home, with arange of about 80 feet, it reaches out even to the garden. Lawrence and Azāriwrote a book on frequency modulation circuit frequency [8]. The FM Transmitter uses FM waves (frequency modulated waves) to send sound. Frequency modulation transmits data (in our case an audio signal) over a carrier wave by changing the frequency of the carrier wave, where the frequency of the carrier wave corresponds to the voltage level of the audio signal. In order to use electromagnetic transmission, the audio signal must first be converted into an electric signal. The conversion is accomplished by a transducer, in this case the microphone. After conversion, the audio signal is used to modulate a carrier signal.

2.2 TECIINICAL BACKGROUND

The basic Frequency Modulation communications systemis shown in figure 2.1has:

1) **Transmitter**: This is the sub-system that takes the information signal and processes it prior to transmission. The transmitter modulates the information onto a carrier signal and broadcasts it over the channel..

2) **Channel**: The medium which transports the modulated signal to the receiver. In this project, an antenna is connected to FM transmitter end. Signals then will be picked up by the receiving antenna at the FM Receiver.

3) **Receiver**: that is the sub-system that takes in the transmitted signal from the channel and processes it to retrieve the information signal. The receiver must be able to discriminate the signal from other signals which may use the same channel medium, amplify the signal for processing and demodulate (remove the carrier) to retrieve the information.

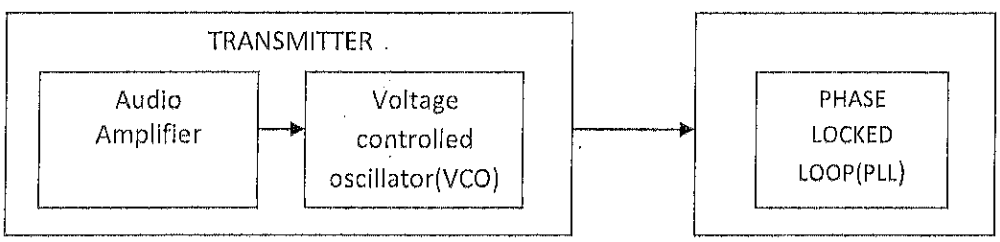

Figure2.1:Asimple drawing for FM system.

2.2.1 Basic Building Block of the Transmitter

When creating a system for transmitting a frequency modulated wave a number of basic building blocks have to be considered. Figure 2.2 gives a very broad impression of the transmitter and its individual parts.

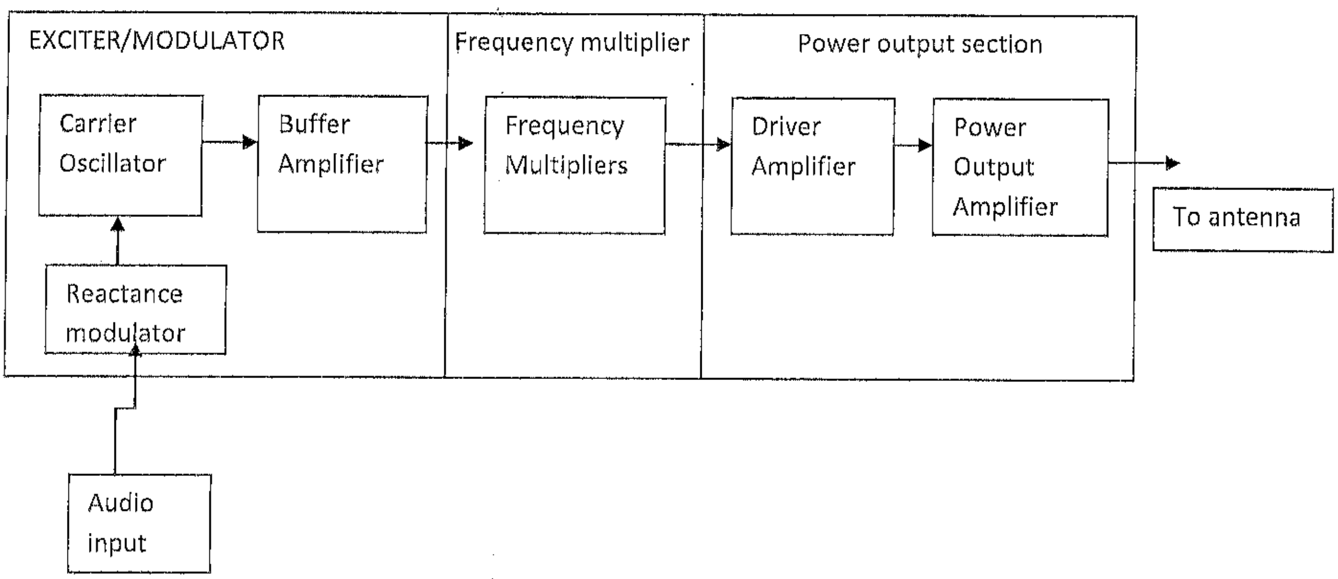

Figure 2.2: Basic building block of a transmitter

2.2.1.1 Exciter/Modulator

Carrier Oscillator generates a stable sine wave for the carrier wave. Linear frequency even when modulated with little or No amplitude changeBuffer amplifier acts as a high impedance load on oscillator to help stabilize frequency The Modulator deviates the audio input about the carrier frequency. The peak + of audio will give a decreased frequency and the peak - of the audio will give an increase of frequency.

2.2.1.2 Frequency Multipliers

Frequency multipliers are tuned-input, tuned-output RF amplifiers. In which the output resonance circuit is tuned to a multiple of the input.

2.2.1.3 Power output section

This develops the final carrier power to be transmitter. Also included here is an impedance matching network, in which the output impedance is the same as that on the load (antenna)

2.2.1.4 The Pre emphasis

Improving the signal to noise ratio in FM can be achieved by filtering, but no amount of filtering will remove the noise from RF circuits. But noise control is achieved in the low frequency (audio) amplifiers through the use of a high pass filter at the transmitter (pre-emphasis) and a low pass filter in receiver (de-emphasis) .The measurable noise in low- frequency electronic amplifiers is most pronounced over the frequency range 1 to2 KHz. At the transmitter, the audio circuits are tailored to provide a higher level, the greater the signal voltage yield, a better signal to noise ratio. At the receiver, when the upper audio frequencies signals are attenuated to form a flat frequency response, the associated noise level is also attenuated.

2.2.1.5 The Oscillator

The carrier oscillator is used to generate a stable sine-wave at the carrier frequency, when no modulating signal is applied to it. When fully modulated it must change frequency linearly like a voltage controlled oscillator. At frequencies higher than 1MHz,Colpitts (split capacitor configuration) or Hartley oscillator (split inductor configuration) may be deployed. A parallel LC circuit is at the heart of the oscillator with an amplifier and a feedback network (positive feedback). The Barkhausen criteria of oscillation require that the loop gain be unity and that the total phase shift through the system is 360. I that way an impulse or noise applied to the LC circuit is fed back and is amplified (due to the fact that in practice the loop gain is slightly greater than unity) and sustains a ripple through the network at a resonant frequency of $\frac{1}{2\pi\sqrt{LC}} Hz$.

2.2.1.6 Reactance Modulator

The nature of FM as described before is that when the baseband signal is Zero the carrier is at its "carrier" frequency, when it peaks the carrier deviation is at a maximum and when it troughs the deviation is at its minimum. This deviation is simply a quickening or slowing down of frequency around the carrier frequency by an amount proportional to the baseband signal. In order to convey the characteristic of FM on the carrier wave the inductance or capacitance (of the tank) must be varied by the baseband. Normally the capacitance of the tank is varied by a varactor diode. Thevaractor diode (in figure 2.3) when in reverse bias has a capacitance across it proportional to the magnitude of the reverse bias applied to it. The formula for working out the instantaneous capacitance is shows that as the reverse bias is increased, the capacitance is decreased.

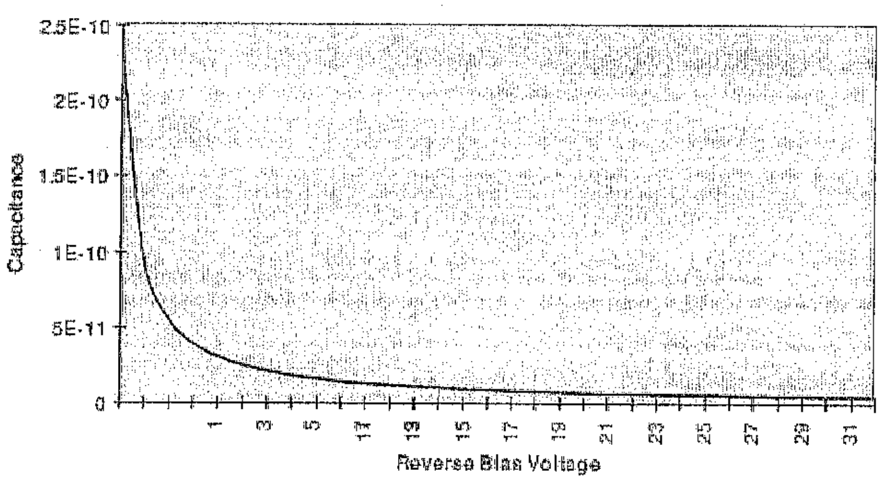

Figure2.3Varactor diode capacitancebehavior

$$C_D = \frac{C_O}{\sqrt{1 + 2|V_R|}} \quad \text{...2.1}$$

where C_0 is the capacitance at zero Reverse bias voltage

Applying this to an LC tank : as the capacitance decreases the frequency increases. So placing a fixed reverse bias on the varactor will yield a fixed capacitance which can be placed in parallel capacitor and inductor. A bypass capacitor can be used to feed the baseband voltage to the varactor diode, the sine-wave baseband voltage has the effect of varying the capacitance of the varactor up and down from the level set by the fixed reverse voltage bias. As the baseband peaks the varactor's capacitance is at a minimum and the overall frequency will increase, applying this logic to when the baseband troughs the frequency will decrease. Looking at the three cases for the varactor diode, Maximum capacitance, and Nominal capacitance set by V_bias (no modulation) and Minimum capacitance and observing the frequency will show that by modulating the reactance of the tank circuit will bring about Frequency Modulation.

$$F_{NOM} = \frac{1}{2\pi\sqrt{L(C1 + Cd_{NOM})}} \quad \text{.......................................2.2}$$

With no baseband influence(the carrier frequency)

$$F_{MIN} = \frac{1}{2\pi\sqrt{L(C1 + Cd_{MAX})}} \quad \text{.....2.3}$$

With peak negative baseband influence

$$F_{MAX} = \frac{1}{2\pi\sqrt{L(C1 + Cd_{MIN})}} \quad \text{.............2.4}$$

with peak positive baseband influence

2.2.1.7 The Buffer Amplifier

The buffer amplifier acts as a high input impedance with a low gain and low output impedance associated with it, and is shown in figure 2.4. The high input impedance prevents loading effects from the oscillator section, this high input impedance maybe looked upon as R_L in the analysis of the Colpitts Oscillator. The High impedance R_L helped to stabilize the oscillator's frequency. Looking at the Buffer amplifier as an electronic block circuit, it may resemble a common emitter with low voltage gain or simply an emitter follower transistor configuration.

