DESIGN AND CONSTRUCTION OF A FREQUENCY MODULATION TRANSMITTER

BY

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DEDICATION

I dedicate this project to almighty Allah and to my parent Mr. and late Mrs Mudashiru Shittu, my uncle and his wife Mr and Mrs AbdulAzeez Oseni and to my younger ones.

DECLARATION

I Mudashiru kabir here by declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinguish the copyright to Federal University of Technology minna.

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All praises be to God Almighty, for sparing my life till this moment and also for allowing me to attain this height in life. To my parent, I can't but say a very big thank you for their support both morally and financially right from my childhood up to this stage.

My profound gratitude goes to my uncle and his wife Mr. and Mrs. AbdulAzeez oseni for their support, guidance and counseling, financial cannot be left out, my unreserved thanks goes to my supervisor Mr. M.A Sadiq for his guidance in the course of the design.

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ABSTRACT

The project presents the design and construction of a Frequency Modulation (FM) Transmitter, covering a distance of 0.5 kilometer in all radius The device when use employs a wireless form of communication, to transmit signals/ messages to a large number of people within the range of coverage at the same time. The transmitted signal is receive by an fm receiver, which help to demodulate the signal at a frequency of 99.9MHz

The project design was carried out with the aim of transmitting signals with high fidelity, rigid control of frequency and large signal- to-noise ratio to a large number of people at the same time. Portability, Stability, and choice of power supply can not be left out. The device can be use in the school, jungle and as tourist guide for communication.

The system is broken down into simpler functional parts namely: the audio mixer, the modulator /oscillator the Radio Frequency (RF) section and finally the antenna. Details of the stages are described in the paper, with chapter(s) one, two, three, four, five forming the introduction, literature review, design & implementation, discussion of results and conclusion respectively.

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CHAPTER ONE

INTRODUCTION

This chapter gives an expository introduction of what the project is all about, the objectives and methodology of the project (**FM TRANSMITTER).**

1.1 COMMUNICATION

In the light of fact, all living creatures communicate with each other and also with their environment. Communication is also seen as the life blood of modern civilization, without which commerce and industry as we know could not exist[1].

Communication is hereby define as the transfer of information from a source to its right destination.Hence an information that is not transfer to the right destination is not communicated.An information to be transfer may be in one or more of several forms: Speech, Television,Facsimile, Telex,Data Music Telemetery etc[1]. Each of this requires different transmission medium which include the use of:

- Coaxial cable (use for transmission of signal with wide bandwidth)
- Microwave transmission (usually propagated through the atmosphere on a direct line of sight)
- Optical transmission (this is done by the use of laser beam)
- Radio wave propagation.

1.2 RADIOWAVE PROPAGATION

This is a form of wireless communication, which allows people greater flexibility while communicating, because they do not need to remain at a fixed location, but can still communicate with other people while travelling or walking, compare to a wire based service, which requires the installation of wires in a fixed location.Radio wave propagation are useful in places where communication service are only temporarily needed such as large sporting events, festivals etc. Also this mode of communication is useful in remote location such as mountains, jungles, deserts, where wire based communication might not exist[1].

Radiowave propagation is divided into relaylinks and broadcasting applications, where transmitted signals are evenly distributed over a large area. This is employed in television tranmission, domestic radio,mobile and marine radio.For effective radio wave propagation a transmitter and a receiver is needed[1].

The main function of a transmitter in radio and broadcasting is to deliver enough radio ferquency (RF) power for radiation by the transmitting antenna.This process involves modulating a high frequency carrier with the message signal for ease of radiation and for other purposes[2].

1.3 MODULATION

This is the process by which amplitude, frequency or phase of a high frequency carrier signal is modified in accordance with the instantaneous value of the message (modulating) signal, to give amplitude, frequency or phase modulation respectively[2]. For the frequency modulation,the frequency of a carrier signal is modified in accordance with the instantaneous value of the message signal; a transmitter that operate and transmit on this basis is called an FM transmitter[3].

1.4 FM TRANSMITTER

The FM transmitter are the most commonly used types of transmitters; they are operated at very high frequencies for broadcast purpose, where noise is considered less than at lowwer frequency band.They have high fidelity and rigid control of frequency. Frequency modulation provides greater signal to noise ratio than the amplitude modulation for the same antenna power input[2]

Hence, FM transmitters provides a form of wireless communication transmitted through Radio wave propagation. It is used in remote areas such as jungles,deserts, mountains etc. for communication.

1.5 PRINCIPLE OF OPERATION

The operating principle of FM transmitter is based on modulation of the frequency of the carrier wave by the audio signal of which the modulated signal is then amplified before it is passed to the antenna[3].

In transmitting a frequency modulated (FM) signal four (4) main stages are involved:

- Audio amplifier stage
- Oscillator stage
- Modulating stage
- Radio frequency power amplifier

These four stages cascaded together is finally matched with a good 50Ω ground plane antenna, to give a reasonable good signal strenght up to a distance of 0.5km

1.6 OBJECTIVE OF STUDY

This project is aimed at developing an easy, flexible and efficient means of communication with a large signal to noise ratio and with signals evenly distributed over a large area for multiple receiver at the same time. It can also be use in remote area such as jungles, desert, where wire base communication might not exist.

CHAPTER TWO

LITERATURE REVIEW

This chapter contains a brief historical background, theoritical background and the methods of generating FM transmission.

2.1 Historical Background

The existence of radiowave was predicted long before they were actually discovered. The production of eletromagnetic wave in 1877 by H. Hertz, by adding a loop of wire to the hyden jar spark transmitter, which results in an increase in distance over which sparks could be transmitted. This brings about radiowave transmission[4].

In 1893 J.C Maxwell formulated the four maxwell's equations of eletromagnetic waves. In 1893 Ernest Rutherford carriedout transmission of spark over a distance of ¾ miles about 700meters[5]. The invention of the spark over a detector by Branley and its subsequent improvement by Karl Bark, Adolph Slaby and Ohver Lodge made it possible to transmit telegraph by coding sparks over a distance without the use of wires[5].

Guliemo Marconi (1895) with a spark inductor coil and a spark detector succeeded in spending telegraph messges over a distance of 100meter and later across the atlantic ocean. This marks the beginning of radio transmission.In 1899 Valdemar Ponlsen and Fessender Alexanderson invented arc generators which produce power higher than power produced by spark transmitters. D. Ehret (1902) using the arc generator, was able to demostrate frequency modulation[5]. In 1906, the invention of vaccum tube diode by John Ambrose Fleming and the invention of triode by Lee Dee Forest in 1913, made possible development of powerful transmitter with improved frequency stability[5]. In 1912, E. Howard Armstrong used the diode and triode to invent a regenerative circuit, this regenerative circuit in 1920 aided high frequency generation; this led to the first significant demostration of speech transmission by J.R Carson in 1915 (the single side band communication)[5].Commercial operation of FM transmitter started in 1940 after the improvement on the frequency capabilities of vaccum tube& tetrodes by Round in 1926, Pentode by Tellogen and Holst in 1928 and development of Phase Locked Loop (PLL) FM generation technique by foster and S.W Sweeley in 1941. Since the invention of transistor by J. Bardeen, W. Schockley and W.H. Brattain in1948, made possible the invetion of multiplex FM transmitter by Armstrong in march 1953[5].

