DESIGN AND CONSTRUCTION OF FREQUENCY MODULATED (FM) RECEIVER

BY

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98-7887 EE

DEPT. OF ELECTRICAL AND COMPUTER ENGINEERING. F.U.T MINNA

NIGER STATE, NIGERIA.

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR ENGINEERING (B. ENG) COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY. FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE, NIGERIA.

DECLARATION

I hereby declare that this project, presented in partial fulfillment of the requirements for the award of Bachelor of Engineering (B. Eng.) degree in Electrical and Computer Engineering, has not been presented before, either wholly or partially, for any other degree elsewhere.

OLALEKE ISAAC BABATUNDE ....

Student Signature and Date

CERTIFICATION

This is to certify that this project titled DESIGN AND CONSTRUCTION OF FREQUENCY-MODULATED (FM) RECEIVER was carried out by OLALEKE ISAAC BABATUNDE under the supervision of ENGR. M. D. ABDULLAHI and submitted to the Electrical and Computer Engineering Department, Federal University of Technology, Minna, in partial fulfillment of the requirement of the Award of Bachelor of Engineering degree.

ENGR. M. D ABDULAHI Project supervisor	28/10/2003 Signature and Date
ENGR.M.N.NWOHU Head of Department	28/10/09 Signature and Date
.... External Examiner	.... Signature and Date

DEDICATION

To Iyabo, for her joy that reminds me to have a smile on my face,

To my mother, for his energy and inquisitiveness that reminds me to be creative;

To Tunji and Yemi, for their patience that reminds me to take small steps;

To Kike, for her love of music that reminds me to live a life of praise;

To Mosun for her commitment to God that reminds me to be a man of right priorities; and to my friend, Funmi, for her love and total devotion as a true friend.

ACKNOWLEDGEMENT

First and foremost I would like to express my gratitude and thanks to Almighty God for the help and kindness bestowed on me throughout the course of this project work.

I wish to express my profound gratitude to my supervisor, Engr. M. D. ABDULLAHI for his guidance, encouragement and support throughout this work. His advice at various stage of the work has been very helpful and I have immensely gained from his wealth experience. I would also like to express my appreciation to all the lecturers and technical staff in my Department for their assistance and suggestions.

I am greatly indebted to my parents Chief C. Adebayo Olaleke and my mother Mrs Ayoade Olaleke for all their moral and financial support and encouragement.

I will also like to acknowledge my appreciation to my Uncle Mr. Anthony Olaleke as well as to my dearest friends Miss Funmi Adeboye, Mr. Johnson Opadere, Mr. Kunle Oyinloye, Mr. Oteksmann, Mr. Yinus Olawale Popoola, Engr. Biodun Alabi and Engr. Muideen Bello.

ABSTRACT

This project is on the design and construction of FM receiver with frequency range of 87.5MHz to 108. 0 MHz.

The main function of FM radio receiver is to select the required radio station (carrier) out of the numerous modulated carriers reaching the receiving antenna and to convert the selected modulated Radio Frequency (RF) signal into Audio Frequency (AF) signal.

A radio receiver circuitry is made up of different types of filters and amplifiers performing specific function as well as a detector circuit that does the conversion from RF to AF signal.

Preliminary processing in the receiver also includes raising the voltage level of the received weak signal. The recovery of the original message involves demodulation, which is an opposite operation to that at the transmitter.

TABLE OF CONTENTS

CHAPTER THREE

CONSTRUCTION, TESTING AND RESULTS.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

CHAPTER ONE

1.1 INTRODUCTION

This project is on design and construction of FM receiver with frequency range of 87.5 MH3 to 108.0 MH3.

A FM receiver selects and recovers the original message from the various Radio Frequency (RF) signals that arrive at the receiving antenna. Preliminary processing in the receiver also includes raising the voltage level of the received weak signal. The recovery of the original message involves demodulation, which is an opposite operation to that at the transmitter.

What motivates me to do this project is that nowadays, there are many FM radio stations compare with in olden days. Therefore, there is a need to produce more efficient radio receiver. One of the advantages of FM receiver is that it has high signal - to – noise ratio. FM receivers are fitted with amplitude limiters, which remove amplitude variations caused by noise.

The principle of operation of FM receiver is based on the conversion of all incoming radio frequency to a signal to a single INTERMEATE FREQUENCY (IF), which is kept fixed. As such, the amplifier circuits operate with maximum stability, selectivity and sensitivity. Figure 1 shows the block diagram of FM radio receiver for broadcasting.

The RF amplifier selects and amplifiers the required frequency band signal from the various signals intercepted by the antenna. The amplified RF signal is coupled to the input of a mixer stage, which beats which beats together two frequency signals. A mixer circuit is so designed that it can conveniently combine two radio frequencies – One fed into it by the RF amplifier and the other by a local oscillator. The first input to the mixer is the amplifier RF signal of frequency FRF, while the other input is from a local oscillator signal of frequency FLO.

The local oscillator is an RF oscillator whose frequency of oscillation can be controlled by varying the capacitance of its capacitor. In fact, the tuning capacitor of the oscillator is ganged with capacitor of the input circuit so that the difference in the frequency of the selected signal and oscillator frequency is always constant.

The output of the mixer is the sum and difference signals of frequencies $F_{LO} \pm F_{RF}$. The function of the IF amplifier is, thus to select the difference frequency signal.

$F_{IF} = f_{LO} - f_{RF}$

f_{IF} know as the Intermediate Frequency (IF). It is also the function of the IF amplifier to amplify the IF signal further. The IF is kept constant by gang - tuning the local oscillator and the RF amplifier. The local oscillator frequency is preferably chosen to be higher than the radio frequency for the narrower relative tuning. The function of the limiter is to remove all amplitude variations (caused by noise) from IF signal which might have crept into the FM signal. This removal of amplitude variations is necessary for distortioness demodulation. The detector carries out the conversion of the IF signal to AF signal.

This audio signal is amplified by the Audio – frequency (AF) amplifier whose output is fed to a loud – speaker which reproduces the original sound.

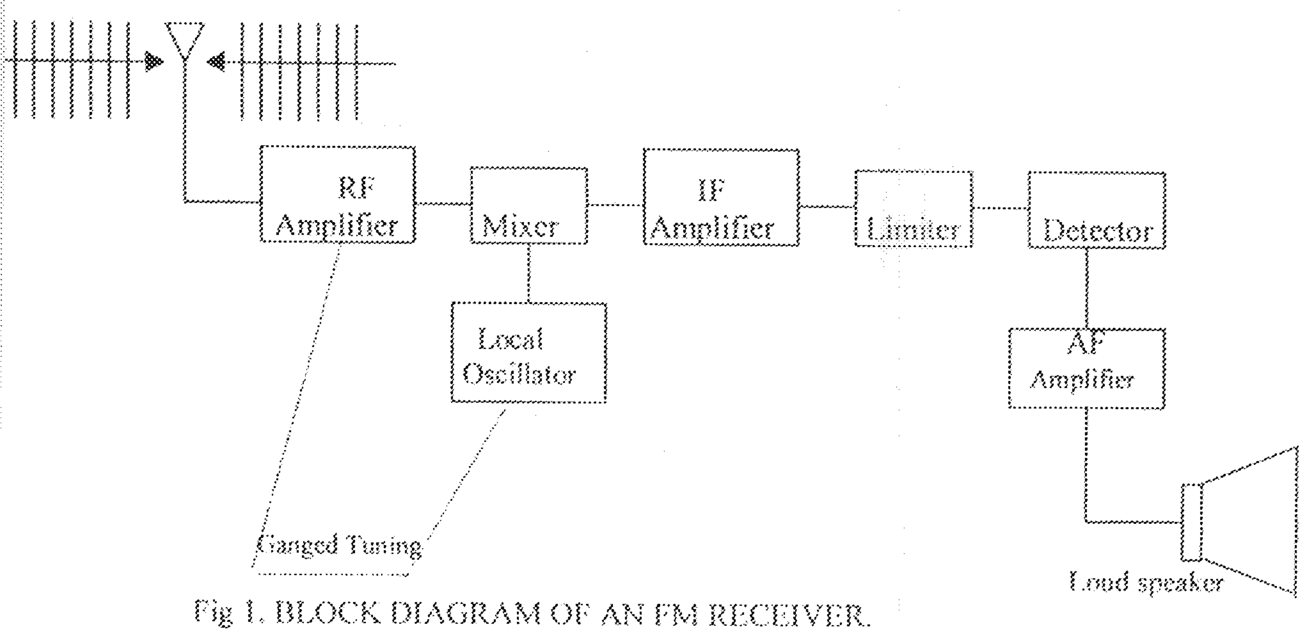


Fig 1. BLOCK DIAGRAM OF AN FM RECEIVER.

1.2 AIMS AND OBJECTIVES

The aims and objective of this project is to design and construct FM receiver with a frequency range of 87.5 MH$_z$ to108.0 MH$_z$, which is able to select the required radio station (frequency band) out of the numerous modulated carriers reaching antenna, and to convert the selected modulated RF signal into AF signal.

A good receiver should be able to select "well" the desired signal and reject "well" any unwanted signal. In this project, I took into consideration many parameters in order to get a quality radio receiver. These parameters include sensitivity, selectivity, output power, and frequency range of operation, quality of reproduction, reliability of operation, power consumption, durability and simplicity of control.

A receiver in a communication system extracts and processes the desired signal from the various signals received at the channel output. The processing function includes conversion of the selected signal to a form suitable for the output transducer. This includes detection or demodulation and amplication (of voltage and/or power) if the received signal is low. It may be necessary or desired to delay the received signal.