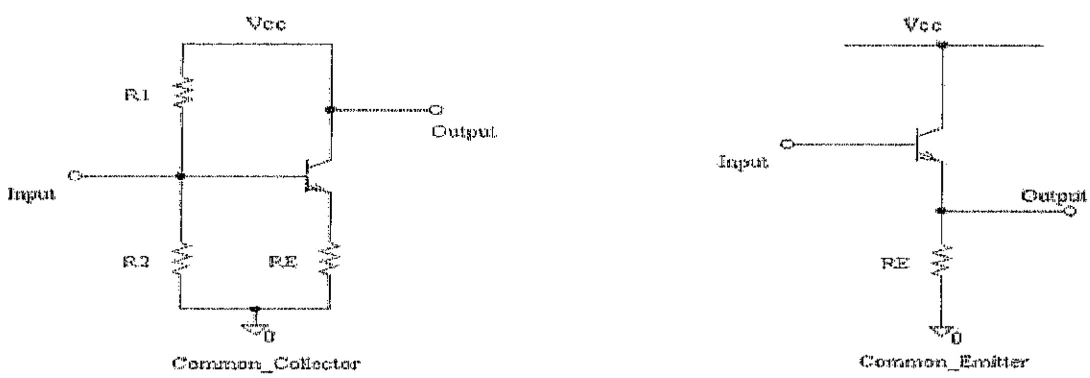

Figure2.4 Circuit diagram of Buffer Amplifier

2.2.1.8 Frequency multiplier

Frequency modulation of the carrier by the baseband can be carried out with a high modulation index, but this is prone to frequency drift of the LC tank, to combat this drift, modulation can take place at lower frequencies where the Q factor of the tank circuit is quite high (i.e. low bandwidth or less carrier deviation) and the carrier can be created by a crystal controlled oscillator. At low frequency deviations the crystal oscillator can produce modulated signals that can keep an audio distortion under 1%.This narrow-band angle modulated wave can be then multiplied up to the required transmission frequency, the deviation brought about by the baseband is also multiplied up, which means that the percentage modulation and Q remain unchanged. This ensures a higher performance system that can produce a carrier deviation of ±75Khz.

Frequency multipliers as shown in Figure 2.5 are tuned input, tuned output RF amplifiers, where the output resonant tank frequency is a multiple of the input frequency. The diagram of the simple multiplier fig 2.5 shows the output resonant parallel LC tank which is a multiple of the input frequency.

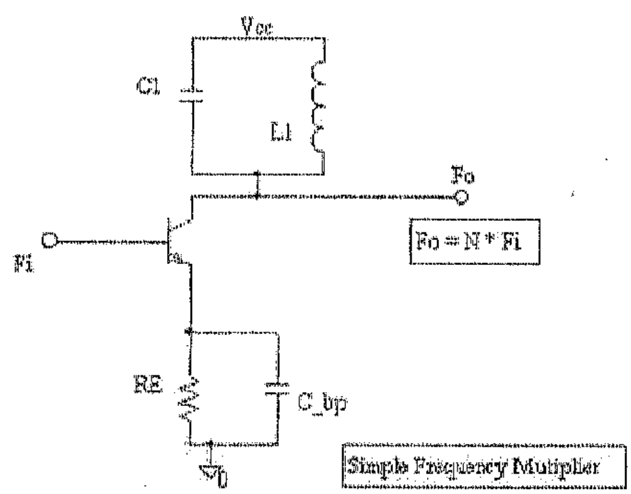

Figure 2.5Circuit diagram of frequency multiplier

2.2.1.9 Driver amplifier

The driver amplifier can be seen to do the same function as the buffer amplifier, i.e. a high input impedance, low gain (close to unity) and low output impedance between the frequency multiplier and power output stages of the transmitter. The circuitry is the same as discussed in the Buffer amplifier description.

2.2.1.10 Power amplifier

The power amplifier takes the energy drawn from the DC power supply and converts into the AC signal power that is to be radiated. The efficiency or lack of it in most amplifiers is affected by heat being dissipated in the transistor and surrounding circuitry. For this reason, the final power amplifier is usually a Class-C amplifier for high powered modulation systems or just a Class B push-pull amplifier for use in a low-level power modulated transmitter. Therefore, the choice of amplifier type depends greatly on the output power and intended range of the transmitter.

2.2.1.11Antenna

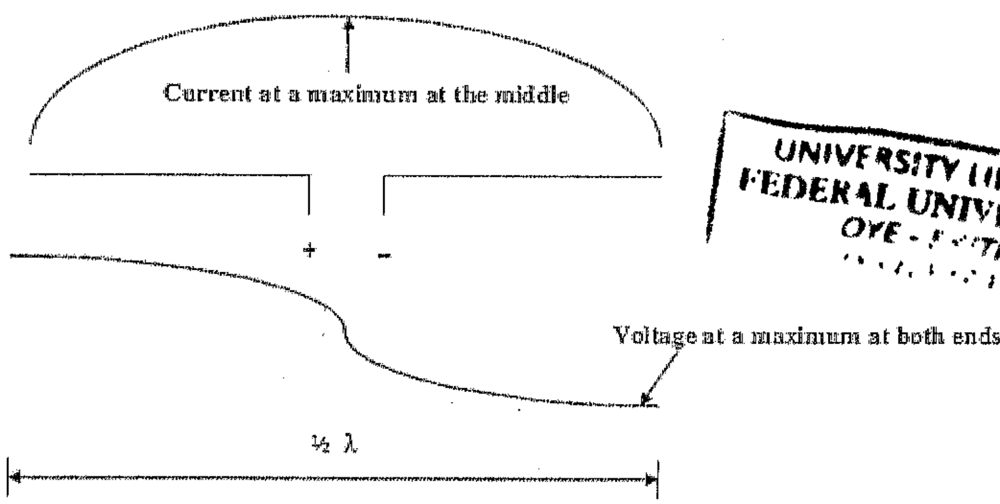

Figure 2.6 schematic diagram of an antenna

The final stage of any transmitter is the Antenna; this is where the electronic FM signals converted to electromagnetic waves, which are radiated into the atmosphere. Antennas can be vertically or horizontally polarized, which is determined by their relative position with the earth's surface (i.e. antenna parallel with the ground is horizontally polarized). A transmitting antenna that is horizontally polarized transmits better to a receiving antenna that is also horizontally polarized; this is also true for vertically polarized antennas. One of the intended uses for the transmitter is as a tour guiding aid, where a walkman shall be used as the receiver, for a walkman the receiving antenna is the co-axial shielding around the earphone wire. The earphone wire is normally left vertical. Therefore, a vertically polarized whip antenna will be the chosen antenna for this particular application, as shown schematically in figure 2.6.

CHAPTER 3

SYSTEM DESIGN AND ANALYSIS

INTRODUCTION

The Wireless music player uses FM waves (frequency modulated waves) to send sound. Frequency modulation transmits data (in our case an audio signal) over a carrier wave by changing the frequency of the carrier wave, where the frequency of the carrier wave corresponds to the voltage level of the audio signal. In order to use electromagnetic transmission, the audio signal must first be converted into an electric signal. The conversion is accomplished by a digital music payer. After conversion, the audio signal is used to modulate a carrier signal. This is shown in figure 3.1.

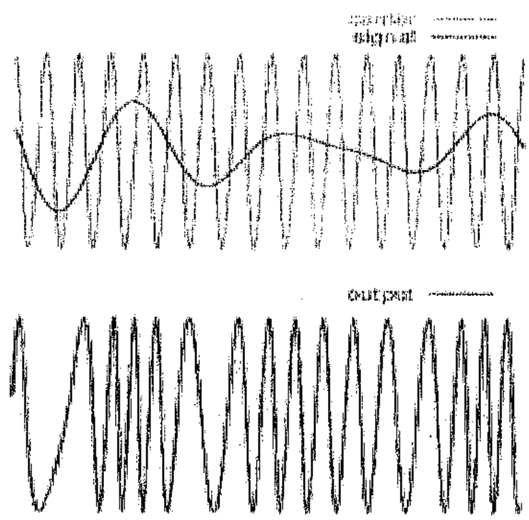

Figure 3.1: Frequency Modulation

The process of modulation means to systematically use the information signal (what you want to transmit) to vary some parameter of the carrier signal [8]. The carrier signal can be a sinusoidal, as shown above, but in our case the carrier signal will be a square-wave that is generated by a voltage-controlled oscillator (VCO)

3.1 The FM Receiver (Phase locked loop, PLL)

The design of the Digital FM Receiver circuit in this project uses Phase Locked Loop (PLL) as the main core. The task of the PLL is to maintain coherence between the input (modulated) signal frequency, and the respective output frequencyvia phasecomparison. This self-correcting ability of the systemalso allows the PLL to track the frequency changes ofthe input signal once it is locked.

3.1.1 FM Demodulator Design

Thetechniqueused to demodulate the FM signal is the popularphase lock loop demodulator. The designapproachisto design the FM demodulator as if it were an analog phase lock loop, only it will be implemented with digital components rather than their analog counter parts.

Therefore, the followingdesignpresented here works whether an analog phase detector, analog filter, andanalogvoltage controlled oscillator are used or a digital phase detector, digitalfilter, and a digital numerically controlled oscillator are used. Instead of voltages, digital wordsare used to represent the signal. The most basic phase lock loop used for FM demodulationconsists of a Phase detector, loop filter and a voltage controlled oscillator. The diagram infigure 3.2 showshowthese componentsare arranged.

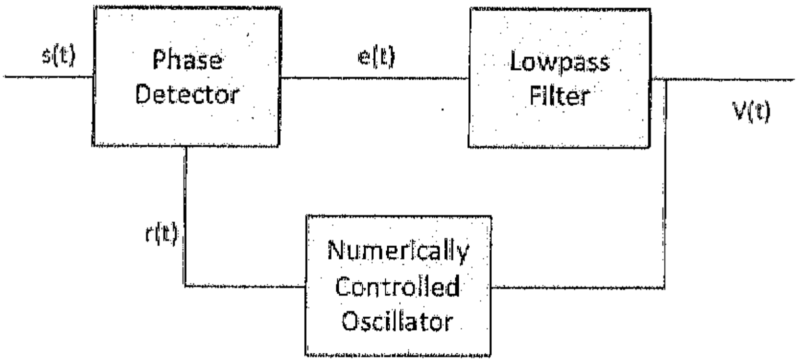

Figure 3.2: Phase lock loop with signals

3.1.1.2 **Phase Detector**

Phase Detector (PD) detects phase error between input signal and output signal from NCO [9]. This operation employs a multiplier module. The input signal is frequency modulated.

The phase detector was implemented with a simple multiplier. While other phase detector designs exist, a multiplier is the simplest to implement. In the VHDL model we could use a

Booth multiplier if area is a greater concern or a Wallace-tree multiplier if high speed is of greater concern [10].All signals will be positive integers. As a consequence, the output is more complicated since the inputs will be DC shifted. If we had signed inputs with a zero DC offset, the output would be as follows:

$$Vref = Vref_0 \cos(w_{ref} + \theta_{ref}) + Vref_0 \qquad \text{3.1}$$

$$V_{vco} = V_{vco_0} \cos(w_{vco} + \theta_{vco}) + Vvco_0 \qquad \text{3.2}$$

$$V_{ref}V_{vco} = [V_{ref_0} \cos(w_{ref} + \theta_{ref}) + Vref_0][V_{vco_0} \cos(w_{vco} + \theta_{vco}) + Vvco_0] \qquad \text{3.3}$$

$$\frac{V_{ref_0}V_{vco_0}}{2}\,[\cos(w_{ref} + w_{vco} + \theta_{ref} + \theta_{vco})\cos(w_{ref} - w_{vco} + \theta_{ref} - \theta_{vco} \ldots\ldots\ldots\ldots 3.4$$

When locked,

$$V_{ref}V_{vco} = \frac{V_{ref_0}V_{vco_0}}{2}[\cos(2w_{ref} + \theta_{ref} + \theta_{vco})\cos(\theta_{ref} - \theta_{vco}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.5$$

I will design a filter to remove the $2w_{ref}$term and will be left with

$$\frac{V_{ref_0}V_{vco_0}}{2}\cos(\theta_{ref} - \theta_{vco}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.6$$

A term related to the phase error between the two signals. However, in our case we have DC

Shifted values and the output will be as follows:

$$Vref = Vref_0\cos(w_{ref} + \theta_{ref}) + Vref_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.7$$

$$V_{vco} = V_{vco_0}\cos(w_{vco} + \theta_{vco}) + Vvco_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.8$$

$$V_{ref}V_{vco} = [V_{ref_0}\cos(w_{ref} + \theta_{ref}) + Vref_0][V_{vco_0}\cos(w_{vco} + \theta_{vco}) + Vvco_0] \ldots\ldots\ldots\ldots 3.9$$

$$= V_{ref_0}V_{vco_0}[\cos(w_{ref} + \theta_{ref})\cos(w_{vco} + \theta_{vco}) + V_{ref_0}V_{vco_0}\cos(w_{vco} + \theta_{vco})$$
$$+ V_{ref_0}V_{vco_0}\cos(w_{ref} + \theta_{ref}) + V_{ref_0}V_{vco_0} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.10$$