Frequency Modulation transmission processes has now become popular due to it's several advantages over the system of amplitude modulation 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 statics. Various eletrical disturbances such as those caused by thunderstorms and automobile ignition system which create amplitude modulated radio signals to be receive as noise by AM receivers does not not affect FM transmitter. hence,a well designed FM receiver is not sensitive to such disturbances when it is tuned to an FM signal of sufficient strength . Also, the signal-to- noise rato in an FM system is much higher than that of an AM system,simply because in FM, the amplitude of the transmitter radio frequency is constant therefore the entire FM system is arrange to be amplitude disturbance. The above features, coupled with the Comparatively low cost of equipment for an FM broadcasting station, resulted in rapid growth in the years[5]

2.2 TECHNICAL BACKGROUND

Table 2.2 frequency ranges and equivalent wavelength

Frequency	**Designation**	**Abbreviation**	**Wavelength**
3-30 kHz	Very low frequency	VLF	100,000 10,000m
30-300 kHz	Low frequency	LF	10,000 – 1,000m
300-3000 kHz	Medium frequency	MF	1000-100m
3-30 MHz	High frequency	HF	100-10m
30-300 MHz	Very high frequency	VHF	10-1m
300-3000 MHz	Ultra high frequency	UHF	1m-10cm
3-30 GHz	Super high frequency	SHF	10cm-1cm
30-300 GHz	Extremely High frequency	EHF	1cm-1mm

FM Transmitter is operated at the very High frequency (VHF) range. The main frequencies of interest are from 88MHz to 108MHz with wavelength between 3.4m-2.77m respectively. The range of transmission on these bands is limited, so that stations operating on the same frequency can be located within a few hundred miles of one another without mutual interference[6].

The transmitter frequency in an fm transmitter is varied above and below the medium by an amount according to the amplitude of the modulation signal and at a rate determined by the frequency of the modulating signal. In the fm transmitter, the frequency of the R.F. (radio frequency) carrier is changed by the audio frequency (A.F.) signal. The change or deviation is proportional to the amplitude of the A.F. at any instant and is expressed in KHzv-1. For example if a 100MHz carrier is modulated by a 1v1KHz sine wave, the carrier frequency might swing 15KHz either side of 100MHz ie from 100.015MHz to 99.985 MHz and this serves as the bandwidth for the station to avoid interference, noise and distortion[7] in accordance to shannon's theorem which states that "the rate of transmission should not exceed the channel capacity so as to avoid noise and interference[3]. By international agreement, the maximum deviation allowed is +- 75KHz. Hence the bandwidth may be taken roughly +- (Δfc + fm) where Δfc is the deviation (carrier frequency) and fm the highest modulating frequency[7].

2.3 FM THEORY

Angle and amplitude modulation are techniques used in communication to transmit data or voice over a particular medium whether it be over wire cable, fibre optic or air (the atmosphere). A wave that is proportional to the original base band (a real time property such as amplitude) information is used to vary the angle or amplitude of a higher frequency wave (the carrier)[3].

Carrier A cos $\Phi(t)$

$\Phi(t) = 2\pi f_c t + \alpha$

Where A is the amplitude of the carrier and Ǿ is the angle of the carrier, which constitutes the carrier frequency (fc) and the phase (γ) of the carrier. Angle modulation varies the angle of the carrier by an amount proportional to the information signal. Angle modulation can be broken into 2 distinct categories; frequency modulation and phase modulation [3].

Phase Modulation (PM): Is an angle modulation which the phase of a carrier is caused to depart from its reference value by an amount proportional to the modulating signal amplitude[3].

Frequency Modulation (FM) is an angle modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulator or intelligence wave[3].

Phase modulation differs from frequency modulation in one important way. Take a carrier of the form: $A(\cos\omega_c t + \theta) = \mathrm{Re}(Ae^{j(\omega ct + \theta)})$

PM will have the carrier phasor in between the + and – excursions of the modulating signal. Fm modulation also has the carrier in the middle but the fact that when you integrate the modulating signal and put it through a phase modulator you get FM and if modulating wave were put through a differentiator, before a frequency Modulator you get a phase modulated wave[3].

Another difference is in the modulation index, where PM uses a constant modulation index FM modulation index varies. Because of this, the demodulative S/N ratio of PM is far better than FM.

The reason why PM is not used in the commercial frequencies is because of the fact that PM need a coherent local oscillator to demodulate the signal, this demands a phase locked loop, back in the early years the circuitry for a PLL couldn't be integrated and therefore FM without the need for coherent demodulation was the first on the market. One of the advantages of FM over PM is that the FM Vco can produce high index frequency modulation whereas PM requires multiples to produce high index phase modulation[3]. PM circuitry can be used today because of a very large scale integration used in electronic chips as stated before to get FM signal from a phase modulator, the base band can be integrated and this is the modern approach taken in the development of high quality FM transmitters[8].

2.4 TECHNICAL TERMS ASSOCIATED WITH FM.

2.4.1 Capture Effect: This is the ability of an FM receiver, picking up the stronger signal and thereby attenuating the unwanted signal pickup in a situation whereby there are two stations or more transmitting at near the same frequency[2].

2.4.2 Modulation Index:

$$M_f = \frac{\Delta f_c(p_k)}{f_m}$$

Modulation index, is used in communications as a measure of the relative amount of information to carrier amplitude in the modulated signal. It is also used to determine the spectral power distribution of the modulated wave. This can be seen in conjunction with the Bessel function. The higher the modulation index, the more side-bands are created and therefore the more bandwith is needed to capture most of the base band's information[3].

2.4.3 Deviation Ratio

The deviation can be quantified as the largest allowable modulation index

D.R= $(\Delta f_{c(pk)}) / f_{m(max)}$ = 75kHz/15Kz = 5 radian

For the commercial bandwidth, the maximum carrier deviation is 75kHz. The human ear can pick up on frequencies from 20Hz to 20kHz, but frequencies above 15kHz can be ignored, so for commercial broadcasting (with maximum baseband frequency of 15kHz) the deviation ratio is 5 radians[3].

2.4.4 Carrier swing.

The carrier swing is twice the instantaneous deviation from the carrier frequency.

Fcs = 2.Δfc. [2]

The frequency in theory can be anything from 0Hz to 150kHz.

2.4.5 Percentage Modulation

The % modulation is a factor describing the ratio of instantaneous carrier deviation to the maximum carrier deviation [3].

$$\% \text{ modulation} = \Delta f_c / \Delta f_c(p_k) \times 100$$

2.4.6 Carson's rule

Carson's rule gives an indication to the type of bandwidth generated by an fm transmitter or bandwidth needed by the receiver to recover the modulated signal. Carson's rule states that the bandwidth in Hz is twice the sum of the maximum carrier frequency deviation and the instantaneous frequency of the baseband [2,3].

$$\text{Bandwidth} = 2(\Delta f_c(p_k) + f_m)$$

$$= 2f_m(1 + m_f)$$

2.4.7 Modulation

This the process by which either the frequency (rate of oscillation), the amplitude (height) of the frequency wave is combined with the carrier waves to give frequency modulation and amplitude modulation respectively and this allows radio transmission. Below is the wave form for a frequency modulated signal [2].