1.3 LITERATURE REVIEW

The development of civilization as we know it today is largely due to man's ability to exchange information and ideas by the natural sense of sight and hearing, and by the written word using some form of accepted language or code. From the very beginning, man has constantly searched for means of passing information beyond the normal range of human vision and hearing.Most people are familiar with such methods as Indian smoke signals, beacon fires, sewmophore flag signaling.

In electrical engineering terms, communication refers to sending, processing and reception of information using electrical means. The information or message to be sent processed and received (i.e tobe communicated) may take different forms. It may be voice, picture written message, electrical signal etc.

A communication system is, therefore a technique or equipment that is used to send, process and receive messages. This may take the form of telephone network, radio links, satellite and optical fibres, amongst others,.

The existence of radio wave was predicted long before it was actually discovered.
The prediction was made in 1864 by James clack Maxwell (1831-1879), the great English mathematical physicist.
In 1888, a German physicist Heinrich Heath (1857- 1894) demonstrated waves actually do exist and they travel through space.

In 1871 – 1837 on English physicist Ernest Rutherford succeeded in sending signal over range of 3/4 mile. Another English man Oliver Lodge (-1851 – 1940) developed the basic principle of tuning but the most successful of all the radio pioneers was Guglieluro Marconi (8174 – 1937) an Italian who went to England to work. Marconi was the father of radio communication. In 1896 he took out his first patent.

In 1904, the first vacuum tube was made by John Ambrose Fleming (1849 – 1945) an English electrical engineer. This tube was diode that had two electrical parts. In 1906 an American Inventor Lee De forest (1873 – 1961) added a third part to Fleming`s vacuum tube. The new vacuum tube was called a triode or audio, it was much like vacuum tube used today.

The first transmission on radio broadcast was heard on Christmas Eve 1906. The radio operator on ship at sea suddenly heard a man speaking then a woman singing on a violin playing then came the word "if you have heard this programe, write to R. A Fessenden at Braut Rock.

The above great men and their respective efforts were to come about how signal can be transmitted in a communications system using devices known as transmitter.

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

As early as 1900 Marconi released the need for more greater transmitter power for transatlantic signaling. For him Fleming designed a 50KW park transmitter that for the first time obtained its park voltage from a high voltage a.c transformer rather than an induction coil.

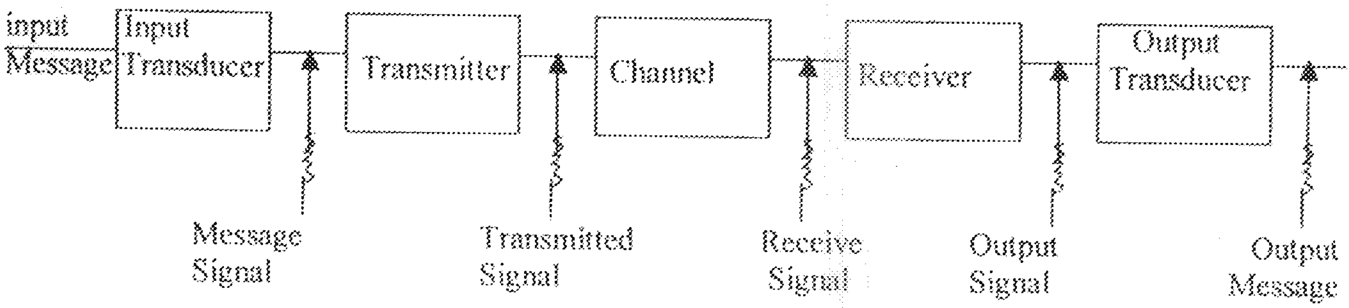
Before 1905, a few individuals suspected that single frequency sinusoidal continuous wave might have advantages in radio communication over the intermittent damped waves radiated by a spark transmitter, whose power diffused over a substantial range of frequencies.

Three lines of research were pursued in the next decade toward achieving the goal of high – power continuous wave generators; improvement of park transmitter, the development of alternator (a.c generator) to produce radio frequency power and the development of the arc oscillator as a radio frequency generator.

The first high – power, continuous – wave transmitter became available about 1913. All of these non – electric techniques of generating radio frequency wave were eventually superceded by high – power triode generators developed between 1915 and 1925.

Public radio began in November 1920 when station KDKA in Pittsburgh Pennsylvania, broadcast the returns of presidential election.

It is obvious that rather the end of communication being in sight, the war has just begun. With further developments in electronics technology, more barriers are expected to be broken or surmounted through the development of better, faster and more efficient communication systems.



BLOCK DIAGRAM OF A COMMUNICATION SYSTEM.

1.4 PROJECT OUTLINE

Chapter one provides an introduction to radio system. It contains Aims and Objectives and Literature review.

Chapter two discusses the basic requirements of telecommunication system, Need for modulation, modulation, Frequency Deviation and carrier swing, construction of FM wave, Detection and Stages involve in the circuit.

Chapter three contains the construction, testing and results.

Chapter four discusses the conclusion and recommendation.

CHAPTER TWO

SYSTEM DESIGN

2.1 BASIC REQUIREMENTS OF TELECOMMUNICATION SYSTEM

First of all the original information energy must be converted into electrical form to produce electronic information signal called BASE BAND SIGNAL. This is achieve by a suitable TRANSDUCER known as INPUT TRANSDUCER (Microphone).

The base band signal is now passed to the destination by a line link, with the energy traveling at a speed approaching that of light (3.0×10^8 m/s), and at the destination, a second transducer known as OUTPUT TRANSDUCER converts the base band signal back into the original energy form as shown in fig. 2.1. Amplifiers may be needed at appropriate point in the system to increase the strength of the base band signal to acceptable values.

For a radio system, a TRANSMITTER is required at the source to send the signal over the radio link (Wireless) and a RECEIVER is required at the destination to recover the signal before applying it to the output transducer (loud speaker) as shown in fig. 2.1

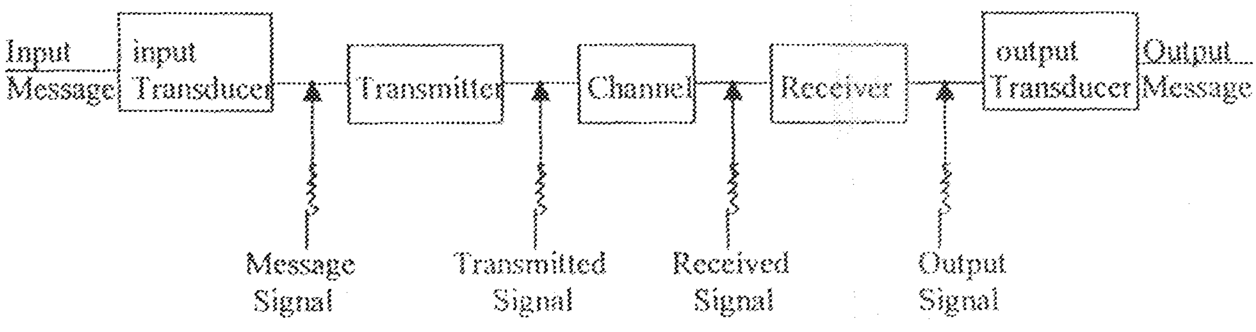


Fig. 2.1 SIMPLE BLOCK DIAGRAM OF A COMMUNICATION SYSTEM.

For successful transmission and reception of intelligence (Code, Voice, Music, e. t. c.) by the use of radio wave, two processes are essential:

(i) Modulation (ii) Demodulation.

Speech and music e.t.c. are sent thousands of kilometers away by a radio transmitter. The scene in front of a Television cameral is also sent many kilometers away to viewers. Similarly a moon probe or Venus probe checking its environments, sends the information it gathers millions of kilometers through space to receivers on earth. In all these cases, the carrier is the high frequency radio wave. The intelligence i.e sight, sound or other data collected by the probe is impressed on the radio wave and is carried along with it to the destination.

MODULATION is the process of combining the low – frequency signal with a very high - frequency radio wave called carrier wave, the resultant wave is called MODULATED CARRIER WAVE. This job is done at the transmitting station.

DEMODULATION is the process of separating or recovering the signal from the modulated carrier wave. It is just the opposite of modulation and is performed at the receiving end.

2.2 WHAT IS CARRIER WAVE?

It is a high – frequency Undamped radio wave produced by radio – frequency oscillators. As seen from fig.2.2, the output of these oscillators is first amplified and then passed on to an antenna. This antenna radiates out these highs – frequency (electromagnetic) waves into space. These waves have constant amplitude and travel with the velocity of light. They are inaudible i.e by themselves they cannot produce any sound in the loudspeaker of a receiver. As their name shows, their job is to carry the signal (audio or video) from transmitting station to the receiving station. The resultant wave is called MUDULATED carrier wave.

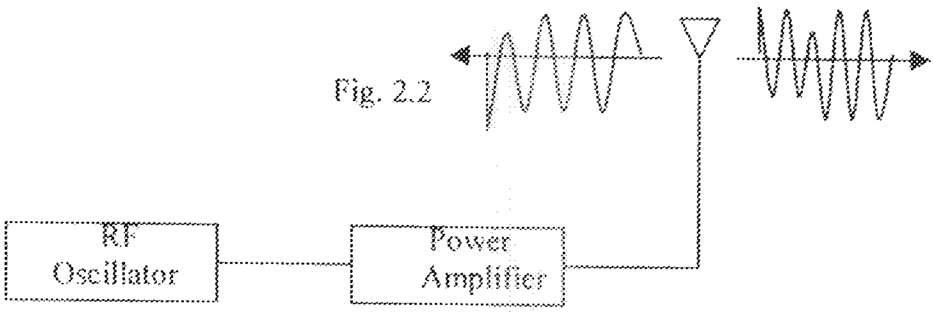


Fig. 2.2

2.3 RADIO FREQUENCY SPECTRUM

Radio frequencies used by different communication system extend from very low Frequencies to extra high frequencies as tabulated below along with t heir acronym abbreviations.