The first term is what we had before when we had no DC offset. However, with the DC offset we get these extra terms.

$$V_{ref_0}V_{vco_0}\cos(w_{vco} + \theta_{vco}) + V_{ref_0}V_{vco_0}\cos(w_{ref} + \theta_{ref}) + V_{ref_0}V_{vco_0} \ldots\ldots\ldots\ldots\ldots\ldots 3.11$$

In addition to filtering out the signal at twice the frequency, we will also need to filter out the signals at the reference frequency. After filtering and when locked, the signal should be as follows

$$\frac{V_{ref_0} V_{vco_0}}{2} \cos(\theta_{ref} - \theta_{vco}) + V_{ref_0} V_{vco_0} \quad \ldots\ldots\ldots \quad 3.12$$

3.1.1.2 **Loop filter**

The laststage of the receiversystemis to perform signal shaping. Here we use 16 tap Finite Impulse Response (FIR) filter to perform digital low pass filter. This filter isessentially average filter since its output is equal to the average value of its input over the last n-tap samples, where nis number of tap used [11]. This configuration needs 16 coefficients, but simplification is taken by assuming all of the coefficients are the same, 1/16. In reality 1/16 multiply can beimplemented by just 4bit right shift operation. Then no multiplier is required. FM broadcast station are between 88MHz and 108MHz. Therefore, any signal that is received on the antenna that is not in this range should be rejected. To accomplish this, a 5^{th}order maximally flat filter with a lower cutoff frequency at 88MHz and an upper cutoff frequency of 108MHz is used

The digital filter is implemented with a first order low pass filter described by the following transfer function:

$$H_{LP} = \left(\frac{1-\propto}{2}\right) \frac{z+1}{z-\propto} \quad \ldots\ldots\ldots \quad 3.13$$

The 3-dB cut-off is determined by:

$$\Omega_c = cos^{-1}\left(\frac{2 \propto}{1 + \propto^2}\right) \dots 3.14$$

$$\Omega_c = 2\pi f_c T_S \dots 3.15$$

Where fc is the cutoff frequency and Ts is the sampling period ([3], pg. 650). If we choose fc=15kHz then we will be able to demodulate the mono audio signal in an FM station.

With sampling rate Ts = 1.25MHz and Fs = 15kHz α is found as follows

$$\Omega_c = 2\pi(15kH_Z)\left(\frac{1}{1.25MH_Z}\right) = 0.0754 \dots 3.16$$

$$\cos(0.0754) = 0,99716 \dots 3.17$$

$$\Omega_c = cos^{-1}\left(\frac{2 \propto}{1 + \propto^2}\right) \rightarrow \alpha^2 \cos(\Omega_c) - 2\alpha + \cos(\Omega_c) \dots 3.18$$

Therefore, our transfer function looks like:

$$H_{LP}(z) = \left(\frac{1 - 0.9273}{2}\right)\left(\frac{z + 1}{z - 0,9273}\right) = 0.03635\left(\frac{1 + z^{-1}}{1 - 0.9273z^{-1}}\right) \dots 3.19$$

Now taking the inverse z transforms,

$$y(n) = 0.03635x(n) + 0.03635x(n-1) + 0.9273y(n-1) \dots 3.20$$

However, I am not going to use floating point values on our FPGA, instead we will multiply all the coefficients by 2^{16}, round to the nearest integer, and then shift the result to the right by 16 bits to effectively divide by 2^{16}. 16 is an arbitrary number of bits that gave a reasonable resolution to the floating point values calculated

$$y(n) = 2^{-16}(2382x(n) + 2382x(n-1) + 60771y(n-1) \qquad 3.21$$

3.1.1.3 **Numerically Controlled Oscillator (NCO)**

The NCO used is of the standard accumulation type. That is, every clock cycle you add a word to the accumulator that corresponds to the output frequency. The accumulator is then used to index into a cosine ROM, which then produces the sinusoidal output. This is shown in the diagram in figure 3.3. For this technique higher frequency signals are produced with lower resolution than lower frequency signals. The Offset signal is used to get NCO oscillating around 360 kHz. The tune signal comes from the filtered error voltage of the phase detector.

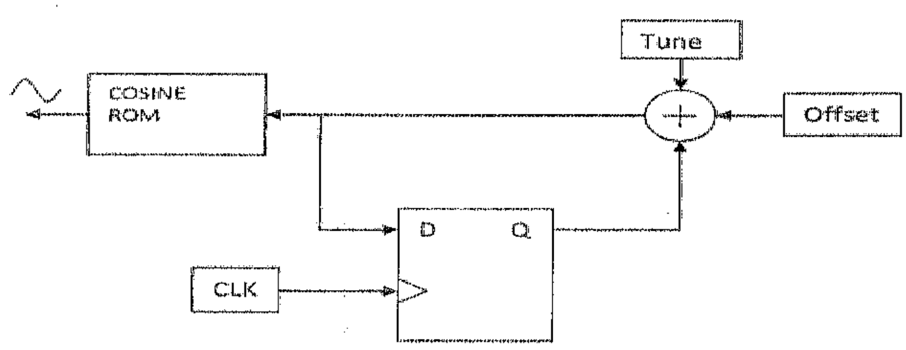

Figure 3.3: Accumulator type NCO

3.1.1.4 **Channel Selection**

The Channel section circuit is designed so that if you rotate clockwise, the frequency will increase 60 KHz every second. If rotate anticlockwise the frequency will decrease 60 KHz every second. This allows the user to scan for the radio station they wish to listen to.

3.1.2 FM Front End Design

The front end design used is a dual conversion superheterodyne front end. We must use two stages because the best ceramic filters for channel selection are at an IF of 10.7MHz, however the A/D converter used has built in filters with a cut-off at 500 kHz and the maximum sampling rate is 1 Mbps. To meet the Nyquist criteria we will use a second stage IF of 360 KHz. A block diagram with all the components that are required is shown in Figure 3.4.

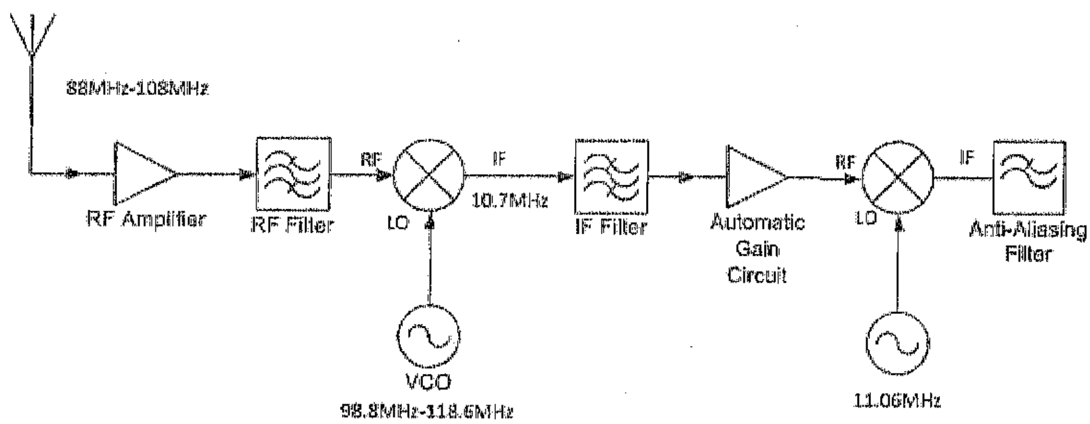

Figure 3.4: FM front end block diagram

3.1.3Receiver Performance Characterization

To understand the design choices made in RF receiver systems, some standard parameters must be utilized to evaluate the performance of the receiver in the corresponding application. Apart from power dissipation which is important for all integrated circuits, an RF receiver is characterized by its sensitivity and dynamic range.

One parameter that describes the sensitivity of a receiver is the minimum detectable signal (mds). It is related to the receiver noise and the system bandwidth by:

mds (dBm) = -174 dBm + 10 log BW + NF + SNR.......................................3.22

Where BW is the overall Bandwidth, NF is the receiver noise figure, which is defined as the ration of the total noise to the noise contributed by the source, all referred to the output. SNR is the signal-to-noise ratio required at the demodulator or detector input to achieve an acceptable bit-error rate.

3.1.4 Power supply design

The FM receiver uses 12V dc power supply rail. The need for power supply stage is to provide the voltage and current requirements for the circuit since all the electronic components work with DC voltages. The required dc voltage and current of the power supply for the project is dependent on the component specifications and the nature of circuits to be powered. The power supply diagram employed in this project is shown in figure 3.5

For this project:

POWER SUPPLY REQUIREMENTS

Supply Voltage	:	DC 12V
Maximum Current	:	500mA

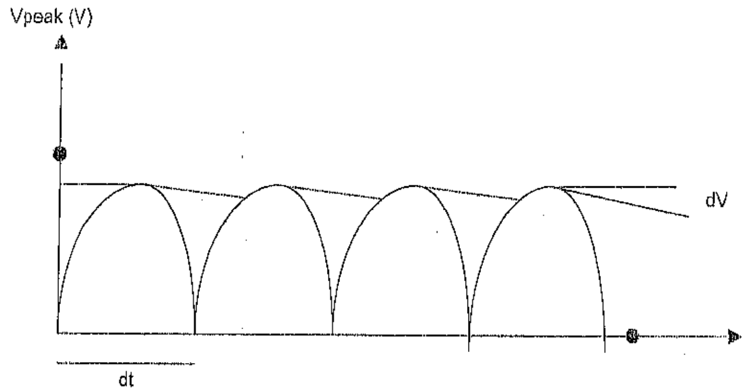

Figure 3.5: Power supply diagram

The electric charge, $Q = IT$.

Since $Q = IT$

$CV = IT$ (since $Q = IT$) 3.21

Where C is the Capacitance

V is the Voltage

I is the Current (A)

T is the period of one cycle of AC waveform.

From (1) $C = I\frac{t}{V}$

$\rightarrow C = I\frac{dt}{dV}$ 3.22

Since C is proportional to the current and inversely proportional to the ripple gradient of the power supply.

The peak unregulated voltage is given by

$V_{peak} = V_{rms} \times \sqrt{2}$ 3.23

Where V_{rms} is the AC voltage stepped down on the transformer.

Hence, considering a peak voltage of 12V dc

$$V_{peak} = 12\sqrt{2} = 16.6v \ldots \ldots \ldots 3.24$$

$$T = \frac{1}{F} = \frac{1}{50} = 0.02secs \ldots \ldots \ldots 3.25$$

$$dt = \frac{0.02}{2} = 0.01 = 10ms \ldots \ldots \ldots 3.26$$

$I = 500mA = 0.5\,A$as required for design $dt = 0.01\,s$ (this is the time duration of the duty cycle of half the waveform).

dV= ripple factor.

If we set ripple factor to 20% of the peak voltage,

$dV = 0.02\ X\ 16.6 = 3.3$.

Hence

$$C = \frac{idt}{dv} = 500mAx\frac{0.01}{3.3} = 1515\mu F \approx 2000\mu F$$

A preferred value of 2200 uF was used.

The power supply circuit diagram is shown in figure 3.6.