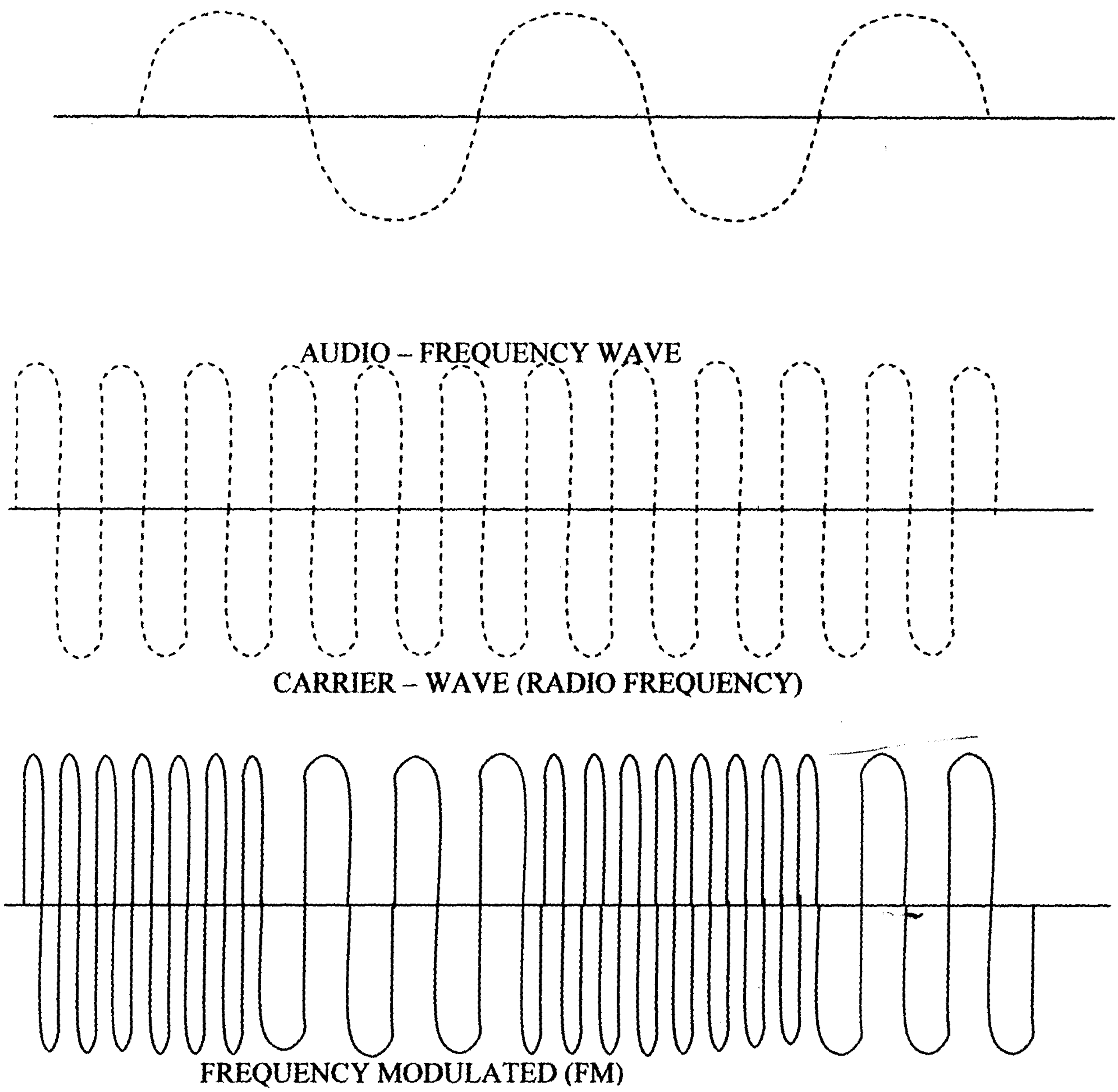

Fig. 2.4.7 illustrates the various wave form

2.5 ELECTRONIC COMPONENTS AND THEIR PROPERTIES

2.5.1 Resistor:

For a resistor the voltage dropped across it is proportional to the amount of current flowing on the resistor $V_R = IR$. Any current waveform through a resistor will produce the exact same voltage wave form across the resistor although this seems trivial[11]. Resistor is a discrete component to be considered for use in a high frequency circuit. Resistors are either fixed or variable resistor and this form the basic components in any electronic circuit.

In choosing a resistor for an intended application, three main factors are considered viz:

a. Tolerance b. Stability c. power rating

2.5.2 CAPACITOR

The voltage across a capacitor lags the current by 90°, the reason for this lag in voltage is that the voltage is proportional to the integral of current entering the capacitor. The impedance of the capacitor can be found to be : Jx(1/WC)[11],

Capacitor is also a discrete component to be considered for use in a high frequency circuit. The resistive elements in a capacitor at a high frequency is brought about by the material inbetween the plates of the capacitor, which inherently controls the permittivity and also the conductive properties of the capacitor at high frequencies. The efficiency in capacitors at high frequencies are generally better than the inductor[11]. Good RF techniques usually employ keeping the leads short when soldering a capacitor into a circuit[11].

When choosing a capacitor the most important factors to be considered are:

a. Leakage current b. polarised/non-polarised c. Temperature coefficient

2.5.3 INDUCTOR

The voltage across an inductor leads the current through it by 90° this is due to the fact that the voltage across an inductor depends on the rate of change of current entering the inductor. The impedance of an inductor is +JWL[11].

Inductors are of two types namely the manufactured inductor and self made inductor. For the manufacture type, the overall Q-factor should taken into consideration, while the self made inductor are very useful when a particular inductance is desired.[12]

$$L = N^2\left(\frac{d^2}{18d+40b}\right) \quad = N = \quad \sqrt{L}\,\frac{(18d+40b)}{d:}$$

L =inductance in μH | d = diameter in inches

N = number of turns | b= coil length in inches

[illegible] discrete components discussed form the basic building blocks used in any [illegible] section of any transmitter/receiver. What makes them important is there [illegible]tain frequencies. At low frequency, the impedance of an inductor is small [illegible] of a capacitor is quite high and vice versa. The resistor maintains their [illegible]dance both at low and high frequency[11]. At a certain frequency inductor's and capacitance's impedance is equal and this frequency is called the resonant frequency. This resonant frequency in FM essentially represents the oscillator carrier frequency in Hertz [13].

$$F_c = 1/2\pi\sqrt{LC}$$

2.5.4 THE QUALITY FACTOR (Q- FACTOR)

Quality of component known as Q-factor is a measure of the energy stored to that which is lost in the component due to its resistive element at low or high frequency. Hence, Q- factor is define by the ratio of maximum energy stored to the amount lost per A.C cycle.The higher the Q the less the energy dissipated[11]

2.5.5 TRANSISTOR

A transistor is a three layer, three terminal and two PN junction semiconductor devices. The three layers are the emitter(E), Collector(C) and the base (B). Transistor are either NPN or PNP. For this transmitter, NPN transistor is taken into consideration..The Emitter- base junction is usually forward base while the collector-base junction is usually reversed biased. The emitter is highly doped While the collector is slightly doped with a narrow base width. When forward biased with the external voltage, most charge from the emitter region cross into the collector region, giving rise to collector current. Only little charge combination takes place in the base[14].