Frequency Band	Classification	Applications
3 – 30 KHZ	Very low frequency (VLF)	Long - range navigation, sonar
30 – 300 KHZ	Low frequency (LF) or Long wave (LW)	Navigation aids, radio beacons.
300 – 3000 KHZ	Medium Frequency (MF) or Medium Wave (MW)	Maritime radio, direction finding, commercial AM sound broadcasting, coast-guard communication.
3 – 30 MH3	High frequency (HF) or short wave (SW)	Telephone, facsimile, AM-SW radio broadcasting, search and rescue, aircraft communications with worships, ship-to-coast communications.
30 –300 MH3	Very high frequency (VHF)	VHF Television broadcast, FM radio, Air traffic control, Private aircraft, Taxicab, police, Navigational aids.
300 – 3000 MHz	Ultra High Frequency (UHF)	UHF television broadcast, Radar, Satellite communications, altimeters, Navigational aids.
3 – 30 GHZ	Super High Frequency (SHF)	Microwave link, Land mobile communication, Radar.
30 – 300 GHZ	Extra High Frequency (EHF)	Railroad service, Radar landing system, e.t.c.

A radio wave can be represented in terms of frequency (f) and /or Wavelength (λ). If the radio wave transmits at a velocity of V m/sec. through the channel, then the relationship between V, F and λ is $V = f\lambda$

For example, a 1 MHz (i.e 10^6 H3) signal transmitting with the velocity of light ($V = C = 3 \times 10^8$ m/s) has a wavelength of

$$\lambda = \frac{C}{f} = \frac{3 \times 10^8}{10^6} = 300m$$

The wavelength and the frequency are inversely proportional to each other. Thus, halving the wavelength doubles the frequency, and vice – versa.

A radio wave is allocated according to one of the frequency ranges shown in Table.

2.4 NEED FOR MODULATION

Sometimes, beginners question the necessity of modulation i.e. using a carrier wave to Carry the low – frequency signal from one place to another. Why not transmit the signals directly and save a lot of lootheration? Unfortunately, there are three main hurdles in the process of such direct transmission of audio-frequency signal:

(1) They have relatively short range.

(2) If every body started transmitting these low frequency signal directly, mutual interference will render all of them ineffective.

(3) Size of antennas required for their efficient radiation would be large i.e. about 75km as explain below.

For efficient radiation of signal, the minimum length of an antenna is one-quarter wavelength (λ/4). The antenna length L is connected with the frequency of the signal wave by the relation

$L = 75 \times 10^6/f$ metre. For transmitting an audio signal of $f = 1000$ H3,

$L = 75 \times 10^6/10^3 = 75,000m = 75km.$

In view of this immense size of antenna length, it is impractical to radiate audio – frequency signals directly into space.

Hence, the solution lies in modulation, which enables a low frequency signal to travel very large distances through space with the help of a high frequency carrier wave. These carrier waves need reasonably sized antenna and produce no interference with other transmitters operating in the same area.

In addition, modulation process is employed in communications systems for the following reasons.

(i) For multiplexing: so that several messages can be transmitted through a single channel.

(ii) To overcome Equipment limitations e.g size and weight.

(iii) To produce noise and interference, particularly at low frequencies.

(iv) For channel Assignment: each message signal is transmitted at a unique frequency band to avoid mix up with each other signals. This is why for example, one radio station only is received within its coverage area without interference from another station.

2.5 MODULATION

It is the process of combining an audio – frequency (AF) signal with a radio frequency (RF) carrier wave. The AF signal is also called a modulating wave and the resultant wave produced is called modulated wave.

During modulation, some characteristic of the carrier wave is varied in time with the modulating signal and is accomplished by combining the two.

METHIODS OF MODULATION

The mathematical expression for a sinusoidal carrier wave is

$$\ell = E_c \sin (w_c t + \emptyset) = E_c \sin (2\pi f_c t + \emptyset)$$

Obviously, the waveform can be varied by any of its following three or parameters:

1. E_c – the amplitude 2. F_c – the frequency, 3. Ø the phase.

Accordingly, there are three types of sine-wave modulations known as:

1. Amplitude Modulation (AM)

   There, the information or AF signal changes the amplitude of the carrier wave without changing its frequency or phase.

2. Frequency Modulation (FM)

   In these case, the information signal changes the Frequency of the carrier wave without changing its amplitude or phase.

3. Phase Modulation (FM)

   there, the information signal changes the phase of the carrier wave without changing its other two parameter.

2.6 FREQUENCY MODULATION

As the name shows, in this modulation, it is only the frequency of the carrier that is changed and not its amplitude.

The amount of changes in frequency is determined by the amplitude of the modulating signal whereas rate of change is determined by the frequency of the modulating signal. In an FM carrier, information (or intelligence) is carried as variations in its frequency. Frequency of the modulated carrier increases as the signal amplitude increases but decreases as the signal amplitude decreases. It is at its highest frequency when the signal amplitude is at its maximum positive value, and is at its lowest frequency when signal amplitude has maximum negative value. When signal amplitude is zero, the carrier frequency is at its normal frequency f_o.

Two important points about the nature of frequency modulation are:

(i) The amount of frequency deviation (or shift or variation) depends on the amplitude (Loudness) of the audio signal. Louder the sound, greater the frequency deviation and vice – versa. However, for the purposes of FM broadcasts, it has been internationally agreed to restrict maximum deviation to 75KH₃ on each side of the centre frequency for sounds of maximum loudness. Sounds of lesser loudness are permitted proportionately less frequency deviation.

(ii) The rate of frequency deviation depends on the signal frequency.

2.7 FREQUENCY DEVIATION AND CARRIER SWING

The frequency of an FM transmitter without signal input is called the resting frequency or centre frequency (f_o) and is the allotted frequency transmitter. In simple words, it is the carrier frequency on which a station is allowed to broadcast. When the signal is applied, the carrier frequency deviates up and down from its resting value f_o.

The change or shift either above or below the resting frequency is called frequency Deviation (Δf)

The total variation in frequency from the lowest to the highest is called carrier swing (CS).

Obviously, Carrier Swing = 2 x frequency deviation of $CS = 2 \times \Delta f$

A minimum frequency deviation of $75KH_z$ is allowed for commercial FM broadcast stations in the 88 to 168MH_z VHF band. Hence, FM channel width is 2 x 75 = 150KH₃. Allowing a 25 – KH_z guard band on either side, the channel width become = 2(75 + 25) = 200. However, a maximum frequency deviation of $25KH_Z$ is allowed in the sound portion of the TV broadcast.

In FM, the highest audio frequency transmitted is $15KH_3$.

2.8 MODULATION INDEX

It is given by the ratio $m_f = \frac{\text{Frequency Deviation}}{\text{Modulating Frequency}} = \frac{\Delta f}{f_m}$

Unlike amplitude modulation, this modulation index can be greater than unity. By knowing the value of m_f, we can calculate the number of significant sidebands and the bandwidth of the FM signal.

2.9 DEVIATION RADIO

It is the worst-case modulation index in which maximum permitted frequency deviation and maximum permitted audio frequency are used.

Therefore deviation ratio $= \frac{(\Delta f)_{max}}{f_{m\,(max)}}$

Now, for FM broadcast stations, $(\Delta f)_{max} = 75KH_Z$ and maximum permitted frequency of modulating audio signal is $15KH_3$.

Therefore deviation ratio $= \frac{75KH_Z}{15KH_Z} = 5$

2.10 PERCENT MODULATION

In FM, it is given by the ratio of actual frequency deviation to the maximum allowed frequency deviation

$$m = \frac{(\Delta f)actual}{\Delta f)_{max}}$$

Obviously, 100% modulation corresponds to the case when actual deviation equals the maximum allowable frequency deviation. If, in some case, actual deviation is $50KH_3$, then

$$M = \frac{50}{75} = \frac{2}{3} = 0.667 = 66.7\%$$

Value of m = 0 correspond to zero deviation i.e unmodulated carrier wave. It is seen from the above equation that mv (Δf) actual. It means that when frequency deviation (i.e signal loudness) is doubled, modulation is doubled.