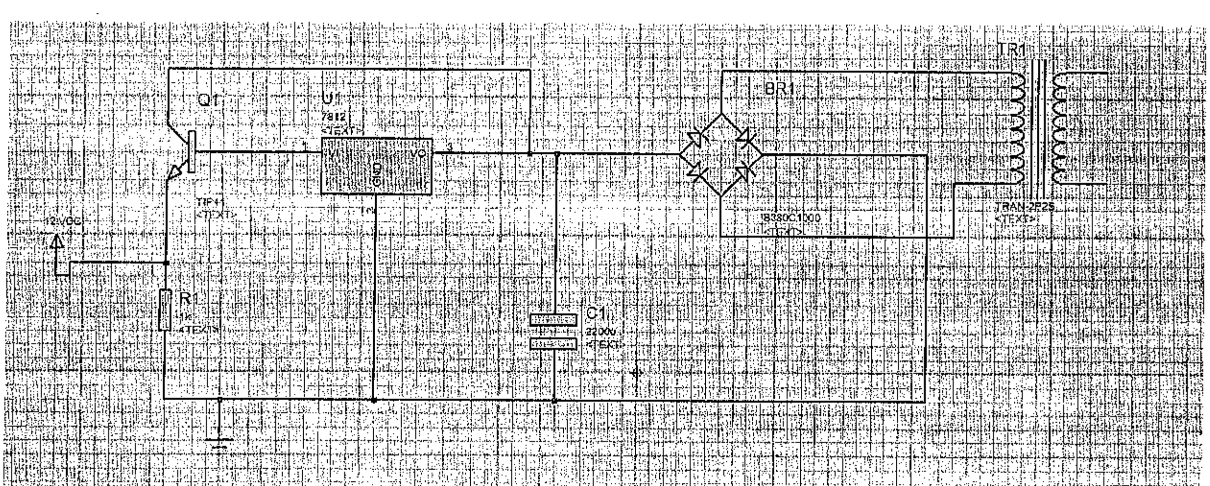

Figure 3.6: Power Supply circuit design.

3. 2 FM Transmitter

The FM transmitter mainly consists of pre-amplifier, FM modulator, oscillator, frequency multiplier and power amplifier. Basically, common FM transmitter contains the following functional blocks as shown in Figure 3.6.

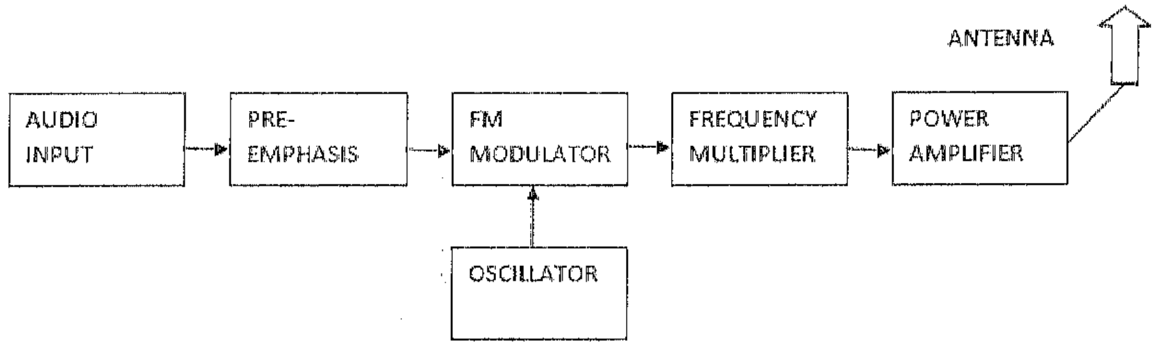

Figure 3.7: Functional blocks of a standard FM transmitter

The preamplifier boosts the audio level from several milli-volts to higher enough stage for feeding into the modulator. Usually a high pass filter network is added between preamplifier and modulator stage. The high pass filter acts as pre-emphasis network to improve the signal to noise level of FM transmission at higher frequency. The pre-emphasis network is optional. However, the receiver will suffer from distortion at higher frequency of audio signal if the stage is ignored. With the carrier signal generated from oscillator, the modulator modulates the carrier with input signal from pre-amplifier stage.

The operating frequency of the generated FM output is still not high enough to be transmitted through free space. Thus, several stages of frequency multiplier are put to increase the operating frequency. After going through a number of multipliers, the attenuation of signal level is compensated by the final stage power amplifier. Power amplifier restored the FM strength to the desired level.

3.2.1 The FM Transmitter Operation

The music source could be from an MP3 or MP4 player. The preamplifier stage is modulating signal to the tuned RF amplifier, designed around a colpitts oscillator circuit.

The colpitts oscillator frequency F, is given by

$$F=\frac{1}{2\pi\sqrt{LC}} \quad \text{..........} 3.28$$

$$\text{Where } C=\frac{C1C2}{C1+C2} \quad \text{..........} 3.29$$

The value of L is deduced from 1 for set values of C1 and C2 and coiled as an air core inductor to oscillate on the commercial FM radio band

For the purpose of this project, the frequency is set to a frequency value, where there is no commercial FM band. The block diagram of the FM transmitter employed in this project is shown in figure 3.8.

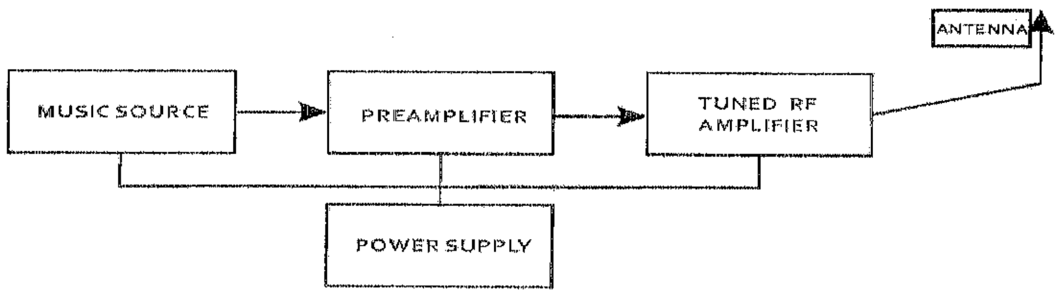

Figure 3.8:The FM transmitter block diagram

3.2.2 Derivation of the FM voltage equation

Consider a voltage controlled oscillator with a free running frequency of f_c, an independent voltage source with voltage $V_M(t)$ which causes the VCO to depart from f_c by an amount Δf, which is equal to the voltage of the independent source multiplied by the sensitivity of the

VCO(K_0 => such as the miller capacitance of a transistor). What is seen at the output of the VCO is a frequency modulated voltage. Now consider the independent voltage source as representing the amplitude of the baseband information shown in figure 3.9

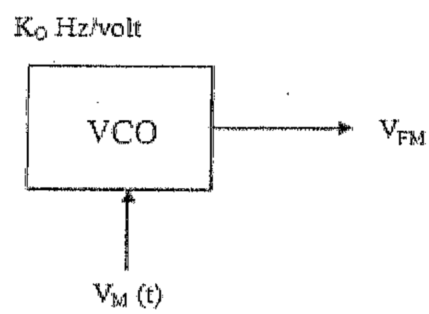

Figure 3.9: Independent voltage source

$V_{FM}=ACos\theta(t)$ 3.30

$f = fc + \Delta f$ 3.31

$\Delta f = K_0 * V_m(t)$

Above are the equations which govern the output of the VCO, f is the overall frequency of the frequency modulated output.

$$\omega = \frac{d\theta(t)}{dt} = 2\pi f \quad \text{......... 3.32}$$

taking the angle θ(t) from equation 1 and differentiating it will give the angular velocity of the output and equate it to 2π times the effective frequency (f)

$$\frac{d\theta(t)}{dt} = 2\pi f_c + 2\pi\Delta f \quad \text{......... 3.33}$$

$$d\theta(t) = 2\pi f_c dt + 2\pi\Delta f dt \quad \text{......... 3.34}$$

Multiply across both sides by the change in time (dt)

$$\theta(t) = 2\pi f_c \int dt + 2\pi Ko \int V_m(t)dt \ldots\ldots 3.35$$

$$V_m(t) = Vpk\, cos(2\pi f_m t) \ldots\ldots 3.36$$

$$\theta(t) = 2\pi f_c dt + \frac{Ko * Vpk}{fm} sin(2\pi f_m t) \ldots\ldots 3.37$$

$$M_f = \frac{Ko * Vpk}{fm} \ldots\ldots 3.38$$

$$M_f = \frac{\Delta f_c(pK)}{fm} \ldots\ldots 3.39$$

Tiding up equation 8, and setting the magnitude of the sine wave as M_f, the modulation index for frequency modulation.

$$Vm = Acos\theta(t) = Acos[\, 2\pi f_c t + M_F\, sin(2\pi f_m t)] \ldots\ldots 3.40$$

The above equation represents the standard equation for frequency modulation. The equation for the other form of angle modulation, phase modulation is rather similar but has a few subtle differences.

$$V_{PM} = Acos\theta(t) = Acos[\, 2\pi f_c t + M_F\, sin(2\pi f_m t)] \ldots\ldots 3.41$$

The difference is in the modulation Index and the phase

3.2.3 Design of Preemphasis

The preamplifier boosts the audio level from several milli-volts to higher enough stage for feeding into the modulator

$$\omega_1 = \frac{1}{rc} \ldots\ldots 3.42$$

$$\omega_2 = \frac{1}{RC} \ldots\ldots 3.43$$

ω_1 *and* ω_2 *is break frequency.* For FM broadcast purpose, the lower break frequency f_1 is about 2.1kHz and the higher break frequency f_2 is chosen to be much higher than the highest frequency term in the message band, so that f_2 lies outside the baseband spectral range.

For audio range, f_2 may be taken as 30kHz.

$$\omega_1 = \frac{1}{rc}. let\ c = 10\mu F\ and\ f_1 = 2.1kHz$$

$$2\pi f_1 = \frac{1}{rc} = \frac{1}{r\ x\ 10\mu F} \quad \ldots 3.44$$

$$r = \frac{1}{2\pi f_1 x\ 10\mu F} \quad \ldots 3.45$$

$$r = \frac{1}{2x3.142x\ 2.1k\ x\ 10\mu F} \quad \ldots 3.46$$

$$r = 0.007578628k\Omega = 7.58\Omega \quad \ldots 3.47$$

$$\omega_2 = \frac{1}{RC}\ let\ c = \ 10\mu F\ and\ f_2 = 30kHz \quad \ldots 3.48$$

$$2\pi f_2 = \frac{1}{RC} \quad \ldots 3.49$$

$$R = \frac{1}{2\ x\ 3.142\ x\ 30k\ x\ 10\mu F} \quad \ldots 3.50$$

$$R = 0.000530516k\Omega = 0.53\Omega \quad \ldots 3.51$$

3.2.4 Designing of an oscillator

Oscillators are necessary in any low power transmitter because they generate a necessary RF signal. The Colpitt's oscillator is designed for generation of high frequency sinusoidal oscillations.

The colpitts is built around Figure 17. The colpitts oscillator frequency Fis given by

$$F = \frac{1}{2\pi\sqrt{LC}} \quad \ldots 3.52$$

Where: L = Self-inductance of the coil (H)

C= capacitance of the condenser (F)

Where $C=\frac{C1C2}{C1+C2}$..3.53

The value of L is deduced from 1 for set values of C1 and C2 and coiled as an air core inductor to oscillate on the commercial FM radio band

3.2.5Design of Antenna length

The audio frequency is translated to a radio frequency carrier of 104.5 MHz, the antenna height required will be:

$$\frac{\lambda}{2}\ but\ \lambda = \frac{C}{f} where\ c = 3\ x\ 10^8 \ldots \quad 3.54$$

$$therefore, \lambda = \frac{3\ x\ 10^8}{104.5\ x\ 10^6} = 2.87m \ldots \quad 3.55$$

$$L = \frac{2.87}{2} m = 1.43m, so, this\ antenna\ height\ can\ be\ practically\ achieved.$$

3.2.6 Radiation Resistance

The power radiated by an antenna is given by the pointing vector theorem p = E X H watts/m^2. Getting the cross product of the E (electric field strength) and H (magnetic field strength) fields multiply it by a certain area (πr^2) and equating the resulting power to I^2Rr, R_r the radiation resistance may be obtained.

$$I^2Rr = Power = 80.\pi^2.I^2(\frac{dl}{\lambda})^n \ldots \quad 3.56$$

$$Rr = 80.\pi^2(\frac{dl}{\lambda})^n \ldots \quad 3.57$$

Where: **dl** is the length of the antenna,

λ is the wavelength and

n is an exponent value that can be found by using (dl/ λ) on the y-axis and then n can be found on the x-axis.