2.5.6 HIGH FREQUENCY RESPONSE OF TRANSISTOR

An interesting property of transistor at high frequency is the junction capacitance from base to emitter and base to collector. The base emitter capacitance is larger than the base collector because of the heavier extrinsic doping and it's forward biasing. As the frequency increase, the two capacitances will drop because the capacitor is effectively in series . The capacitance is also influence by the rate of change in base current magnitudes so, at high frequency the response of the NPN model is that of output collector signal is being fed back to the base and this increase the likelihood of continuous oscillation at high frequency[8].

2.6 BASIC BUILDING BLOCK FOR AN FM TRANSIMITTER

When creating a system for transmitting a frequency modulated wave, a number of basic building blocks have to be considered. For the purpose of this transmitter, the block diagram is given thus,

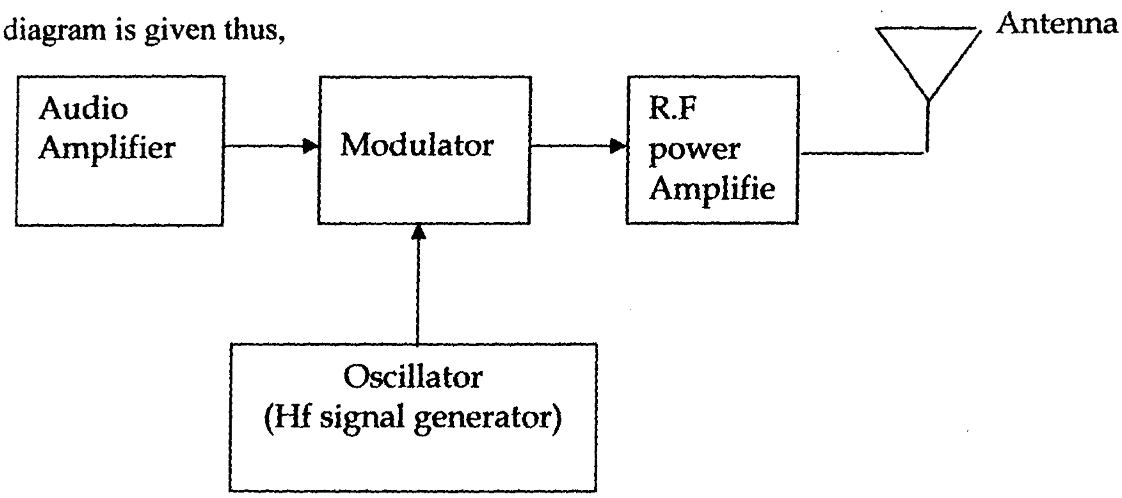

Figure 2.6 block diagram of a transmitter

2.6.1 Audio Amplifier

An audio amplifier is employed to boost or amplify the incoming information signal to a level suitable for further processing by the modulator. A pre- emphasis high- pass filters at the transmitter is use to reduce noise, and this is achieve by filtering, thereby increasing the signal – to – noise ratio[3].

2.6.2 Modulator

This is the stage in which the parameter of a high frequency signal (the carrier) is modified in accordance with the instantaneous value of the modulating signal

In order to convey the characteristics of fm on the carrier wave, inductance or capacitance (of the tank) must varied by the base band. Normally the capacitance is varied by a varactor diode[8]

2.6.3 Oscillator

This stage generates the carrier frequency on which the information signal or audio signal is impressed by the modulator so as to prepare this signal for onward transmission[3]

2.6.4 Radio Frequency Amplifier

This stage is designed with the objective of obtaining maximum power, for radiation. The amplifier takes the energy drawn from D.C power supply and converts it to the A.C signal power that is to be radiated. The choice of this amplifier type depends greatly on the output power and intended range of the transmitter[3].

2.6.5 Antenna

This the final stage of any transmitter , this is where the electronic FM signal is converted to electrmagnetic waves[10], which are radiated into the atmosphere. These waves;on reaching the antenna oscillate along the length of the antenna and back. Each oscillation pushes electromagnetic energy from the antenna thereby emitting the energy through free space as radiowave[5].

The power radiated by an antenna is given by poynting vector theorem

$P = E*H$ where E is the electricfield and H is the magnetic field[2]

2.7 METHODS OF GENERATING FREQUENCY MODULATION .

- Direct method (uses varactor diode or base reactance)
- Indirect method (uses phase modulator

CHAPTER THREE

3.1 DESIGN AND IMPLEMENTATION OF THE FM TRANSMITTER

The FM transmitter being constructed consists of a microphone/audio input section, a main stage (which is made up of the oscillator and modulator), the last stage (which consists of the RF amplifiers) and an antenna. A block diagram of the FM transmitter is shown below.

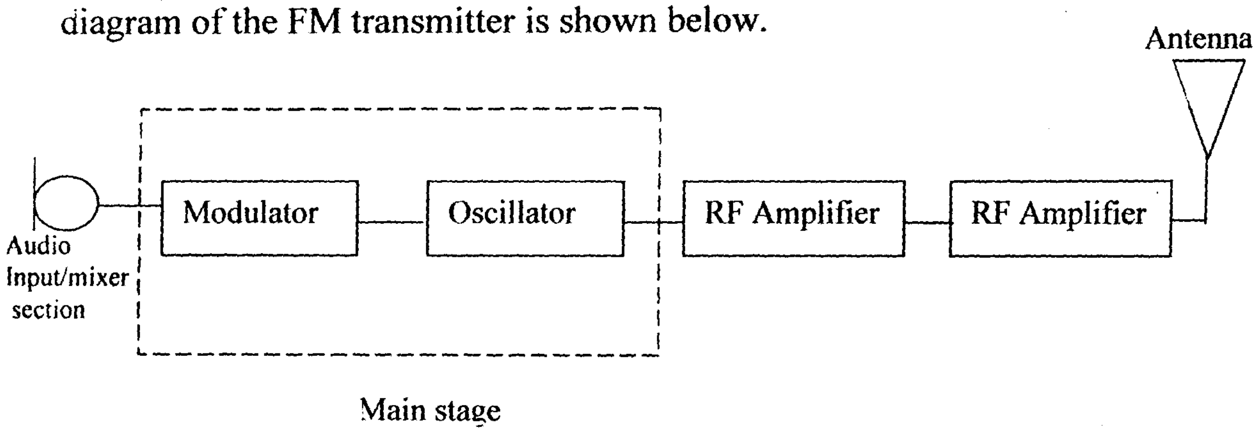

Fig. 3.1 Block diagram of the transmitter

The design of the FM transmitter was carried out by cascading the system listed below:

1. Two microphone, two auxiliary monophonic audio mixer
2. The modulator/oscillator.
3. The R.F Amplifiers and antenna
4. A rechargeable lead-acid battery with a charging circuit built to supply power.