2.11 CONSTRUCTION OF FM WAVE

Fig. 2.3a and 2.3b show the modulating signal and the carrier signal waveform respectively, both being sinusoidal signals. in order to obtain the FM waveform, the instantaneous frequency of the carrier is increased as the instantaneous value of the modulating signal increases. FM signal frequency is maximum when the modulating signal reaches its positive peak value (point). It is minimum when the modulating signal reaches its minimum peak value (point R). The FM signal frequency remains unchanged when the instantaneous value of the modulating signal is zero. The resulting FM signal is shown in Fig. 2.3c

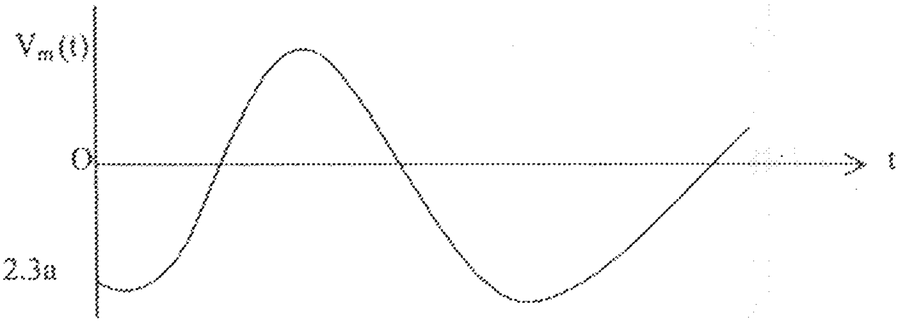


Fig. 2.3a

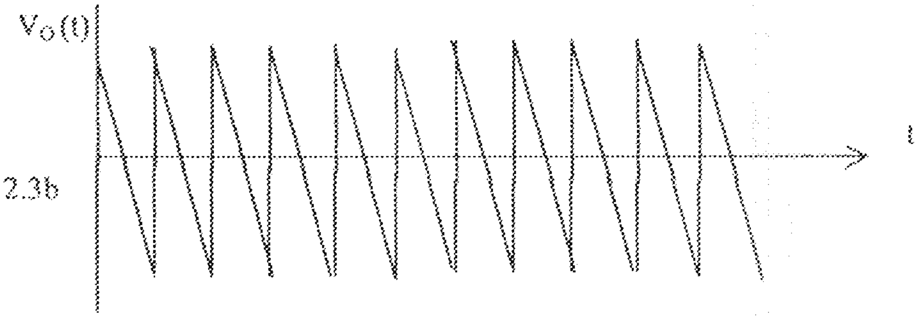


Fig. 2.3b

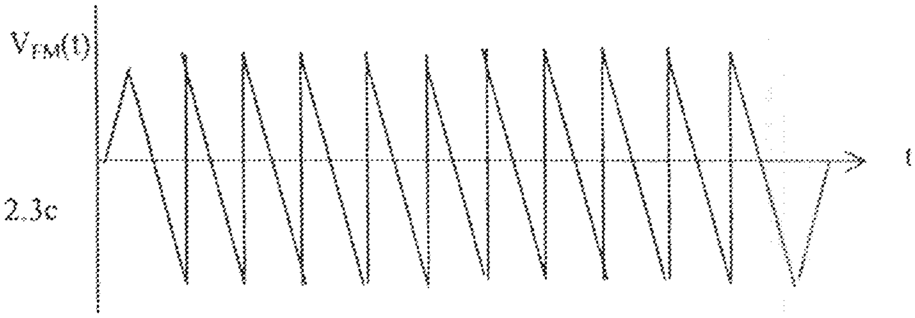


Fig. 2.3c

CONSTRUCTION OF AM WAVE.

2.12 FM SIDEBANDS

In FM, when a carrier is modulated, a number of sidebands are formed. Though theoretically their number is infinite, their strength becomes negligible after a few sidebands. They lie on both sides of the centre frequency spaced f_m apart as shown in fig. 2.4 sidebands at equal distances from f_O have equal amplitudes. It f_O is the centre frequency and f_m the frequency of the modulating signal, then FM carrier contains the following frequencies:

(i) f_O (ii) $f_O \pm f_m$ (iii) $f_O \pm 2f_m$ (iv) $f_O \pm 3f_m$ and so on.

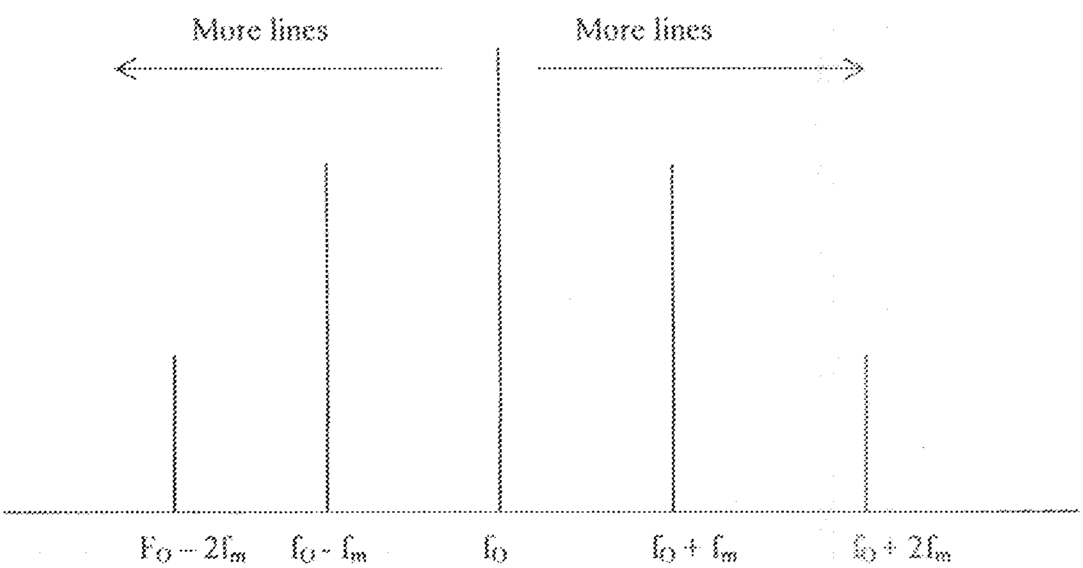


Fig. 2.4

The bandwidth occupied by the spectrum is BW =2(1+mf) fm

Now, $mf = \frac{f}{fm}$, hence $BW = 2(\Delta f + f_m)$

This expression is based on the assumption that sidebands having amplitudes less than 5% of the unmodulated carrier wave are negligible or when m_f is at least 6.

2.13 NUMBER OF SIDEBANDS

It is found that the number of sidebands

1. Depends directly on the amplitude of the modulating signal.
2. Depends inversely on the frequency of the modulating signal.

Since frequency deviation is directly related to the amplitude of the modulating signal, the above two factors can be combined in one factors called modulation index.

Hence, number of sidebands depends on $m_f = \frac{\Delta f}{f_m}$

Obviously, the number of pairs of sidebands

(i) Increases as frequency deviation (or amplitude of modulating signal) increases.

(ii) Increases as the modulating signal frequency decreases.

2.14 MATHEMATICAL EXPRESSION FOR FM WAVE

The unmodulated carrier is given by $e_c = A \sin 2\pi f_O t$

The modulating signal frequency is given by

$\ell_m = B \, Sin 2\pi \; f_m t$

The modulated carrier frequency f swings around the resting frequency f_O thus $f = f_O + \Delta f. \, Sin 2\pi \, f_m t$

Hence, equation for frequency modulated wave becomes

$\ell = A sin 2\pi ft = A Sin \, [2\pi(f_O + \Delta f. \, Sin \, 2\pi f_m t)t]$

$$\ell = A\sin(2\pi f_0 t + \Delta f + \cos 2\pi f_m t)$$

$$= A\sin(2\pi f_0 t + m_f \cos 2\pi f_m t)$$

2.15 DEMODULATION OR DETECTION

When the RF modulated waves, radiated out from the transmitter antenna, after traveling through space, strike the receiving aerials, they induce very weak RF currents and voltages in them. If these high-frequency currents are passed through headphones or loudspeakers, they produce no effect on them because all such sound-producing devices are unable to respond to such high frequencies due to large inertia of their vibrating disc e.t.c. Neither will such RF currents produce any effect on human ear because their frequencies are much beyond the audible frequencies (20 to 20,000 H_z approximately). Hence, it is necessary to demodulate them first in order that the sound-producing devices may be actuated by audio-frequency current similar to that used for modulating the carrier wave at the broadcasting station.

This process of recovering AF signal from the modulated carrier wave is known as demodulation or detection.

The demodulation of an FM wave involves three operations:

(i) Conversion of frequency changes produced by modulating signal into corresponding amplitude changes,

(ii) Rectification of the modulating signal and

(iii) Eliminating of RF component of the modulated wave.

2.16 FM DETECTION

As discussed earlier, an FM carrier signal contains information (or intelligence we wish to convey) in the form of frequency variations above and below the centre frequency of the carrier. For recovering the information, we must first convert the FM signal in such a way that it appears as a modulated RF Voltage across the diode. A simple method of converting frequency variations into voltage variations is to make use of the principle that reactance (of coil capacitor) varies with frequency. When an FM signal is applied to an inductor, the current flowing through it varies in amplitude according to the changes in frequency of the applied signal. Now, changes in frequency of the FM signal depend on the amplitude of the modulating AF signal. Hence, the current in the inductor varies as per the amplitude of the original modulating signal. In this way, frequency change in FM signal are converted into amplitude changes in current. These changes in current when passed through a resistor produce corresponding change in voltage. Hence, we find that, ultimately, frequency variations in FM signal are converted into voltage changes. Also, there exists a linear between the two-something essential for distortionless demodulation.

FM demodulation may be carried out with the help of

(i) Ratio detector and (ii) Quadrature detector.

2.17 QUADRATURE DETECTOR

This detector depends on the frequency/phase relationship of a tuned circuit. It uses only one tuned circuit and is becoming increasingly popular in the integrated FM strips.