A graph of exponent value for n of Rr is shown in figure 3.10

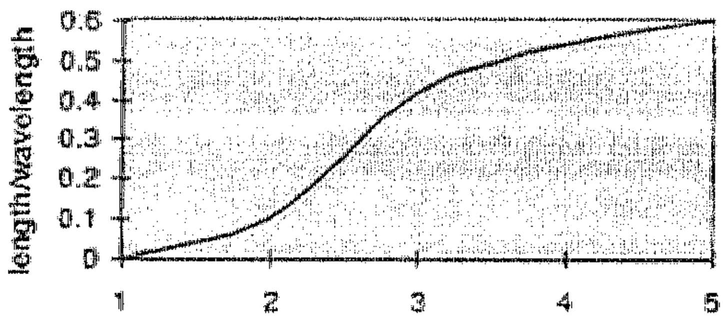

Figure 3.10 A graph of exponent value for n of Rr

For 1 half wavelength, n is found to be 3.2, l =1.43m, $\lambda = 2.87m$ then when we substitute this values into the following fomula we get:

$$Rr= 80.\pi^2\left(\frac{dl}{\lambda}\right)^n \qquad 3.58$$

$$Rr= 80.\pi^2\left(\frac{1.43}{\lambda 2.87}\right)^{3.2}\ \Omega \qquad 3.59$$

$$Rr= 80.\pi^2(0.5)^{3.2}\Omega \qquad 3.60$$

$$Rr= 80.\pi^2(0.1)\ \ \Omega= 78.9\ \Omega \qquad 3.61$$

3.2.5 Impedance Matching

Between the final power amplifier of the transmitter and the antenna, an impedance matching network may be considered. One of the possible surprises in power amplifiers is the realization that output impedance matching is not based on the maximum power criteria. One reason for this, is the fact that matching the load to the device output impedance results in power transfer at 50% efficiency. The purpose of the impedance network is to transform a load impedance to an impedance appropriated for optimum circuit operation [12].

3.3 CIRCUIT DIAGRAM

The FM transmitter circuit diagram employed in this project is shown in figure 3.11

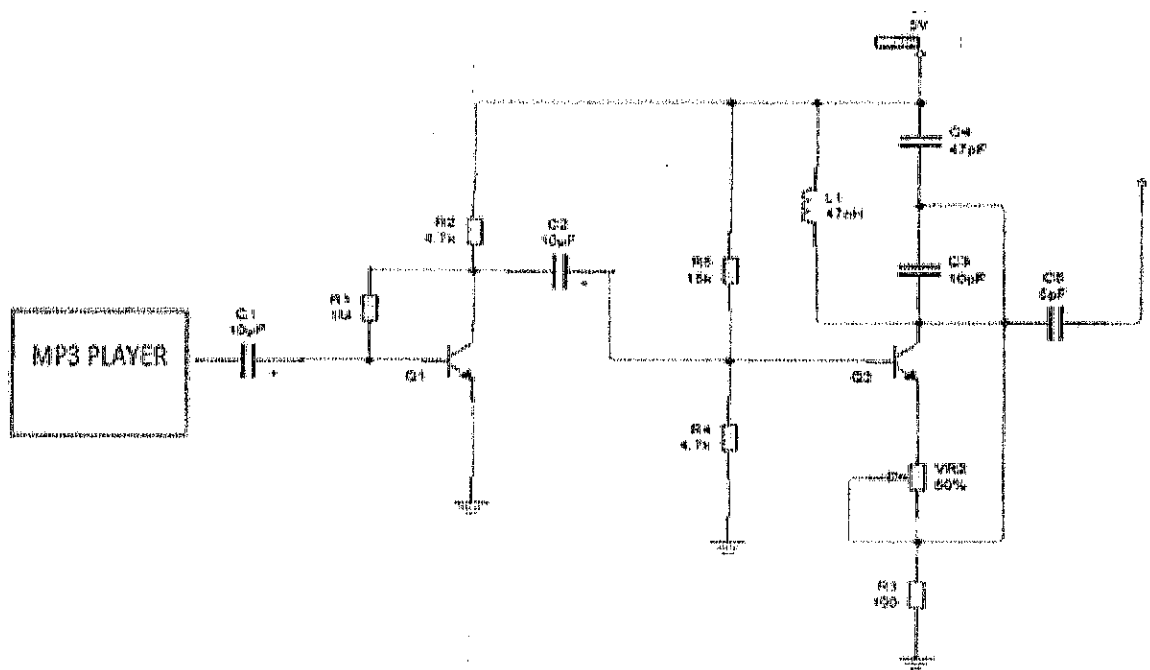

Figure 3.11 The FM transmitter circuit diagram

The FM Receiver circuit diagram employed in this project is shown in figure 3.12

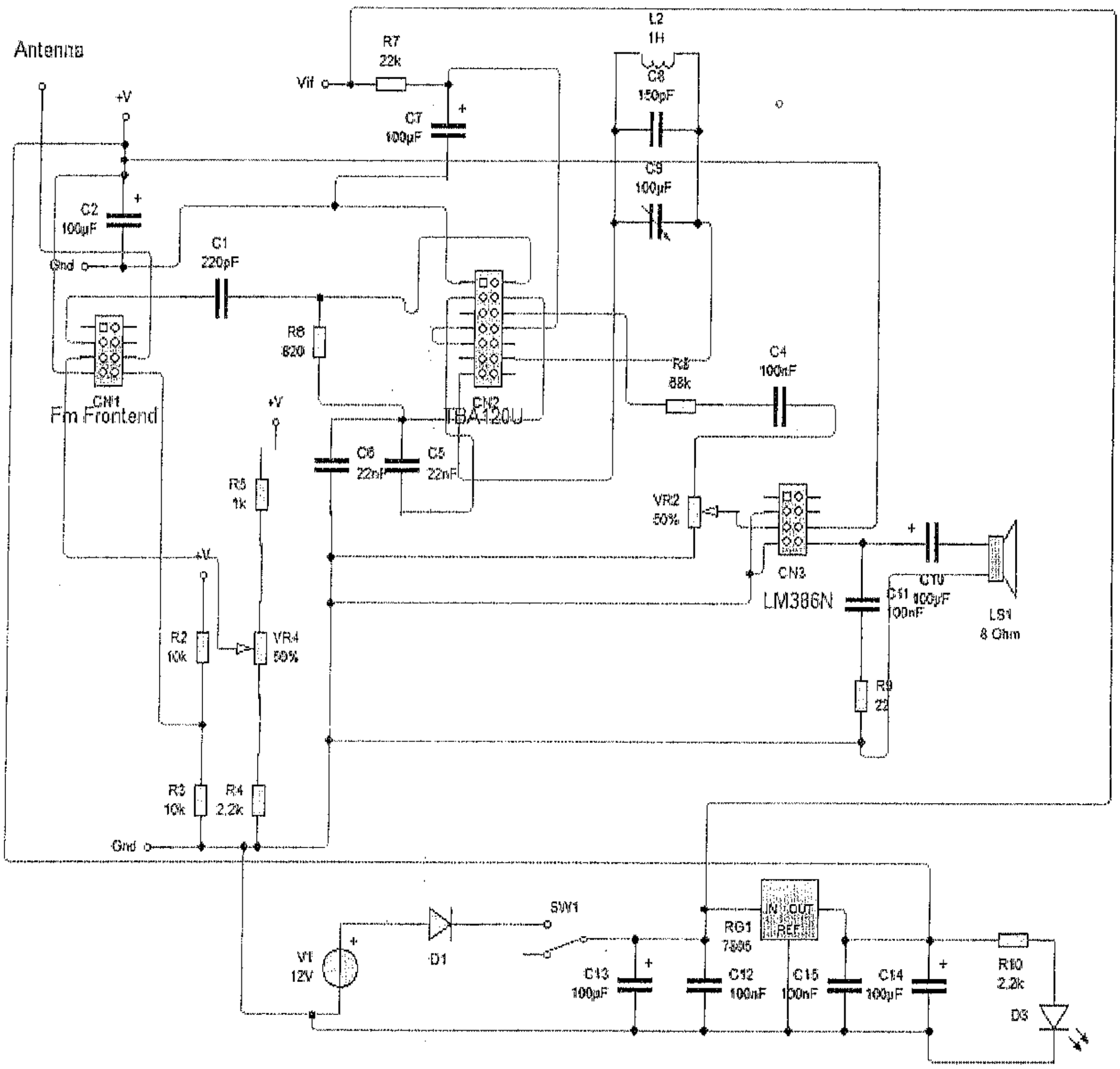

Figure 3.12The FM receiver

3.4 PCB LAYOUT

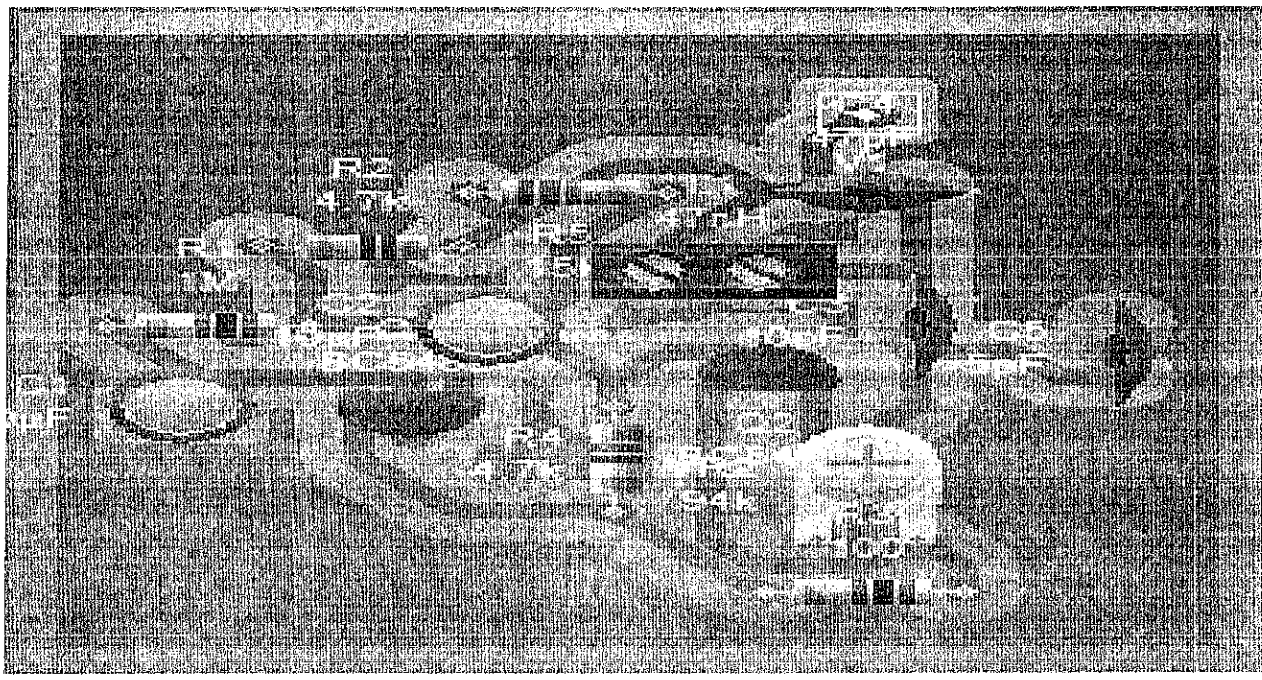

Figure 3.13 PCB layout of the FM transmitter(top view)