AUDIO INPUT/MIXER SECTION

The function of this section in the design is to convert the voice/audio signal into an electrical signal (input transducer).

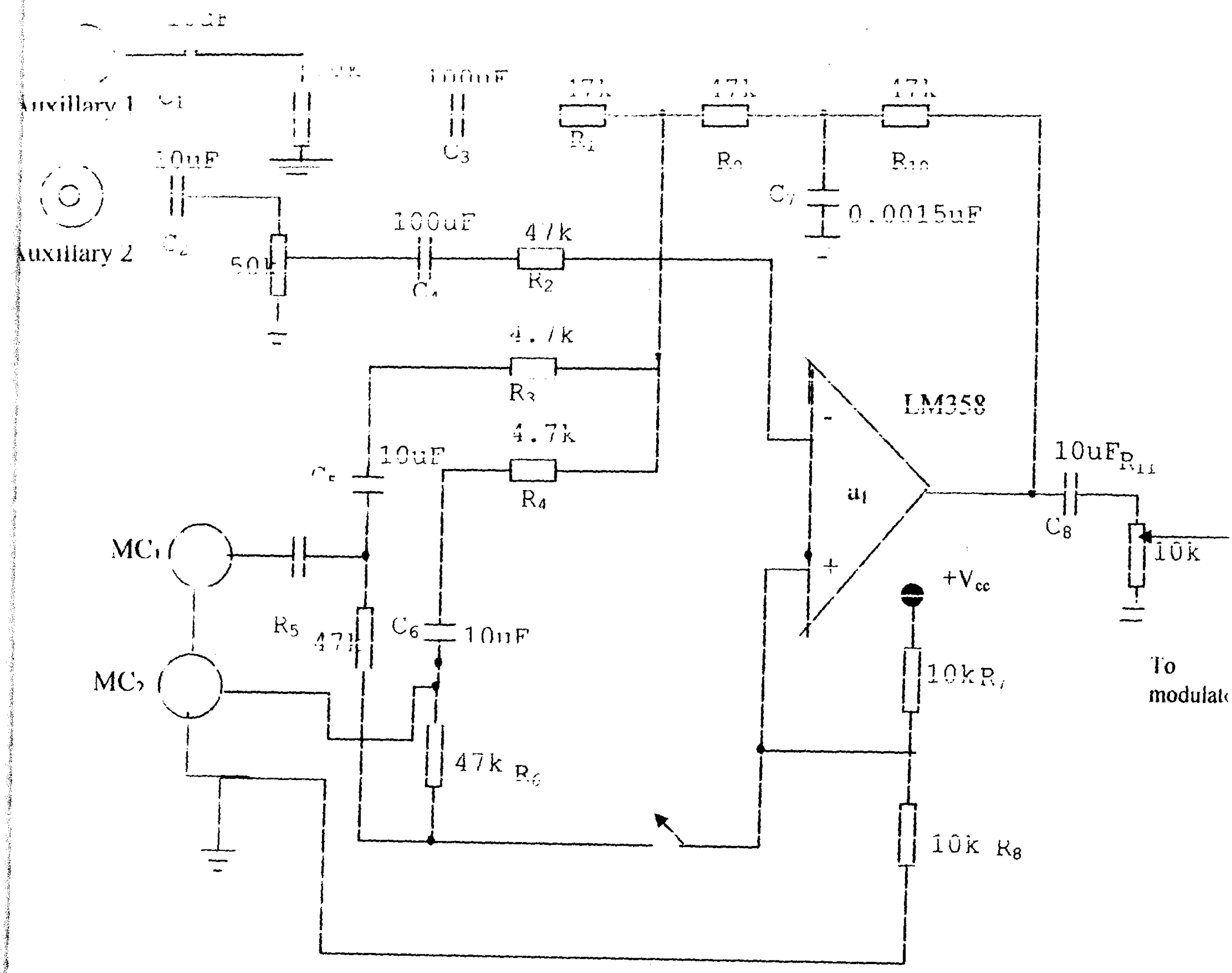

Fig 3.2 Circuit diagram of audio input/mixer

When the signal from the two microphones, and the auxiliary input is combine, they are passed through the series arrangement of the capacitors and resistors, which form the high pass cut off filter, principally use to pass all lowest possible desire audio frequency signals without attenuation.

For efficient modulation, an appreciable gain is needed to raise the audio signal level, hence a LM358 dual op-amp is used to combine the different signal in the summing amplifier configuration. Also included is the pre-emphasis circuit formed by resistor R_9 and R_{10} alongside capacitor C_7, this is incorporated to improve high frequency performance and to improve the signal-to-noise ratio of the transmitted information. The summed output is feed into the modulator through a 10kΩ adjustable potentiometer.

Calculation of audio signal gain

a. For the summing amplifier

i. $AV\ (\text{gain in decibel}) = \frac{-94000}{47000} = -2$ (for auxillary 1&2)

ii. $AVdb = \frac{-94000}{4700} = -20$ (for microphone 1&2)

b. For the pre-emphasis

$T_C = RC$

Where Tc = Time constant: 75 μs [2] was choose due to the choice of component values.

R = Resistance = 45 $k\Omega$

T_C =RC

$$75\times10^{-6} = 47\times10^{3}\times c$$

$$C = \frac{75\times10^{-6}}{47\times10^{3}}$$

C = 1.6nf

By choice of component, the nearest chosen value available is 1.5nf (0.0015µF)

The frequency $F = 1/2\pi Rc$

$$F = \frac{1}{2\pi\times47\times10^{3}\times0.0015\times10^{-6}}$$

$$F = \frac{10^{7}}{2\pi\times47\times10^{3}\times0.015}$$

F =2.257KHz

c. High pass cut off filter:

The frequencies for the input signal is given by

$$F = 1/2\pi Rc$$

For microphone

$$F_{mic} = \frac{}{\left(2 \times \pi \times 4700 \times 10 \times 10^{-6}\right)}$$

$F_{mic} = 3.4Hz$

For auxiliary

$$F_{a} = \frac{1}{\left(2 \times \pi \times 47000 \times 100 \times 10^{-6}\right)}$$

F =0.04Hz

Note

R = 4700kΩ for microphone

R = 47000 kΩ for auxiliary

C = 10μf for microphone

C = 100μf for auxiliary

All in accordance to the circuit diagram

3.3 Modulator/Oscillator

A modulator is a circuit that super-impose a low frequency voice information component on a high frequency carrier signal which is generated by the oscillator.

Oscillator is an electronic circuit that has been designed to produce an alternating e.m.f of a known frequency and waveform thus; an oscillator is an amplifier that generates its own input signal which is derived from the output signal.

Connected to the output of the audio mixer is the modulating circuit (modulator). This circuit works to modify the high frequency signal (the carrier) with the instantaneous value of the modulating signal to give F.M signal. A direct F.M generation is employed, in which a modulating voltage is applied to the base emitter junction of TRI through C1 this causes a change in the base current and hence the collector current which in return varies the inter electrode capacitance of the common base junction of TR_1, which now varies the frequency of oscillation[8].