Theory

Let us first consider the general principle. A sinusoidal current is given by the equation

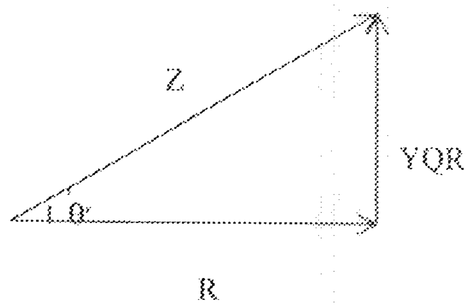
$$i = I_m \, Sin\theta = I_m \, Sin\omega t$$

Suppose, it flows through a circuit shown in Fig 2.5(a) the voltage V_L across the inductor (assumed pure) leads the current I by 90^0 $V_L = V_L \cos wt$

The voltage V_Z across the parallel tuned circuit will be in phase with I at resonance. However, at frequencies slightly different (± 1%) from the resonant frequency, the phase θ will be given by

$$\text{Tan } \theta = \frac{YQR}{R} = YQ$$

Assuming $f_0/f_1 \cong 1$



Here $y = \frac{w}{w_0} - \frac{w_0}{w} = \frac{f}{f_0} - \frac{f_0}{f} \cong \frac{2\Delta f}{f_0}$

where $\Delta f = f - f_0$

f_0 = resonant frequency

f = Slightly Off-raonance frequency

Hence, equation for V_Z is given by $V_Z = V_Z \text{ Sin } (wt - \theta)$

When the two voltages V_L and V_Z are applied as inputs to a multiplier, the output voltage V_0 is found to be proportional to their product as shown in Fig 2.5 (b)

$$V_o \propto V_L . V_Z \propto \text{Coswt. Sin}(wt - \theta)$$

$$\propto \sin (2wt + \theta) + \text{Sin } \theta$$

A low – pass filter is used to reject the double frequency component Sin (2wt + θ) and select only the low-frequency Sin θ component

∴ $V_0 \propto \text{Sin } \theta \propto \tan \theta$ - Since θ is very small

$\propto y\, \theta \propto y \propto \frac{2.\Delta f}{f_0}$ - where U_m is the modulating AF voltage.

Now, $\Delta f = f - f_0 \propto KV_m$

$\therefore \quad V_O \propto V_m$

It shows that output voltage V_O is proportional to the original modulating signal voltage.

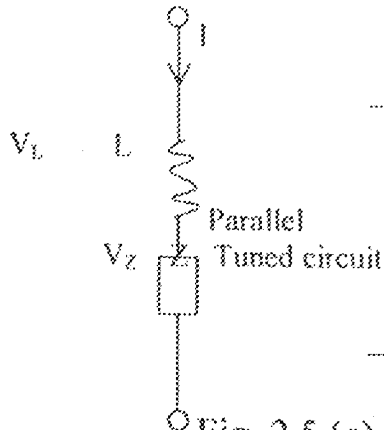


Fig. 2.5 (a)

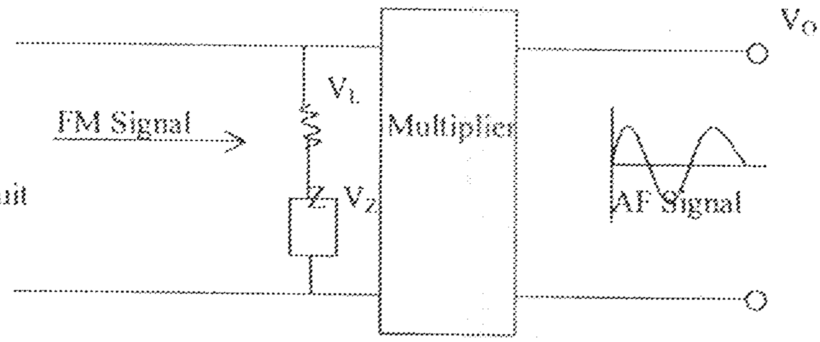


Fig 2.5 (a)

2.18 STAGES INVOLVE IN THE CIRCUIT.

2.181 POWER SUPPLY UNIT

The power supply unit consist of a transformer whose function is to convert the a.c. mains supply voltage to the lower value required by the equipment and a rectifier whose function is to convert the a.c. voltage supplied by the transformer to a d. c. voltage and a filter whose purpose is to remove ripple from the rectified voltage.

2.182 THE RECTIFIER CIRCUIT

Fig. 2.6 shows the circuit diagram of a bridge rectifier designed for this project. It has four rectifier elements operated from a single a.c. source. During one half-cycle point A become positive takes place through rectifiers D_1 and D_3. During the other half of the cycle conduction takes place through rectifier D_4 and D_2 when point C is positive with respect to point A an one half of the cycle. therefore rectifiers D_4 and D_2 are in series with the output circuit and on the other half cycle, rectifiers

D_3 and D_1 are in series with the circuit. The bridge circuit is a full wave system since current flows during both halves of cycle of the alternating current

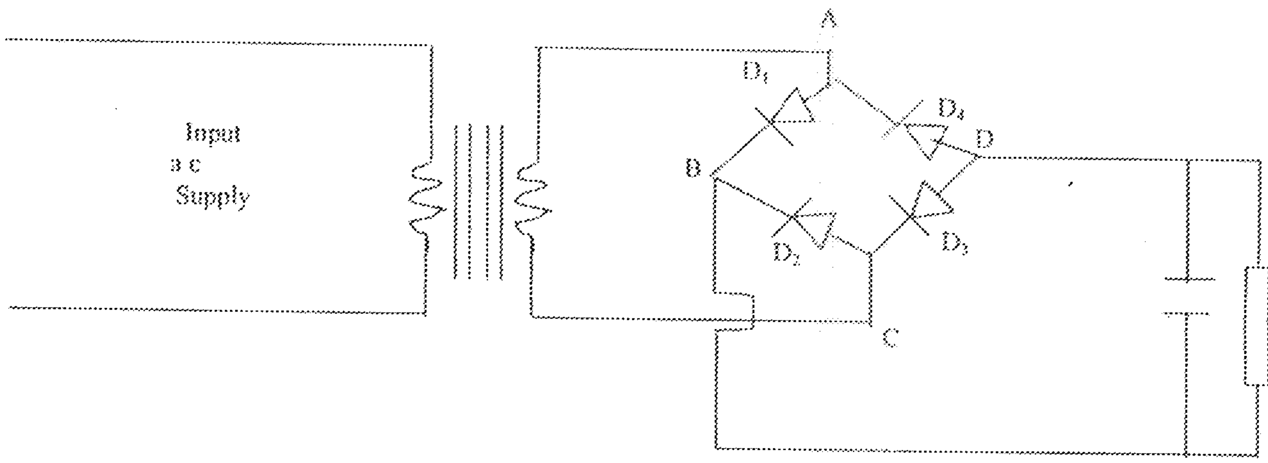


Fig. 2.6 BRIDGE RECTIFIER CIRCUIT

2.183 RECEIVING ANTENNA

An antenna or aerial is a structure that couples the input of a receiver to space. It converts electromagnetic waves into high-frequency current

2.184 TUNED CIRCUIT

The Radio frequency (RF) signals picked by the receiving antenna. Are fed to the tuned input circuit of the receive. Another signal Flo which is generated from the local oscillator is gang tuned to select the required radio station and reject the unwanted one.