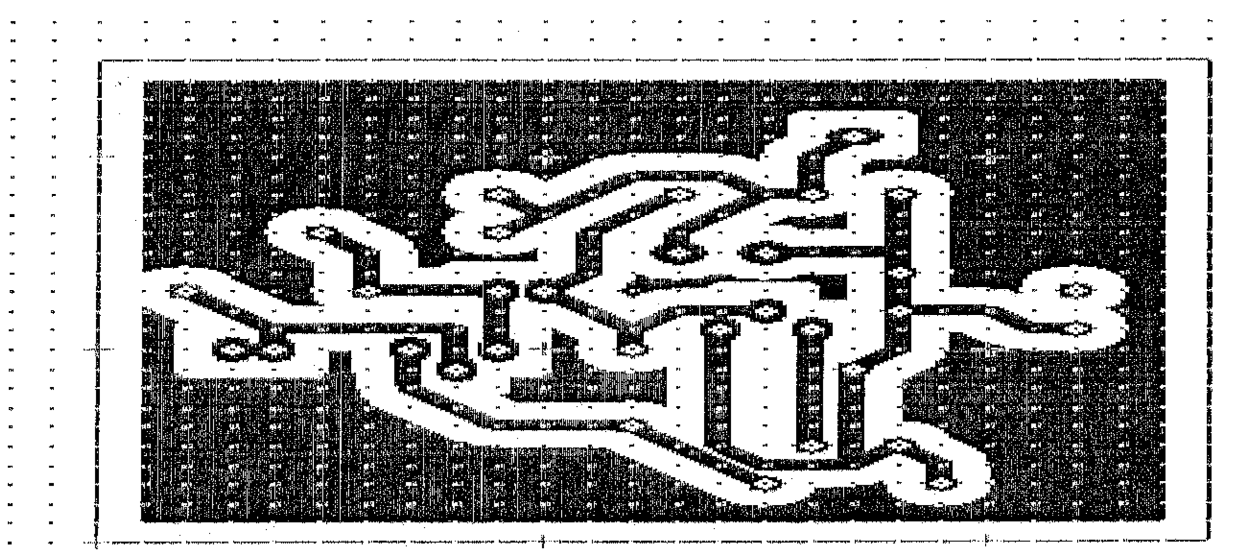

Figure 3.14 PCB layout of the FM transmitter (pdfview)

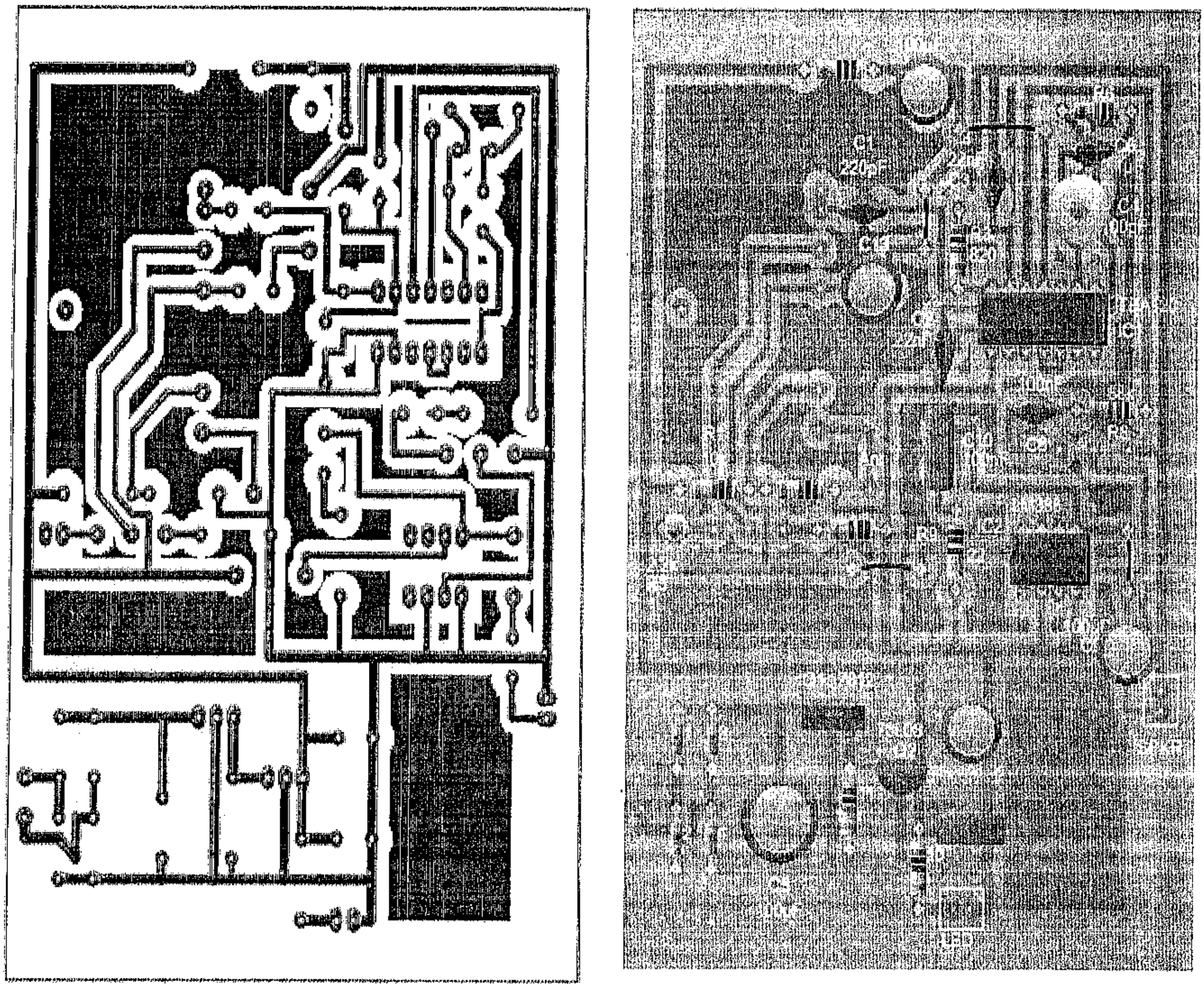

Figure 3.15 PCB layout of the FM receiver

CHAPTER 4

RESULTS AND TESTING

4.1 TESTING

The physical realization of the project is very vital. This is where the fantasy of the idea meets reality. The designer will sell his or her work not just on paper but also on a finished hardware. After carrying out all the paper design and analysis, this project was implemented and tested to ensure it's working ability, and was finally constructed to meet desired specifications. The process of testing and implementation involved the use of some test and measuring equipment stated below.

4.1.1 BENCH POWER SUPPLY

This was used to supply voltage to the various stages of the circuit during the breadboard test before the power supply in the project was soldered. Also, during the soldering of the project the power supply was still used to test various stages before they were finally soldered. The bench power supply used in testing the project is shown in figure 4.1

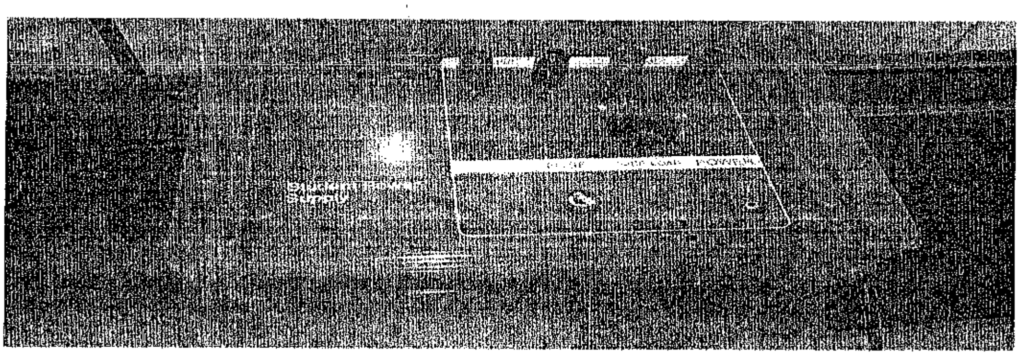

Figure 4.1 Bench power supply

4.1.2DIGITAL MULTIMETER: The digital multimeter basically measures voltage, resistance, continuity, current, frequency, temperature and transistor hfe. The process of implementation of the design on the board required the measurement of parameters like voltage, continuity, and resistance values of the components and frequency measurements of the transmitter modulating stage as well as the PLL VCO frequencies. The digital multimeter was used to carry out these measurements.The digital multimeter used in testing the project is shown in figure 4.2

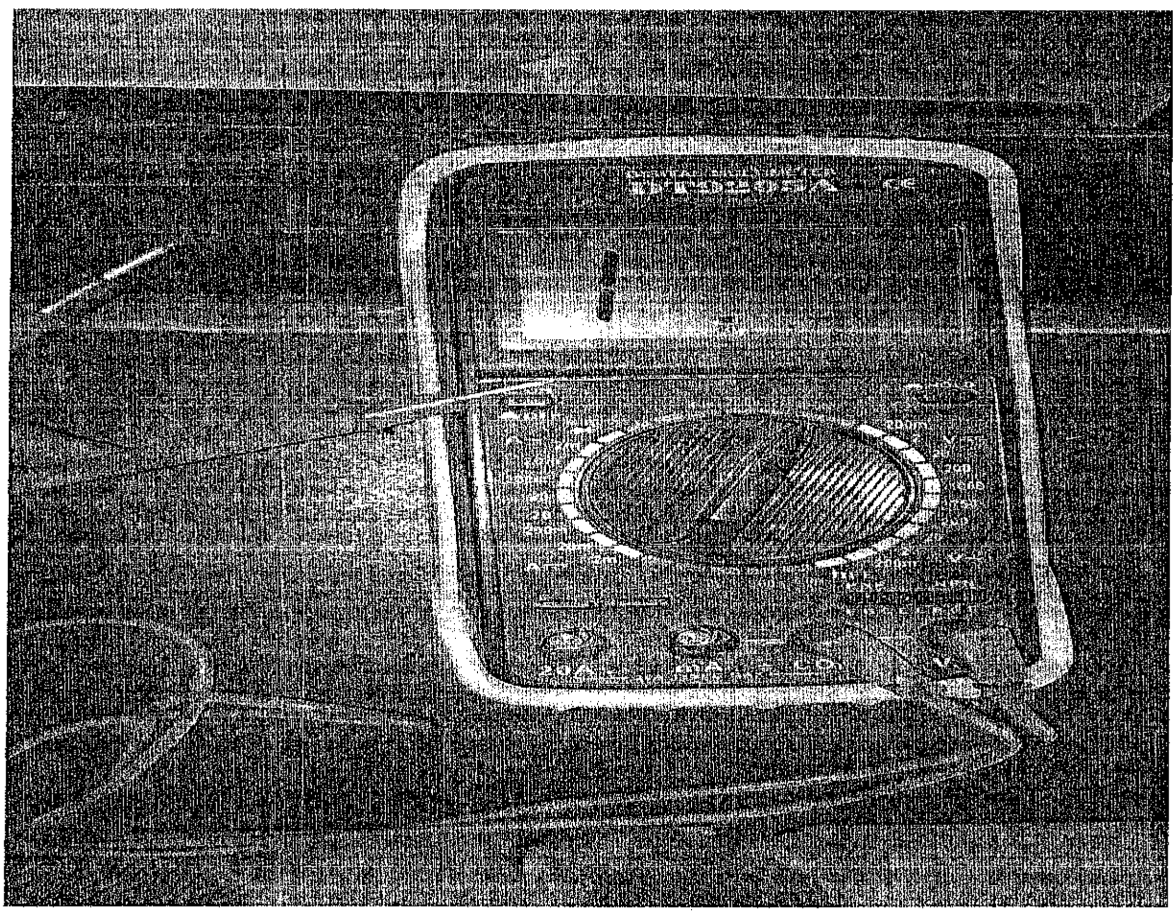

Figure 4.2 Digital multimeter

4.1.3 CAPACITANCE METER

A capacitance meter is a piece of electronic test equipment used to measure capacitance, mainly of discrete capacitors. For must purposes and in most cases the capacitor must be disconnected from circuit. The process of implementation of the design on the board required the measurement of capacitive value of the capacitors. The capacitance meter was used to carry out these measurements.The capacitance meter used in testing the project is shown in figure 4.3