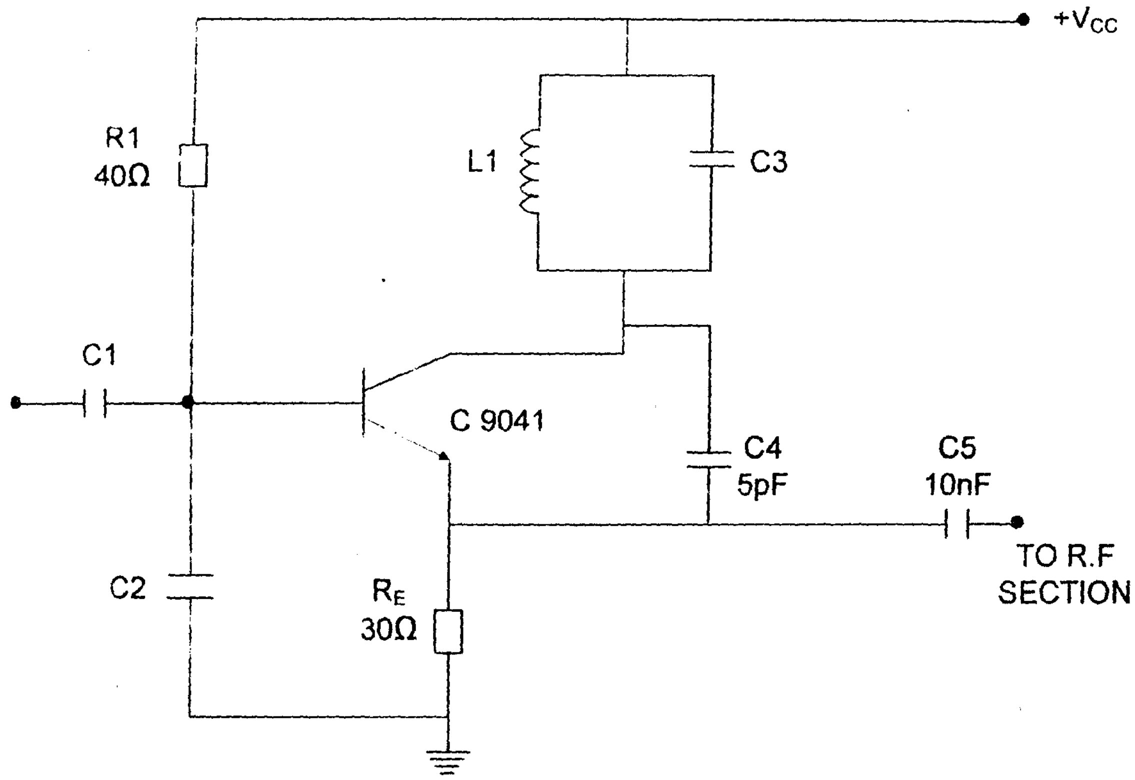

Fig 3.3 modulator/oscillator circuit

In the above circuit, the frequency of oscillation is determined by the inter electrode capacitance of the common base junction and by L_1 and C_3 which formed the tank circuit.

The tank circuit generates a carrier frequency centered around

$$F = \frac{1}{\left(2\pi\sqrt{L_1C_3}\right)}\text{Hz}$$

For an unmodulated centre frequency of about 107MHz using a 10pf capacitor C_3

$$L_1 = \frac{}{4\bar{u}^2 FC_3}$$

$$L_1 = \frac{1}{(4\times\bar{u}\times(107\times10^6)^2\times10\times10\hat{}-12)}$$

$$L = 0.22\mu H$$

Using the formula $N = \frac{\sqrt{L(18d+40b)}}{d}$ [9]

Where L = Inductance in uH

d = diameter in inches

b = coil length in indices

N = number of turn

$$N = \frac{\sqrt{0.22(18\times0.3+40\times0.4)}}{0.3}$$

$$N = \frac{\sqrt{0.22(5.4+16)}}{0.3}$$

$$\frac{\sqrt{14.71}}{0.3} = \frac{2.17}{0.3} = 7turns$$

7 turns of 22 gauge enamelled copper wire is fabricated around an air core, to give required inductance.

Transistor TR_1 operate in the common base mode as oscillator, with C_4 producing positive feedback, there by enhancing a continuous oscillation. Resistor R_1 provides a base bias current for TR_1.The oscillatory current developed a voltage across the R_E which is pass to the R.F section for amplification. capacitor C_5 serves as DC-blocking capacitors, C_2 provides AC short circuit for TR_1.

V_{cc} = supply voltage = 6v

Ic = collector current = 100mA

V_B = Base voltage

β = Gain (600)

$$R_B = R_1 = \frac{V_{cc} - V_{BE}}{I_B}$$

$$I_C / I_B = \beta$$

$$I_B = \frac{100mA}{600} = 0.17mA$$

$$R_1 = \frac{6 - 0.7}{0.17mA} = 32k\Omega$$

$$\therefore R_1 = 40k\Omega$$

For R_E:

$V_{cc} = V_{CE} + I_E R_E$

$I_C = I_E + I_B$

$(100 - 0.17) = I_E$

I_E = 99.93mA

$V_{CE} = \frac{V_{cc}}{2}$ for maximum swing

$V_{CE} = 6/2 = 3V$

$$\therefore RE = \frac{V_{cc} - V_{CE}}{I_E}$$

$$RE = \frac{6-3}{99.83mA} = 30\Omega$$

3.4 R.F Section

The radio frequency (RF) power amplifier stage is designed with the objective of obtaining maximum power, while limiting distortion to a minimum level. The number of the amplifier built will determine the power generated and hence the power that will be transmitted to the antennae, which in turns determine the distance of coverage.

For this design four low power turned amplifier stages were cascaded and a single high power R.F output amplifier stage connected to antenna.