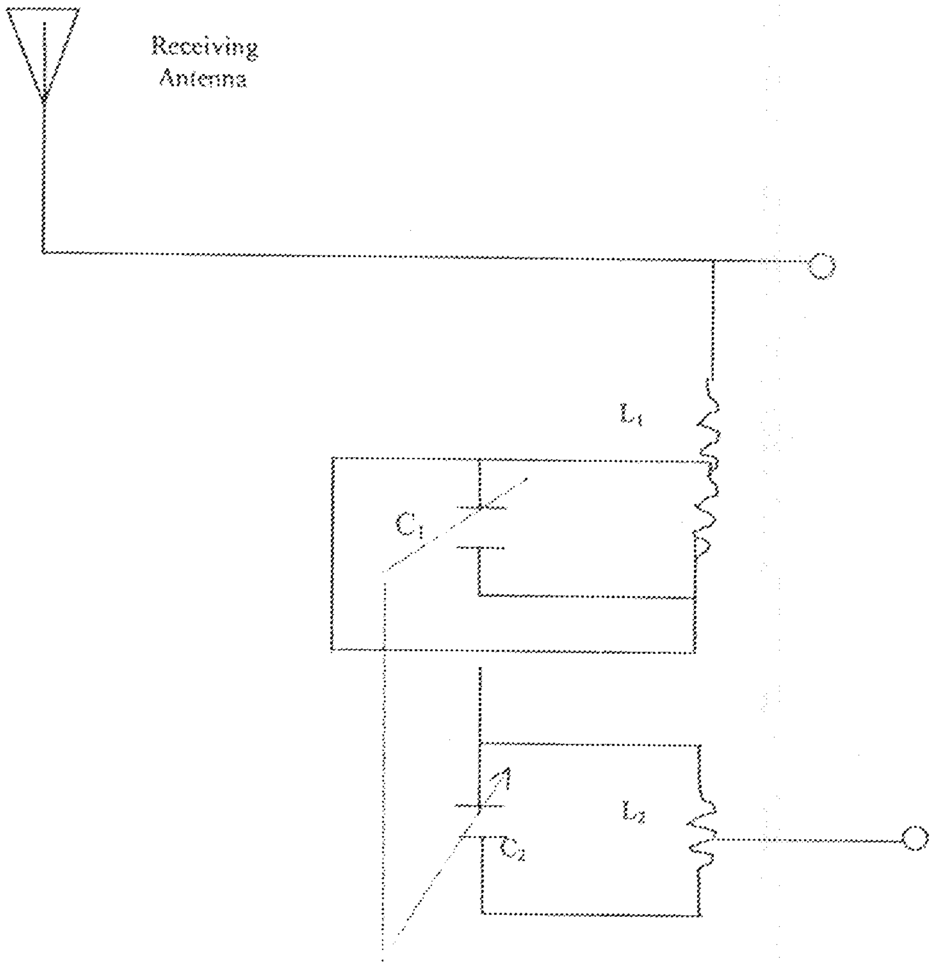
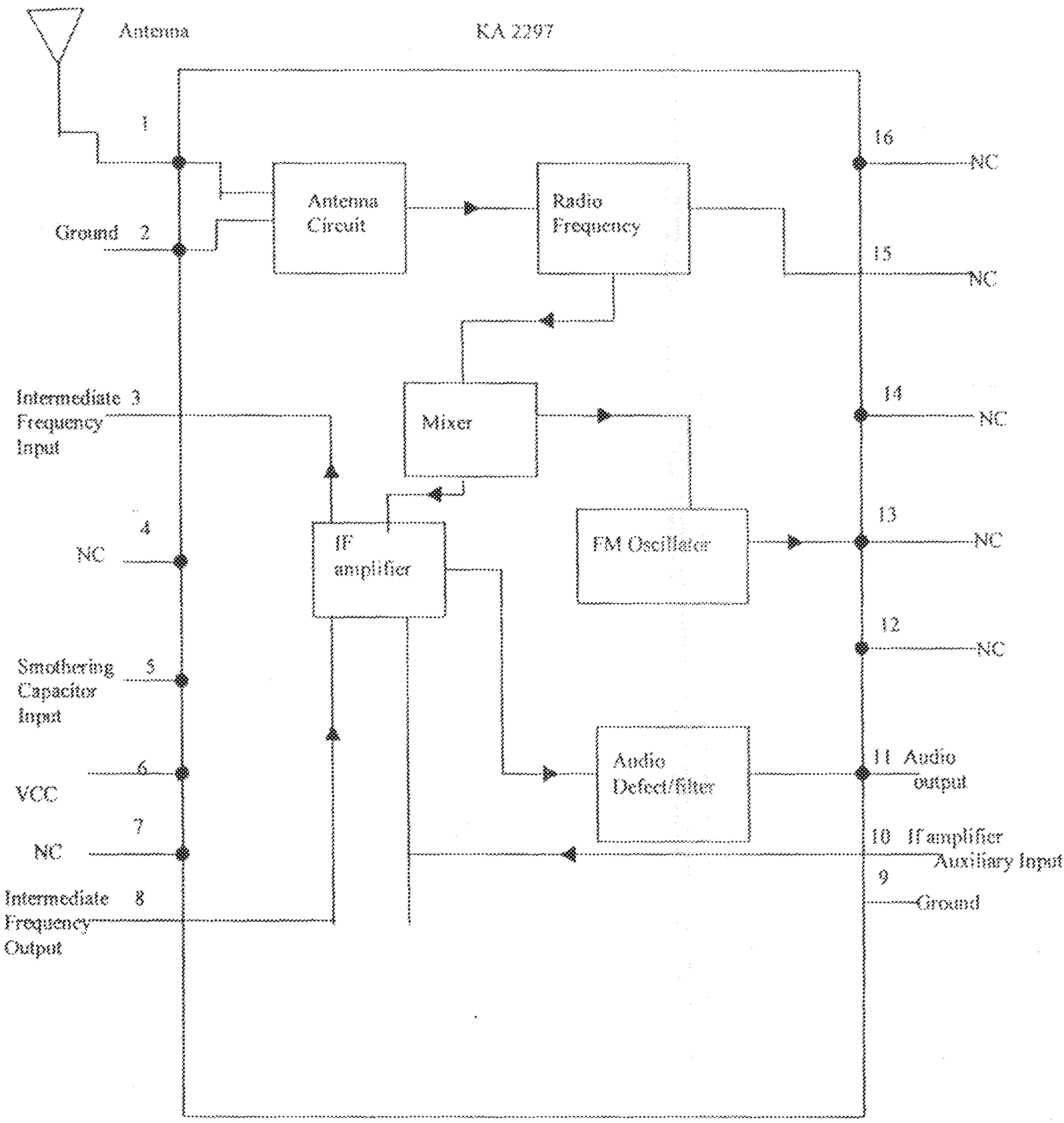


Fig. 2.7 CIRCUIT DIAGRAM OF THE TUNED CIRCUIT

2.185 THE MIXER



NC mean not connected.
Fig. 2.8 shows the Pin configuration of the mixer KA 2297

The amplified Radio frequency (RF) is coupled to the input of the mixer, as show in fig. The mixer circuit is so designed that it can conveniently combine two radio frequencies – one fed into it by the RF simplifier and the other by a local oscillator. The mixer beats together two frequencies signal .

2.186 AUDIO FREQUENCY AMPLIFIER (AF AMPLIFIER)

The audio frequency (AF) signal from the output of detector is amplified by the audio frequency (AF) amplifier whose output is fed to a loudspeaker which reproduces the original sound.

In this design TA 7368P is used as on audio amplifier. The connections are shows below.

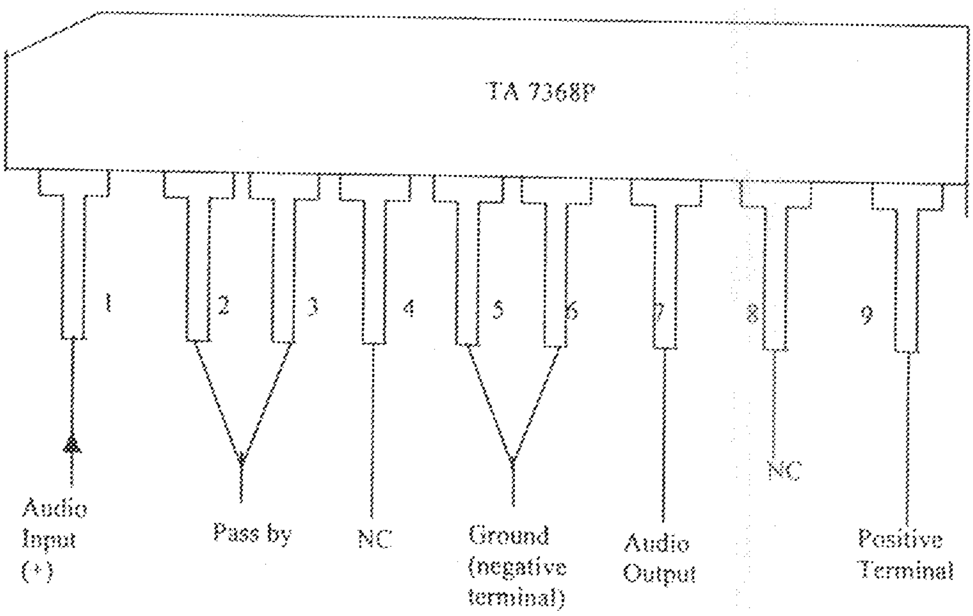
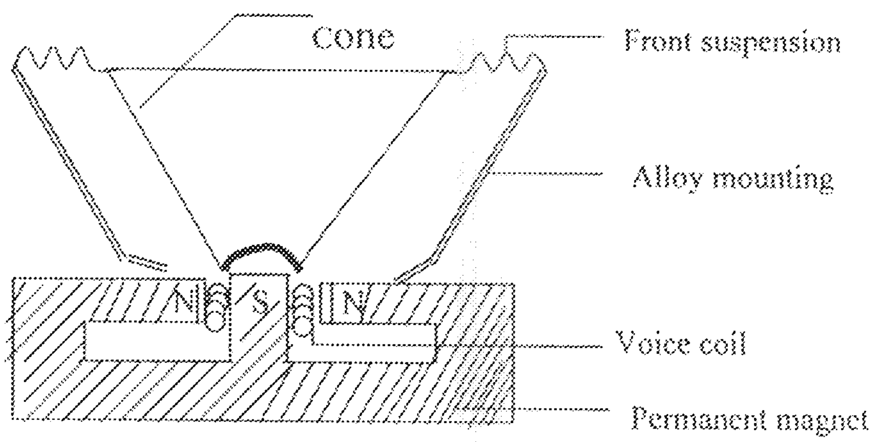


Fig 2.9

2. 187 LOUDSPEAKERS

A loudspeaker converts low-frequency alternating current energy into sound wave energy (acoustic waves). A good loudspeaker must not only be able to deliver high-power audio output but must also faithfully reproduce sounds of different frequencies. Must modern loudspeakers employ moving-coil or electromagnetic units. However, other types like ionic and piezoelectric unit's exits.

Fig 2.10



CONSTRUCTION OF MOVING-COIL LOUDSPEAKERS

Various forms and variations of moving-coil loudspeaker unit exist and they are used in more than 95% of modern loudspeakers. They are capable reproduce high sound levels with a distortion level of less than 1% above $100H_z$ Fig. 1.4 shows the operational diagram of a moving-coil loudspeaker.

The audio signal is applied to the voice coil situated between magnetic pole pieces which produce a radial magnetic field. The interaction between the varying magnetic field set up by the audio current in the voice coil and the static (constant) magnetic field makes the voice coil to oscillate along its own axis at the frequency of the applied audio signal. The oscillation of the coil radiates a sound from the diaphragm. The magnitude of the force on coil is given by the expression.

$F = BLI$

Where B is the magnetic flux density within the air gap, L is the length of wire in the voice coil and I is the audio current flowing in the coil.

The voice coil of the electrodynamics speaker is wound with a thin wire and usually has a resistance of a ohms, hence a low-impedance device. As a result, they are usually connected to radio receivers through a step-down transformer, the primary of which is connected to the receivers whose output impedance may be of several thousand ohms.