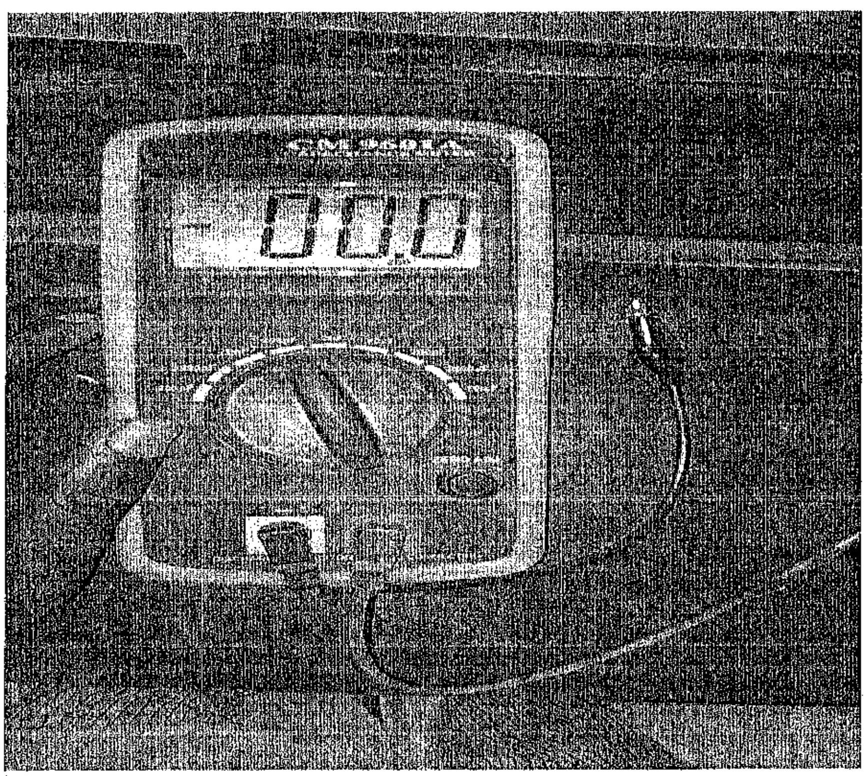

Figure 4.3 capacitance meter

4.1.4 RADIO SET

I employed the use of a radio set that has a frequency meter to detect the frequency at which the transmitter is transmitting. The radio set used in testing the project is shown in figure 4.4

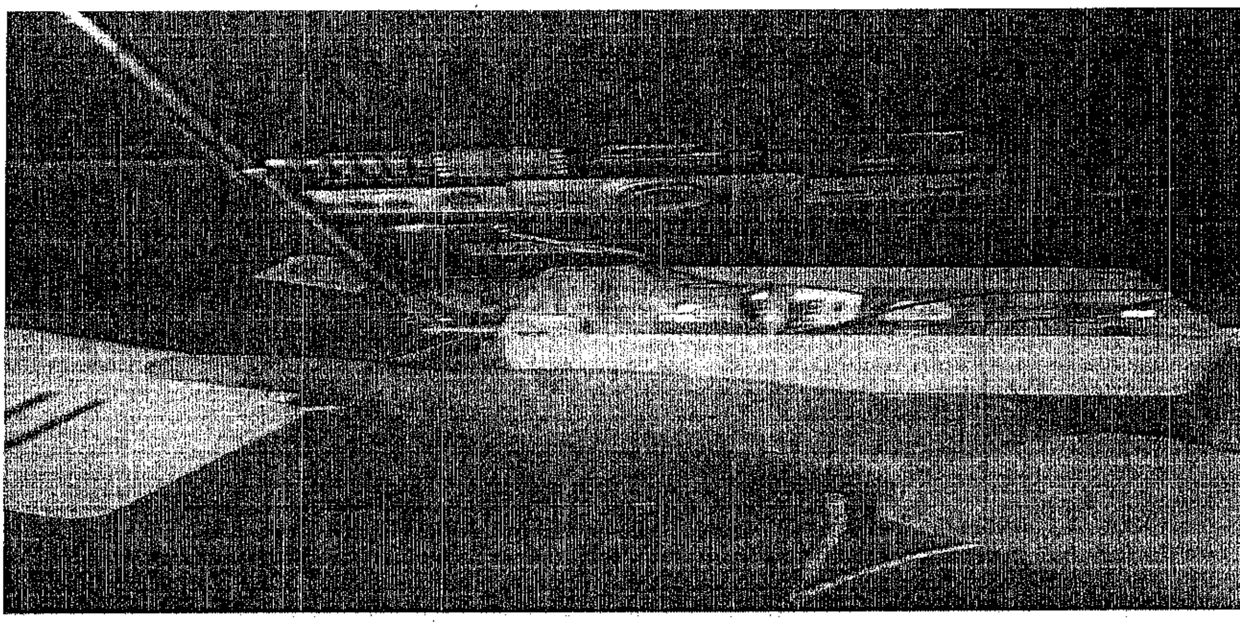

Figure 4.4 A radio set

4.2 REVIEW AND EVALUATION

The implementation of this project was done on the breadboard. The power supply was first was derived from a bench power supply before soldering on a strip board was done. Below are figures of the soldered and coupled project.

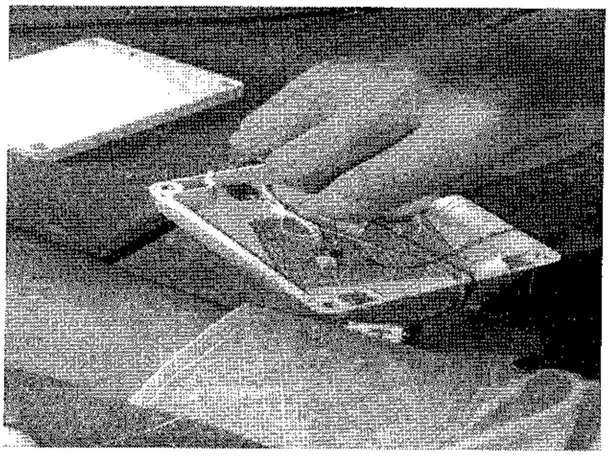

Figure 4.5 Tuning the variable resistor to set the frequency

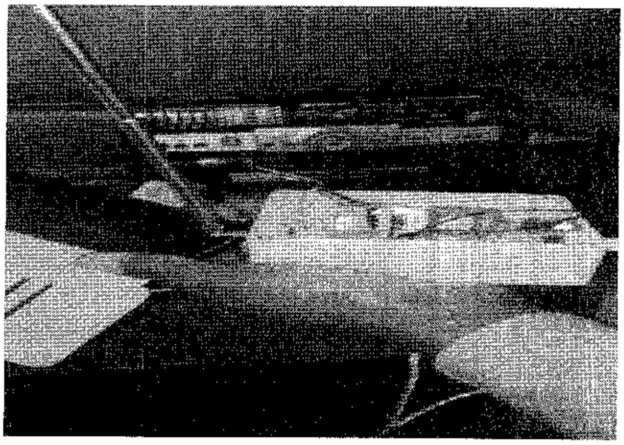

Figure4.6 Using a radio set to get the transmitting frequency

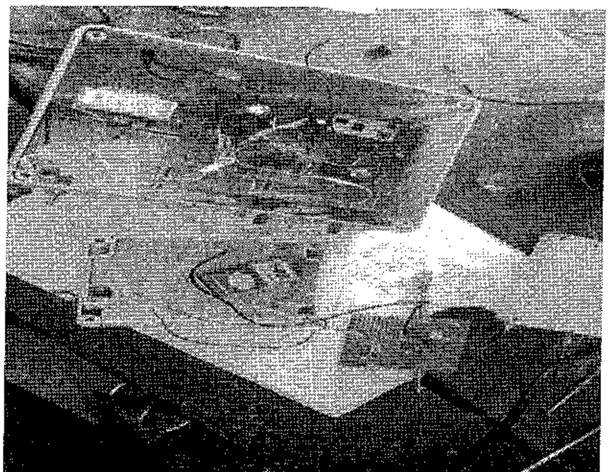

Figure 4.7: fixing the battery

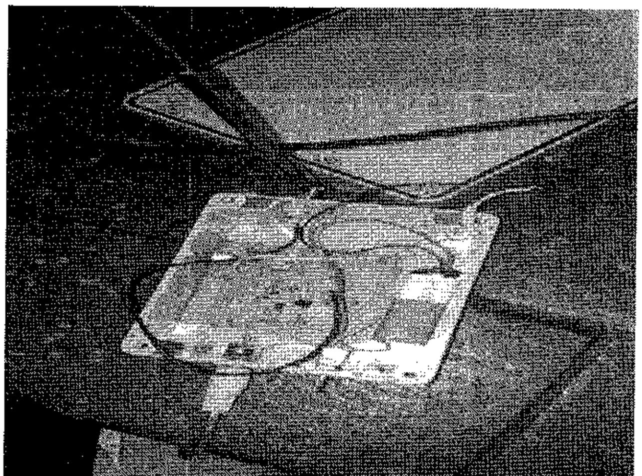

Figure 4.8 fixing the antenna

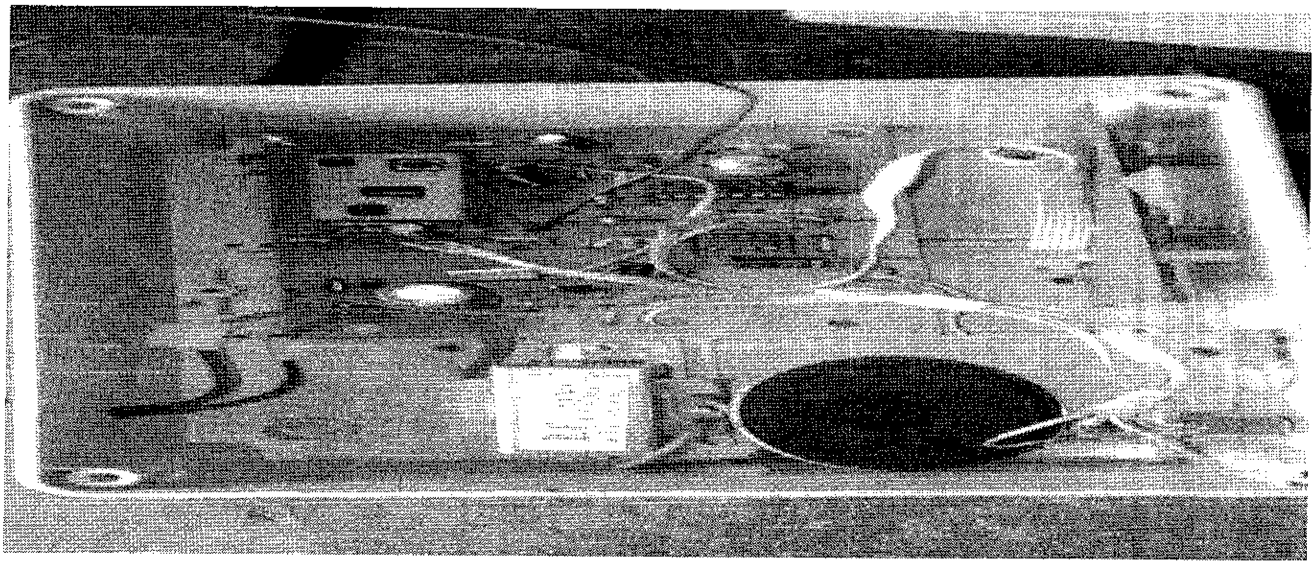

Figure 4.9Internal structure of theFMreceiver(a)

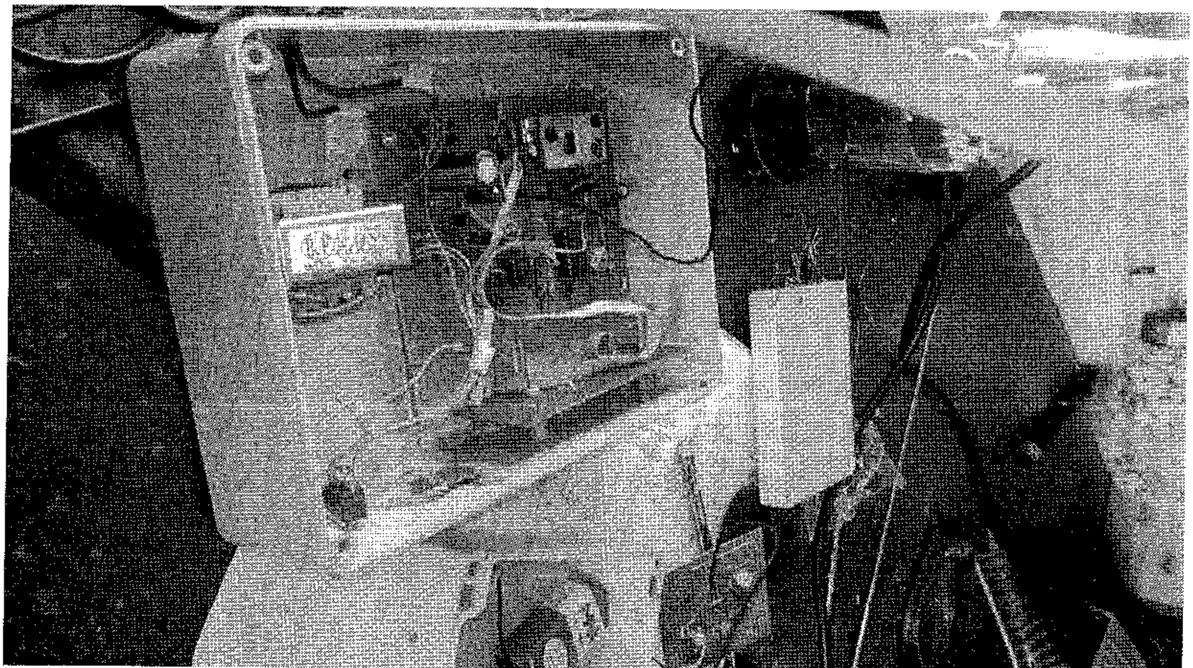

Figure 4.10Internal structure of the FM receiver (b)