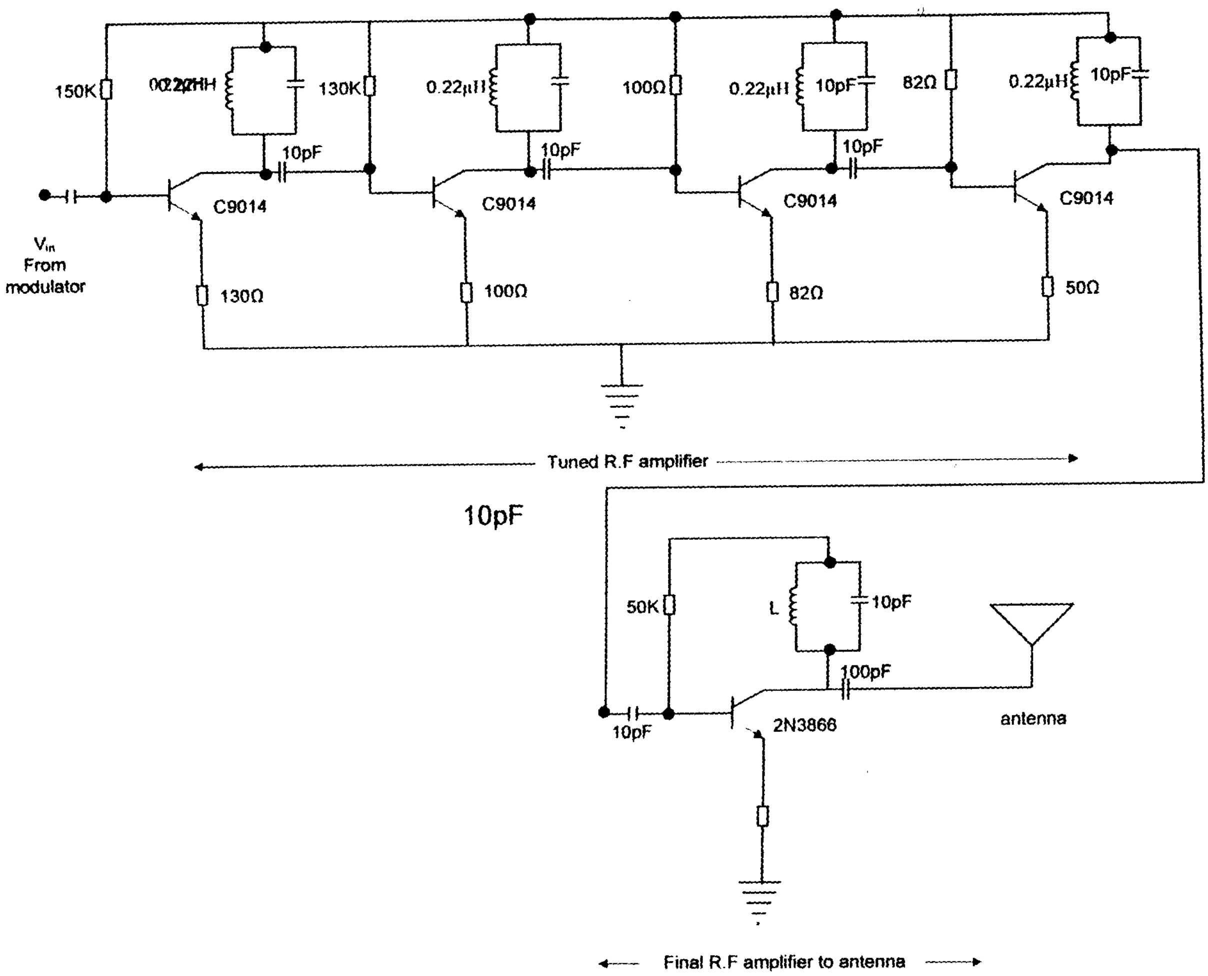

Fig 3.4 ciurcuit diagram of the RF stage

For the low power R.F. tunned amplifier a frequency modulator centred around 107MHz is chosen for maximum signal transfer between modulator output stages.

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

$$\left(107 \times 10^{6}\right)^{2} = \frac{1}{2\pi\sqrt{LC}}$$

$$L = \frac{1}{4\pi^2 \times (107^2 \times 10\text{^}{-12}) \times 10^{-12}}$$

$$L = 0.22\,uH$$

From $N = \frac{\sqrt{L(18d + 40b)}}{d}$

Where L = inductance in µH

d = diameter in inches

b = coil length in inches

N = number of turns

Hence a 7 turn enameled copper wire is fabricated around an air core, to give the required inductance.

Connected to the low tunned amplifier is the final R.F output stage built around a 2N3866 high frequency RF power transistor which is connected through a loop capacitor to the antenna.

For an output of about 1 watt into a 50Ω load (antenna)

P = I^2R

$I = I^2(50)$

$$I = \sqrt{\frac{1}{50}}$$

I = 0.141 Amps

The resistor value

$$R_B = \frac{V_B - V_{be}}{I_B}$$

$$R_B = \frac{6 - 0.7}{0.17mA} = 32K\Omega$$

A 56KΩ resistor was used to minimize excessive heat dissipation.

3.5 Antenna

The antenna helps in radiating the signal generated. When the signal reaches the antenna, they oscillate along the length of the antenna and back; each oscillation pushes electromagnetic energy from the antenna, emitting the energy through free spaces as radio wave.

Knowing the transmission frequency, the length of the antenna can be calculated using.

$$\lambda = \frac{v}{f}$$

V = $3x10^8$m/s and f = 99.9MHz

$$\lambda = \frac{3x10^8}{99.9x10^6} = 3m$$

For better radiation, the length of antenna must be a quater wave length.

Length = $\frac{\lambda}{4} = \frac{3}{4} = 0.75m$

Length = 75cm.

Hence. a length of 75cm is needed for the antenna.

3.6 power Supply

The power supply unit comprise of a constant current and voltage lead acid battery of 6v, being charge by a charging circuit driven by an AC converted DC supply. A step down 12 volt 0.5A transformer whose output was fed to a full wave bridge rectifier diode was used to achieve these . The Connection is as shown below.