2.19 THE SUMMARY OF OPERATION OF FM RECCEIVER

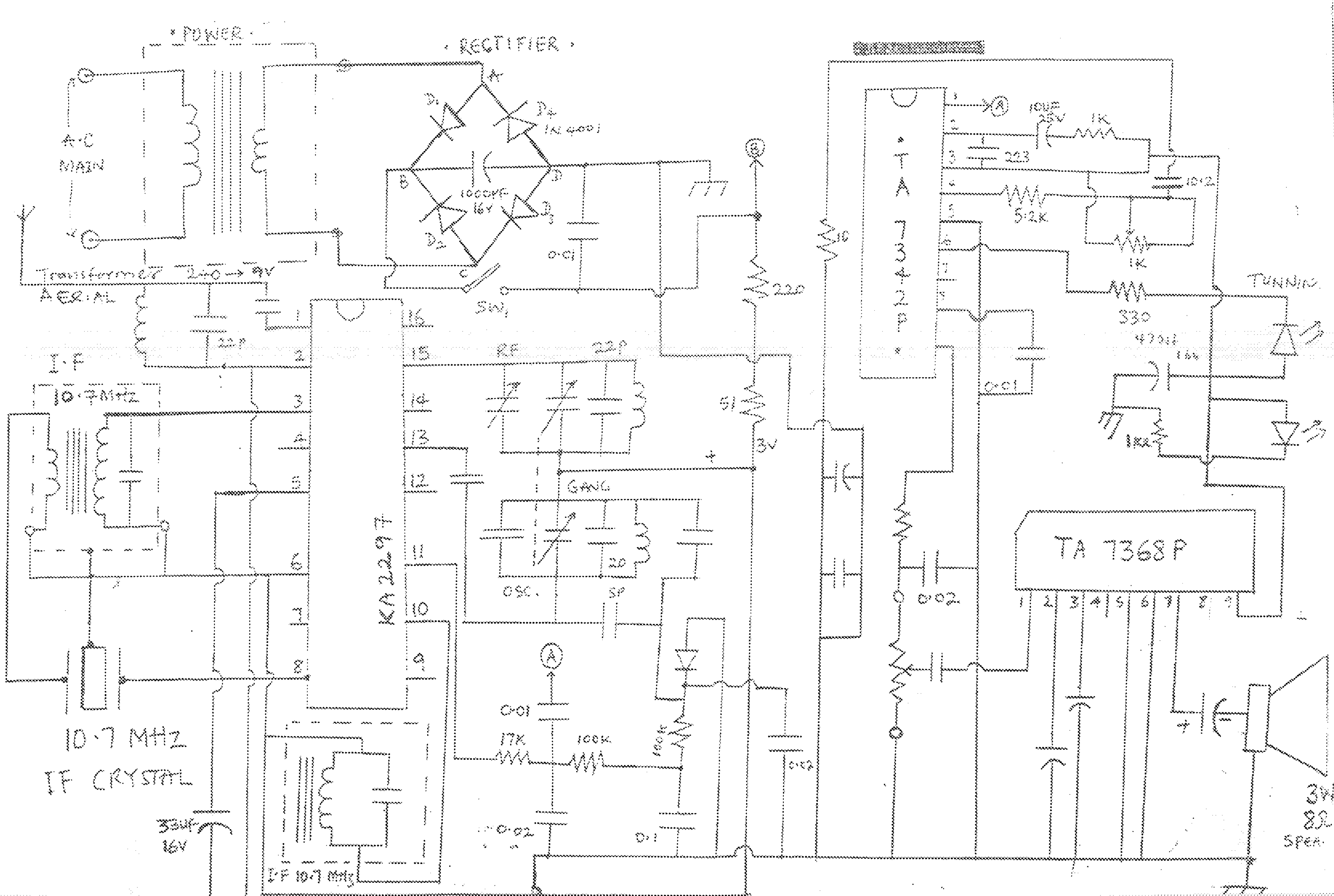
The principle of operation of FM receiver is based on the conversion of all incoming radio frequency signal to a INTERMEDIATE FREQUENCY ((IF), which is kept fixed. As such the amplifier circuits operate with maximum stability, selectivity and sensitivity. Figure 2.11 shows the block diagram of FM radio receiver for broadcasting.

The RF amplifier selects and amplifiers the required frequency band signals from the various signals intercepted by the antenna. The amplified RF is coupled to the input of a mixer stage which beats together two frequency signals. A mixer circuit is so designed that it can conveniently combine two radio frequencies One fed into it by the RF amplifier and the other by a local oscillator. The first input to the mixer is the amplified RF signal of frequency F_{RF},while the other input is from a local oscillator signal of frequency F_{LO}

The local oscillator is an RF oscillator whose frequency of oscillation can be controlled by varying the capacitance of its capacitor. In fact, the tuning capacitor of the oscillator is ganged with capacitor of the input circuit so that the difference in the frequency of the selected signal and oscillator frequency is always constant.

The output of the mixer is the sum and difference signals of frequencies $F_{LO} \pm F_{RF}$. The function of the IF amplifier is, thus to select the difference frequency signal.

$$F_{IF} = F_{LO} - F_{RF}$$



POWER
RECTIFIER
A.C
MAIN
Transformer 240 → 9V
AERIAL
D1
D2
D3
D4
1N4001
1000PF
16V
0.01
SW1
220
51
3V
22P
I.F
10.7MHz
KA2297
RF
GANG
OSC.
20
5P
17K
100K
0.01
0.02
0.1
10.7 MHz
IF CRYSTAL
33uF
16V
I.F 10.7 MHz
TA 7342P
10uF
25V
1K
223
5.2K
330
10
0.01
0.02
TUNNING
1KΩ
TA 7368P
3W
8Ω
SPEA.

f_{IF} is known as the intermediate frequency (IF). It is also the function of the IF amplifier to amplify the IF signal further. The IF is kept constant by gang – tuning the local oscillator and the RF amplifier. The local oscillator frequency is preferably chosen to be higher than the radio frequency for the narrower relative turning. The function of the limiter is to remove all amplitude variations (caused by noise) from IF signal which might have crept into the FM signal. This removal of amplitude variations is necessary for distortioness demodulation. The detector carries out the conversion of the IF signal to AF signal. This audio signal is amplified by the Audio frequency (AF) amplifier whose output is fed to a loudspeaker which reproduces the original sound.

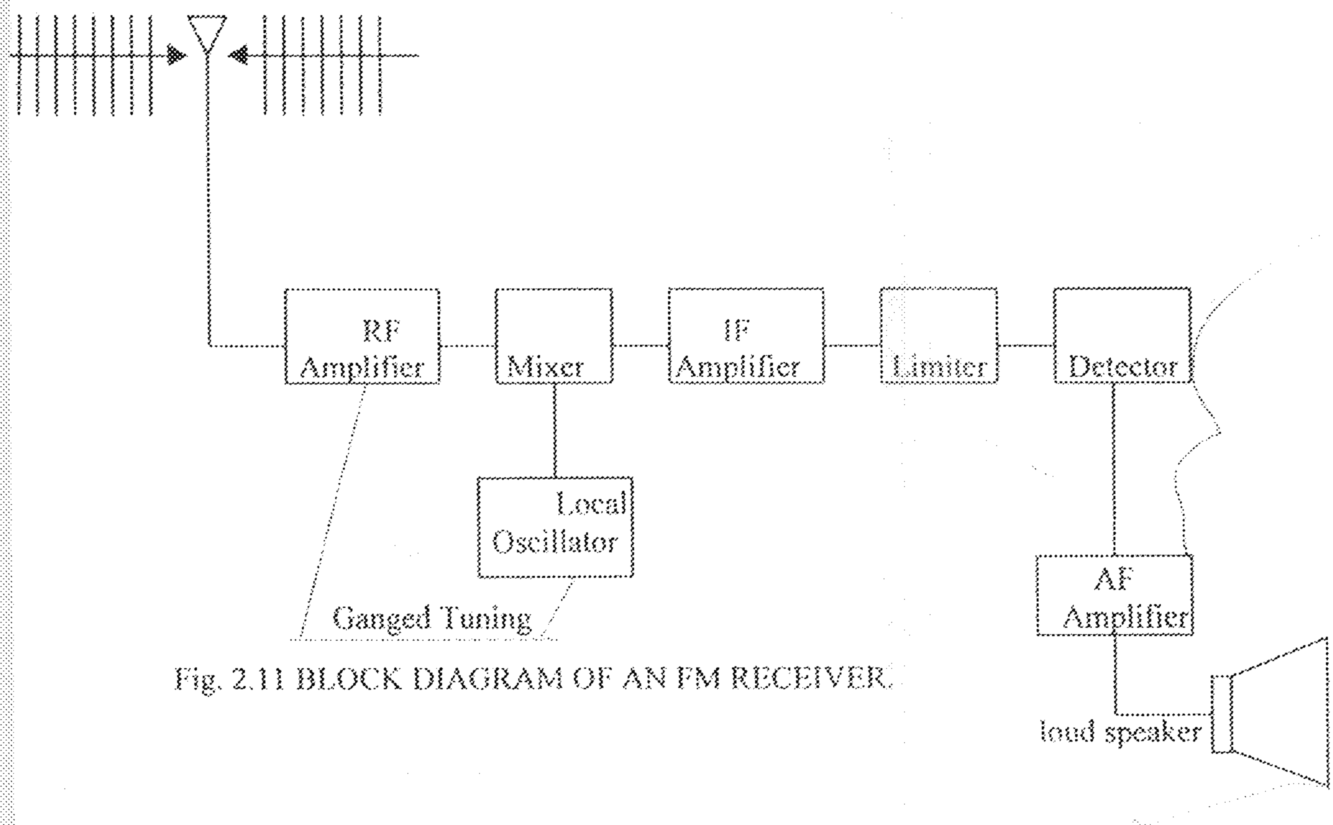


Fig. 2.11 BLOCK DIAGRAM OF AN FM RECEIVER.