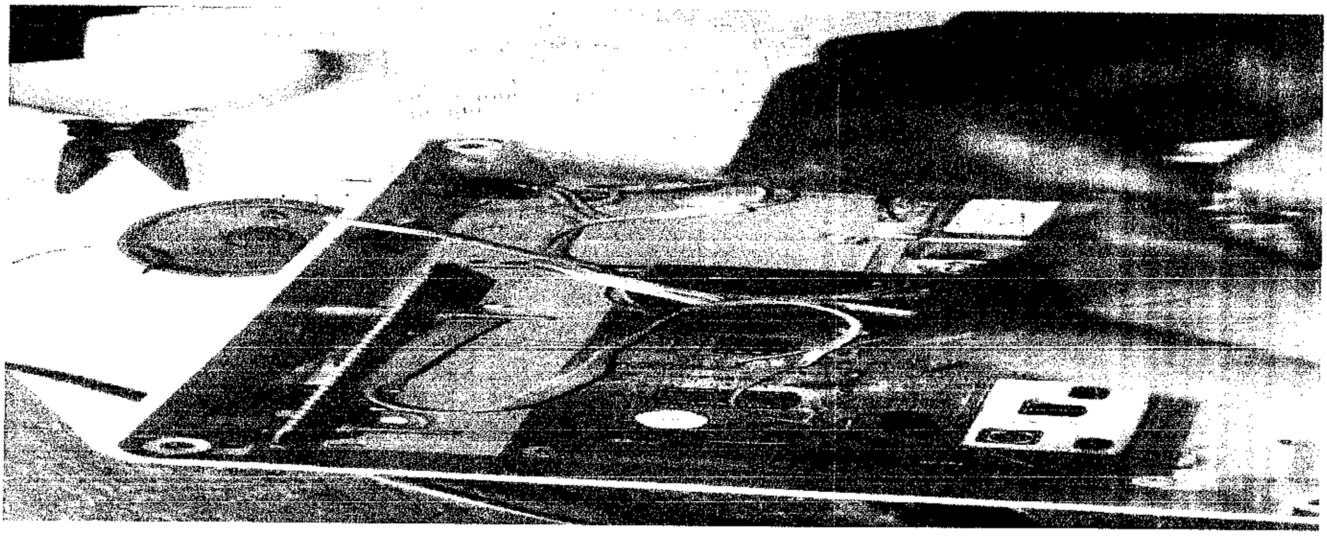

Figure 4.11 Fixingthe Speaker

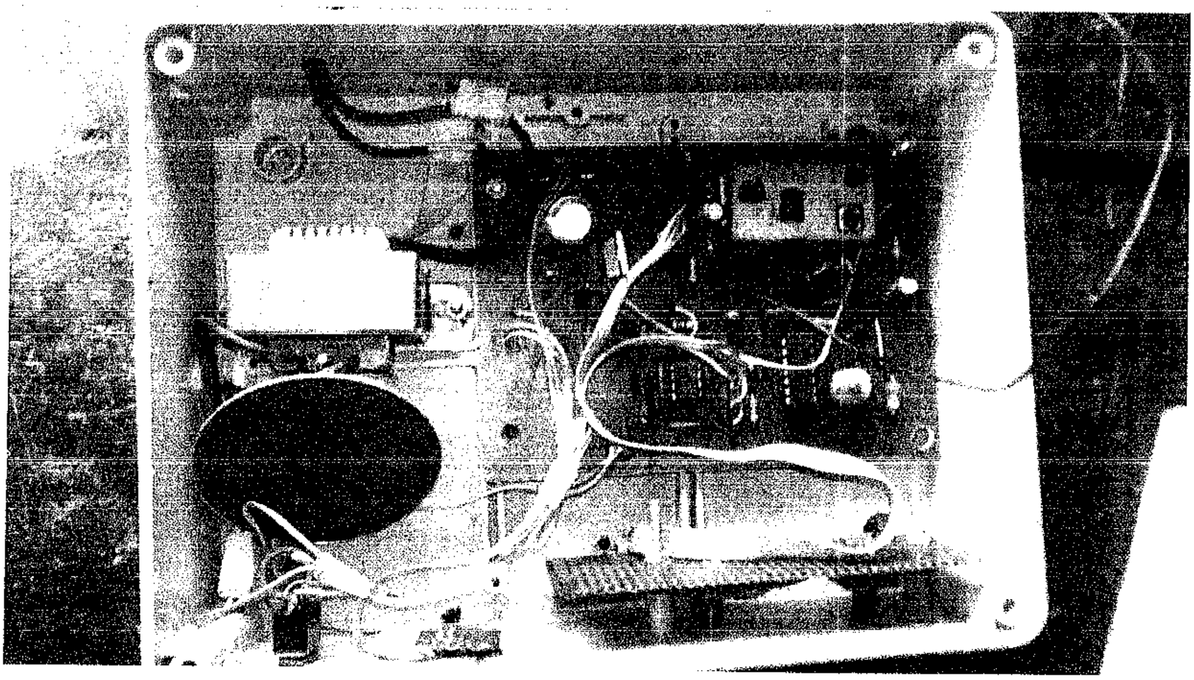

Figure 4.12 Internal structure of the FM receiver(c)

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

This project which is the design and implementation of Wireless music player was designed considering some factors such as design economy, availability of components and research materials, efficiency, compatibility and portability and also durability. The performance of the project after test met design specifications. However, the general operation of the project and performance is dependent on the user who is prone to human error.

Also, the operation is dependent on how well the soldering is done, and the positioning if the components are on the Vero-board. If poor soldering lead is used, the circuit might form dry joint early and in that case the project might fail. Also if logic elements are soldered near components that radiate heat (like the power supply regulators), overheating might occur and affect the performance of the entire system.

Other factors that might affect performance include transportation, packaging, ventilation, quality of components, handling and usage.The construction was done in such a way that it makes maintenance and repairs an easy task and affordable for the user should there be any system breakdown.

The project has really exposed me to the design and construction of practical electronics project generally, which is one of the major challenges I shall meet in my field now and in future. The design of the Wireless music player involved research in frequency modulation circuits and other wireless families.

The project was quite challenging, and tedious but eventually was a success. I wish to thank the department and my supervisor for giving me the opportunity to do this project. However, like every aspect of engineering, there is still room for improvement and further research on the project as suggested in the recommendations.

5.2 RECOMMENDATIONS

The design used for this project is essentially quite the difficult one, and it is using the last effort of which partially brings it down when it comes to the overall reliable performance. I was faced with different problems like how to get the exact components of the design materials. Like every research and practical engineering work, diverse kinds of problems are often encountered. The problems encountered in this project are listed below.

1. Wrong choice of components were used, resulting in the general poor performance at first.

2. Bridge in the circuit due to wrong connections and soldering made.

3. Instability in the oscillator part of the circuit.

4. The power supply was soldered and connected wrongly, thereby the power supply stage was heating up.

After learning a lot from this project, there would have been a few things that could done to the final design to improve its performance.

1. Increasing the signal attracting power of the FM receiver

2. The stability of the oscillator could have been greatly increased.

3. Follow the oscillator with a buffer amplifier to reduce effects of load changes.

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LIST OF APPENDICES

APPENDIX I: COST EVALUATION OF THE FM TRANSMITTER

Table 3.1: Cost evaluation of the FM transmitter components.

Name	Cost(naira)	Quantity	Total(naira)
10 μF Electrolytic Capacitor	10.00	2	20.00
100 Resistor (1/4W)	5.00	1	5.00
10 pF Capacitor	10.00	1	10.00
15k Resistor (1/4W)	5.00	1	5.00
1M Resistor (1/4W)	10.00	1	10.00
2.5 (W) x 2.5 (H) in Printed Circuit Board	100.00	1	100.00
4.7k Resistor (1/4W)	5.00	2	10.00
47nH inductor	10.00	1	10.00
47pF capacitor	10.00	1	10.00
5pf Capacitor	10.00	1	10.00
Variable resistor	10.00	1	10.00
BC548B NPN Transistor	20.00	2	40.00
Switch	100.00	1	100.00
Audio Jack	150.00	1	150.00
Antenna	200.00	1	200.00
LED	25.00	1	25.00
Casing	500.00	1	500.00
In To In audio cord	200.00	1	200.00
Battery	100.00	1	100.00
Battery contact point	100.00	1	100.00
TOTAL(naira)			**#1,615**

APPENDIX II: COST EVALUATION OF THE FM RECEIVER.

Table3.2: Cost evaluation of the FM receiver components.

Name	Cost(Naira)	Quantity	Total(Naira)
10 µF Electrolytic Capacitor	20.00	5	100.00
100k Variable Resistor	150.00	1	150.00
100nF Capacitor	15.00	4	60.00
10k Resistor (1/4W)	10.00	2	20.00
TBA 120 IC	250.00	1	250.00
150pF Capacitor	10.00	1	10.00
Antenna	200.00	1	200.00
1k Resistor (1/4W)	10.00	1	10.00
1N4001 Diode	50.00	1	50.00
2.2k Resistor (1/4W)	20.00	2	40.00
200 µF Variable Capacitor	10.00	1	10.00
20k Potentiometer	50.00	2	100.00
22 Resistor(1/4W)	10.00	1	10.00
220pF Capacitor	20.00	1	20.00
22k Resistor (1/4W)	10.00	1	10.00
22nF Capacitor	20.00	2	40.00
Speaker	100.00	2	200.00
FM FRONTEND	500.00	1	500.00
68k Resistor (1/4W)	10.00	1	10.00
7812 (5V, 1A) Voltage Regulator	20.00	1	20.00
8 (W) X 8 (H) in Printed Circuit Board	150.00	1	150.00
820 Resistor (1/4W)	10.00	1	10.00
LM 386	20.00	2	40.00
LED (Red)	40.00	1	40.00
Audio Jack	150.00	1	150.00
Switch	50.00	1	50.00
Tuning knob (for volume and frequency)	50.00	2	100.00
Plug	100.00	1	100.00
Casing	1000.00	1	1000.00
Transformer	250.00	1	250.00
Rectifier Diode	50.00	4	200.00
Voltage regulator	150.00	1	150.00
Electrolytic Capacitor(2200micro farad)	100.00	1	100.00
TOTAL(Naira)			**4150.00**

APPENDIX III: DEFINITION OF TERMS

FM= Frequency Modulation

AM = Amplitude Modulation

C= the speed of light = 300,000km/s or 3.0 x 10^8m/s

F= frequency

VLF = Very low frequency

MF = Medium Frequency

LF = low frequency

VHF= Very high Frequency

UHF = Ultra high frequency

SHF = supper high frequency

EHF = Extremely high frequency

A_V = voltage Gain

Rr = Radiation resistance

Pt = Transmitted power

Z_{out} = Output impedance

Z_{in} = Input Impedance

L = Self inductance of the coil (H)

C= capacitance of the condenser (F)