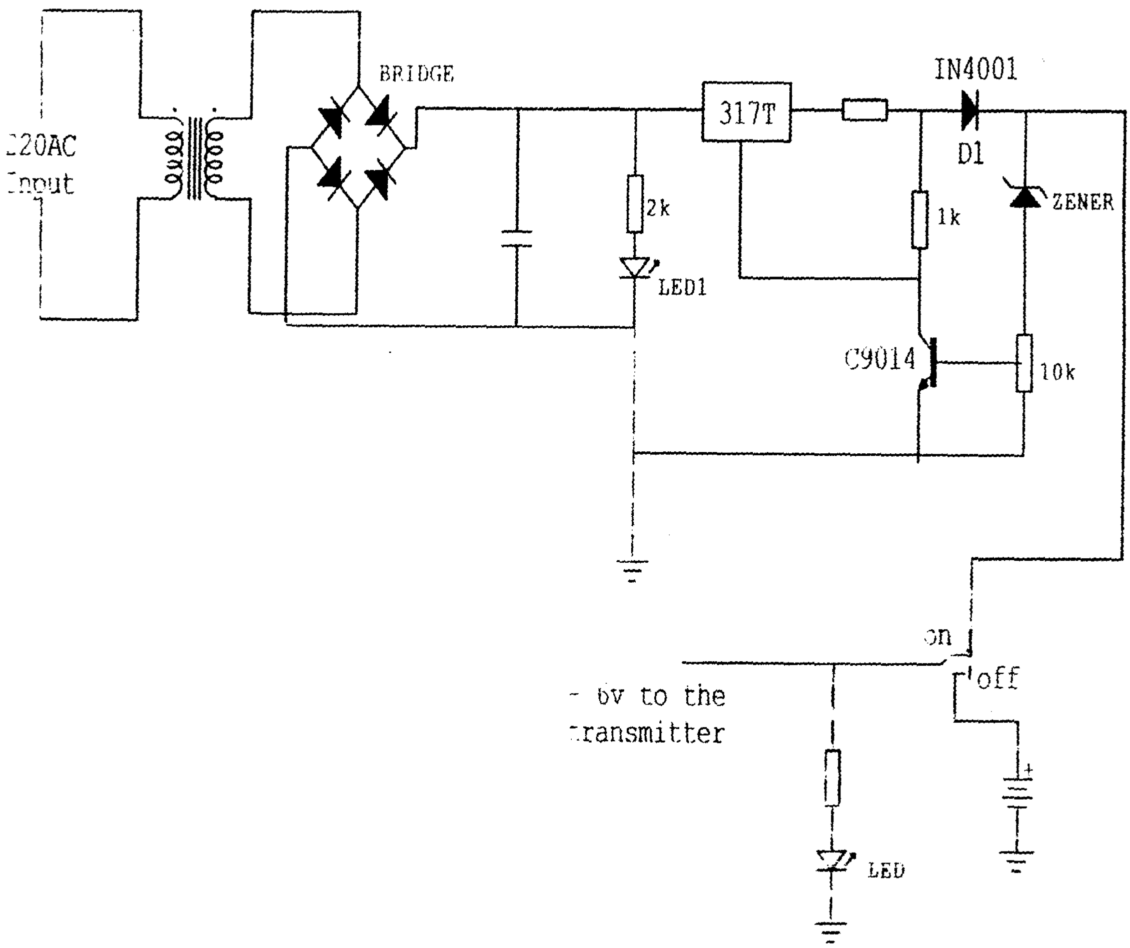

Fig 3.6 circuit diagram of power supply

Peak $V_{output} = V_r\sqrt{2} = 12\sqrt{2} = 16.97volt$

This peak voltage is passed through a 4900 μf capacitor for filtering.

Assuming a ripple voltage of 15% = 1.8v

$Q = CV^2$

$CV = It$

$C = \frac{It}{V}$

$2t = \frac{1}{50}$

$t = \frac{0.02}{2} = 0.01$

$\therefore C = \frac{0.5x0.01}{1.8} = 2800\mu f$

The capacitance value for 15% is 2800 μf but for effective ripple free d.c output a 4900 μf capacitance was used. A light emitting diode was placed to indicate AC supply with a resistor placed across to limit the current flow through the LED.

$R_S = \frac{17-3}{10mA} = 1.4K\Omega$

Any value below this should not be use, hence the LED will get burnt.

The battery charging circuit is implemented using a current/voltage 3 terminal LM317T regulator. This LM317T regulator is used to charge the lead-acid battery when the circuit is powered. the LM317T supply a charging current to the battery and as charges progresses, the battery terminal voltage rises. The battery voltage is determined by the zener diode voltage (5.6v) and the transistor $V_{be} = 0.7$

$$V_{total} = 5.6 + 0.7 = 6.1 \text{ volt}$$

After which when the 0.7 volt is reached. the transistor turns on which in return force the adjacent pin of the regulator to ground and a constant charging mode is attained. The diode ~~D5~~ prevents back discharge of the battery when the D.C charging voltage is removed.

CHAPTER FOUR

DISCUSSION OF RESULTS

4.1 Discussion

This section will discuss the test carried out on the circuit, the findings, and the problem encountered and troubleshooting.

The design chosen was portable, low powered and the circuit was constructed on a veroboard, though some few problems were encountered in the cause of construction which will be discussed later in this chapter; among these odds, the design was successful, these was due to the following conditions that was strictly adhere to.

✓ It was ensured that the leads were kept short; else, at high frequency it will act as an inductor which in turn will affect our frequency.

✓ The use of jumper was avoided.

✓ It was ensured that the circuit was compacted as much as possible, for effective power transfer; else at high frequency, distortion may result.

Adherence to this points, give an expecting outcome. As progress was being made on the design series of test was being carried out among which include the use of DIGITAL MULTIMETER, to measure resistance values, test for continuity and to measure the voltage and current.

At the developmental stages of the design, a digital and analogue receiver were used to demodulate the transmitted signal but the signal was not strong enough. In this effect another R.F circuit was introduce, to increase the R.F section from four (4) to five (5) which will simply help in better amplifying the signal. Demodulation was carried out and the signals were received on a band width of 95.1MHz to 102.3MHz but with a stable and clearer signal at 99.9MHz up to a distance of 400 meters in all radius.

The project is termed successful, though the distance in accordance to the aim is 500 meters but from my finding distance of transmission is a function of the height of the antenna. Hence, placing the antenna at an height above human head, gives better radiation (note body moisture and water content in human body bounces the electromagnetic waves hence it affects the distance of coverage)[10].

In conclusion, to add to the beauty of the design, an audio mixer was introduce, also the choice of power supply is effective as compare to previous work.

4.2 Problem encountered

1. Spill over of frequency was notice during the test at the developmental stage which account for the use of 4 R.F section for better amplification and also using the same centre frequency for proper matching and transfer of power.

2. Burning of resistor both at LED end and across the 2N3866 high frequency transistor. The cause of this was due to high current passage and heating.Though the problem was solved by the use of high value resistor as seen in the design.

4.2 Limitation

1. If the transmitter is to be used in areas with occupied frequencies, capture effect may set in as, signal with the highest signal will be receive[2].

This can be solve by introducing a variable capacitor at the R.F section, simply for turning the centre frequency.

2. At room temperature, the design can be used for not more than six (6) hour continuously due to the choice of power.

4.4 Trouble Shooting

This section talks about some likely fault that may affect the design and some of the major causes.

PROBLEM	CAUSES
1. Battery not charging	1. No A.C power supply from mains or the plug not position well. 2. The transformer may be burnt 3. The diodes

2. The white LED fails to come up	1. No charging and absence of charging may be due to the cause of problem 1 above 2. The resistor to the LED might have got burnt 3. The LED might be bad
3. Poor signal	1. Receiving frequency 2. The location of signal reception (tree can cause interference) 4. The audio mixer auxiliary section
3. No signal	1. The receiver and the frequency of reception 2. No modulating signal 3. The audio mixer section 4. The transistor in the R.F section might have gotten burnt 5. The 5PF capacitor in the oscillation may be bad, hence no feed back.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

A frequency modulated (FM) transmitter is essentially a design and implementation project. To approach a project like this. a parallel path has to be taken in regards to the theory and the practical circuit. For a successful conclusion in any project these paths must meet and this only happens when they are fully understood. This is why a good grounding in the basics of communication theory and analogue design must be achieved before ever approaching a project like this.

In this design, some factors such as economic application, design economy, availability of components and research materials, efficiency, compatibility, portability and durability are put into consideration. The construction was done in such a way that it makes maintenance and repairs an easy task for the user in case of any system breakdown.

5.2 Achievement

The construction of the FM transmitter is at low cost, the system was also design to have a good quality, low noise output by taking into consideration the gain and the feed back of the amplifiers. The overall design and construction is also user-friendly.

5.3 Recommendation

The design used for this project is essentially quite a simple one, after learning a lot from this project, there would have been a few things that could have been done to the final design to improve it's performance.

Follow the oscillation with a buffer amplifier to reduce the effect of load change.

If the transmitter is to be used in areas with occupied frequencies a variable capacitor may be introduced in the R.F stage, this will enable tuning of the transmitter so as to prevent interference.

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