2.20 FM SOUND TRANSMITTER

Frequency modulated (FM) transmitters are commonly used above the HF rage. Particularly for sound transmission e.g. the 88 – 108MH$_z$ Band. Because of such high frequencies involved. It is difficult to obtain crystals that will oscillate well. Other oscillator types are also found to be very unstable at high frequencies. One obvious method of circumventing this is to employ a low-frequency oscillator (e..g. crystal oscillator) and then multiply the output frequency as many times as to give the required high frequency. Such frequency multipliers may take the form of class C amplifiers tuned to the required frequency. A better alternative is to make use of frequency synthesizers, which provide better frequency agility than the crystal-controlled oscillator. A frequency synthesizer basically accepts a single frequency of high stability, which is processed to provide full frequency coverage.

Fig. 2.12 shows a simplified block diagram of an FM sound transmitter

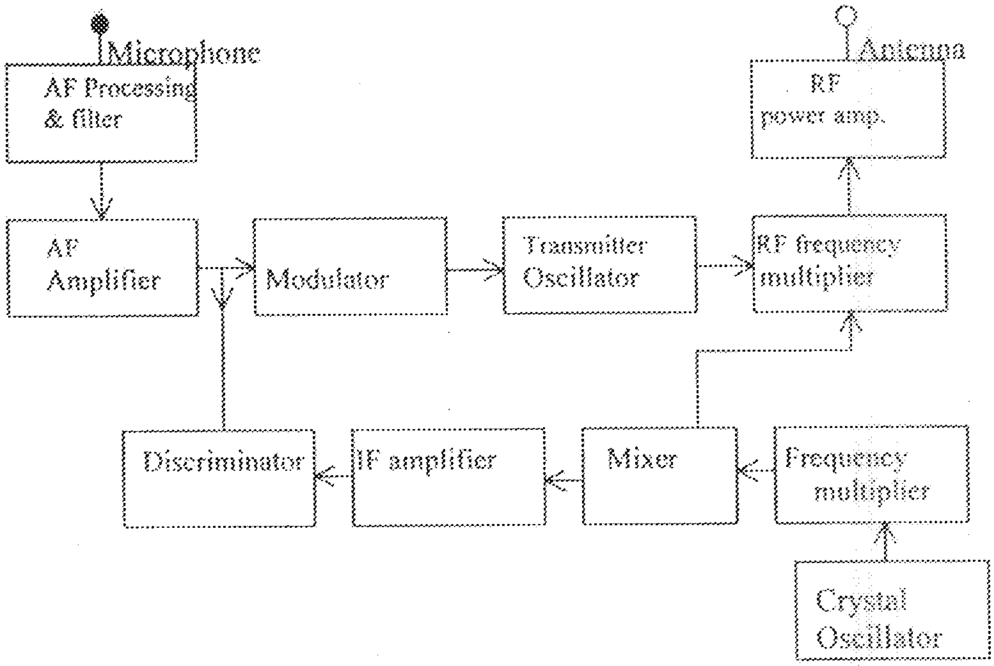


Fig. 2.12 .BLOCK DIAGRAM OF FM SOUND TRANSMITTER

The microphone converts the voice information to a message signal, which is processed, filtered and amplified within the required voice bandwidth of about 4Khz. The FM modulator coverts the changes in the message signal amplitude into frequency changes. The modulator may consist of a reactance modulator (e.g. varactor modulator) and an oscillator whose frequency is changed in accordance with the variation in the instantaneous value of the message signal. The resulting signal is then passed through a series of frequency multipliers that produce the required operating frequency. The final RF power amplifier boosts the power to a level high enough for radiation by the antenna.

The lower part of the circuitry constitutes the automatic frequency control (AFC) network. Broadcasting regulations require that the centre frequency of the carrier (i.e. unmodulated carrier frequency) be held constant within specified limits. The aim of the network is, therefore, to stabilise the centre frequency. If, for example, the crystal oscillator frequency f_2 is multiplied n-times to give nf_2, then the output frequency of the mixer will be $f_1 - nf_2$. This intermediate frequency signal is boosted in amplitude by the tuned IF amplifiers. The output voltage is finally applied to a phase-shift discriminator circuit, which produces a fixed d.c. Voltage output as long as the input frequency is constant. Any variation in the input frequency lead to a change in the output voltage of the discriminator. This then serves as a reference potential for establishing the proper operating frequency of the transmiter.

CHAPTER THREE

CONSTRUCTION, TESTING AND RESULTS

3.1 CONSTRUCTION

Construction is the practical aspect, which involves the assembly of components and testing. The project work consists of both the electronics and the casing parts.

The electronics part consists of audio amplifier, Mixer and so on. All these were connected one after the other as designed and analysed in the designed aspect of the project in chapter two.

After all calculation, and the design was completed, the components with the preferred values were bought, then the components were arranged on a breadboard starting with the rectifying circuit.

While on the breadboard, the output of electronics part was tested with digital meter and oscilloscope. The oscilloscope displayed the wave form output of each stage.

The power unit was also tested to ensure that the required output voltage is 9 volt. After the whole connection on a breadboard, the FM receiver was tested and it was functioning well then, the stages with the power unit were transferred and soldered on Vero-board using soldering Iron and soldering lead.

3.2 CONSTRUCTION TOOLS AND EQUIPMENT.

During the construction of this project, some electronics tools and equipment were used. These tolls and equipments are discussed below.

(1) Soldering Iron :- A modular soldering the iron with 40W heating element was used for soldering the components together. A very high voltage soldering iron will damage the electronic components.

(2) Soldering Stand.- This was used for keeping the soldering iron in a safe and upright position. The stand is made up of metal and it is constructed so that the bit of the soldering iron does not touch any metallic or plastic materials.

(3) Solder:- Flux-core colder type was used for the soldering of the electronic components.

(4) Sponge.- This was used for occasional clearing of the soldering bit when soldering. The sponge was always kept damp and used to wipe the soldering bit.

(5) Lead Sucker:- This was used for suckling up molten solder. It also used to remove bad components out of the vero board.

(6) Wire Cutters.- Cutters were used to cut wires to require length and to tip off the excess leg of electronic components after soldering.

(7) Strippers:- Wire strippers were used to scrip off the insolation from solid or stranded hook up wires.

(8) Digital Multimeter:- This was used for quite a number of functions. It perform the following function during the construction of the project.

1. It was used to test the continuity of each line on the Vero board.
2. It was used to measure the secondary voltage of the 230/9V transformer.
3. It was used to know the terminals of the transistors used.
4. It was used to know the value of the colour-coded resistors, capacitors and inductors
5. It was used also to know the voltage at each stage of the receiver.

(9) CRT Oscilloscope:- This was used to know the wave forms at the following stages.

i. RF stage
ii. Detector stage
iii. Output of the audio amplifier stage

iv. Power supply stage.

(9) Veroboard:-This allows permanent prototyping of an electronic design. The Vero board was pre-etched, therefore the various electronic components were simply soldered in place, using connecting leads (wire) and blade to make and break continuity respectively between them when necessary.

3.3 TESTING

All design work, be it electrical, electronics, mechanical e.t.c. require testing after construction before being commissioned into service, that is why this project work was firstly, constructed on the bread- board for proper testing.

Various testing were performed during the construction. At each stage, the project was tested to confirm if the waveform obtained conform to the target.

Also, at the end of construction, the project was tested in the lab and it is able to receive Niger FM radio with frequency 91.2KH_3. The ability of the receiver to receive signal from the nearest FM station shows that the receiver work s as was planned.

3.4 RESULT

From the tests performed above, I was able to achieve the following results:

(1) The noise was minimal.

(2) The selectivity was high.

(3) The output power matched the input of the loudspeaker.

(4) The sensitivity is also high.

(5) The level of distortion is low.

3.5 PRECAUTIONS/ PROBLEMS ENCOUNTERED DURING CONSTRUCTION

During construction enough care was taken while soldering as much as possible to avoid joint soldering which could lead to short circuit.

During soldering, the power unit of the receiver was completely disconnected from the A.C main source and from the receiver in order to avoid voltage flowing in the receiver while soldering which could cause damaging to the system components.

There was an unstable power supply from NEPA, which cost much time for the construction to be completed.

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1 RECOMMENDATION

This project "Design and construction of FM Receiver" achieved its objectives within a reasonable degree of efficiency.

At the end of the construction the following recommendations were made.

Firstly, the power supply unit can be replaced by battery. This will give the receiver the chance to use battery incase of power failure.

Secondly, terminals of components and connecting leads used during the construction must be very short to avoid instruction of additional capacitance and inductance into the circuit.

Lastly. A push-pull power amplifier can be connected to the output of the audio amplifier I.C. used for higher output power,

4.2 CONCLUSION

The design and construction of FM receiver was very successful. It gave me insight into quite a number of practical concepts in Electronics and Telecommunication Engineering. It enhances my skills and techniques in handling electronic and equipment.

The constructed FM receiver was able to select the require radio station (Frequency band) out of the numerous modulated carriers reaching the receiving antenna and to convert the selected modulated Radio Frequency (RF) signal into Audio Frequency (AF) signal.

It will be of great use to engineers, reporters, pressmen, motorist, students, traders, laborers, e.t.c. for receiving message, information or signals from the FM station.

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