DESIGN AND CONSTRUCTION OF 2M AMATEUR BAND TRANSCEIVER

BY

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REG. NO: 98/7677EE

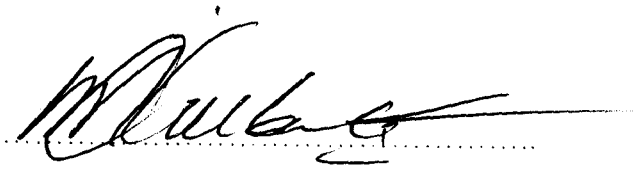## DEPARTMENT OF ELECTRICAL / COMPUTER ENGINEERINGSCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGYFEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

A THESIS SUBMITED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN THE DEPARTMENT OF DEPARTMENT OF ELECTRICAL / COMPUTER ENGINEERINGSCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGYFEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

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APPROVAL

The undersigned certified that this project work had been carried out by me, BISUGA ISIAKA OLUSOLA and approved as meeting the requirement of the Department of Electrical/Computer Engineering of Federal University of Technology, Minna in partial fulfilment of the requirement for the award of bachelor in Engineering Degree.
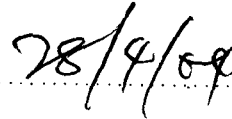

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Project Supervisor   **Date**

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Head of Department   **Date**

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External Examiner   **Date**

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DECLARATION

I hereby declare that this project work done was genuinely designed and constructed by

Bisuga Isiaka Olusola under the supervision of Engineer Musa Abdullahi.. Information

derived from the published work of others has been acknowledged.

DEDICATION

Dedicated to my parents Alhaji and Mallama R.O Bisuga

ACKNOWLEDGEMENT

I seize this opportunity to express my profound gratitude Almighty God whose divine favor and guidance made it possible for me to attain this level of academics achievement and also through the completion of this project.

I wish to express my appreciation to Engr. Musa Abdullahi under whose supervision the project was carried out.

My gratitude goes to my parents Alhaji and Alhaja R.O Bisuga, my senior brothers Musibau Oladapo, Abiodun Nurudeen, and my senior sister Alhaja Kudirat Sonubi, my junior brothers Abdul Rasheed Olajide, Kazeem Oluwakorede and not forgetting my junior sisters Serifat Abiola and Ganiyat Titilayo for their love, support and care, may God bless and reward you all accordingly.

My heartfelt appreciation goes to the love of my heart Adetutu Sekinat for her love, care, and patience and understanding right from my Polytechnic days, to her I love you.

I will not fail to express my thanks to my mentor Engr Femi Obiri and to my boss Engr Don Dudman you both have been my source inspiration and encouragement.

To my friends KamarTikare, Seyi Odujoko, Waheed Bello, Seun Kujore, Alabi Abiodun, Taiwo Ogunsowo, Babatunde Fatai, Taofeeq Imran and my classmates Ganiyu, Akeem, Tokunbo,even in our differences we still found our similarities. You all added colors to my life. Thank you all.

ABSTRACT

There are many ways of information dissemination, but one important factor is the security of classical information. However since the goal is to establish communication between two people or more there comes the need for the means, and in this project radio is utilized.

There are many ways of radio wave transmission and reception but the superheterodyne method is engaged here. Virtually every radio manufacture today incorporates the superheterodyne where the incoming signal is amplified with either a single stage or more of tuned IF amplifier stage. All the stages are analyzed thoroughly later in the report.

The distinctive feature of this project is its ability to send and receive both voice and code.

Lastly, the circuit used in the entire construction of both code section and the transceiver were joint effort of the project students based on experience obtained from both theoretical and practical knowledge of electronics and telecommunication.

TABLE OF CONTENT

CHAPTER ONE

1.0 INTRODUCTION

One of the greatest assets of man is his ability to think thoroughly and to transform his thought through experiment, practice, and persistence into reality. This advantage has been of immense benefit to the engineering discipline and the modern society at large. Science and technology has come a long way to produce communication systems and devices of all kinds for passing messages across. There is a great need for people to get in touch, communicate with one another.

To make the world a better place, information and communication devices were made possible and with the recent technology, its design and construction has also increased in sophistication and style. Modern communication systems use a wide range and variety of electronic equipment to meet the need of the users.

Communication simply means the sending, processing, and receiving of information between two different points. However, in a general sense, communication can be seen as a chain of events in which the significant link is a message. The chain connects to a source that originates and a destination that interprets the message. Conclusively, communication could be defined as the sending, processing, and reception of signals using electrical means. The information to be sent takes the form either of a written message, voice message, or an electrical signal etc. The means of communication can be in the form of a radio link, optical fiber, satellite and telephone network.

It is difficult to imagine what modern living would be like without ready access to reliable economical and efficient means of information and communication. There are times when it would not be possible to send direct speech and all one can send is a code

as signal to a destination from the source. A critical example is a war situation; especially during peacekeeping where we have people from different lingua franca participating in the process of peace keeping. Taking into consideration that there are generally-accepted military language which may not be too difficult for enemies to decode. Codes are sent for information between parties to ensure security and confidentiality of information.

Sequel to the aforementioned, it has actually led to the research and construction of my project 2m amateur band transceiver. This is expected to radiate an effective power of about 10 milliwatts, and operate a distance of about twenty to thirty meters. This limitation is due to unavailability of an oscilloscope to vary the tuning frequency in accordance with the distance.

AIMS AND OBJECTIVE

Communication is very vital to the existence of human life. It enables information to be passed from one individual to the other, from one place to the other. Therefore in the world of competition, information and communication, expediency has become extremely necessary and inevitable. To this effect I was motivated to research and construct a communication device, which is effective, affordable and portable. Transceivers are very easy to use than cell phones and walkie-talkies at short ranges. Its major advantage is that noise is reduced to minimal.

METHODOLOGY.

The prime requirement of an F.M modulation is a variable-output frequency, with the variation proportional to the instantaneous amplitude of the modulating voltage. The

subsidiary requirement is that the unmodulated frequency should be constant and the deviation independent of the modulating frequency. However, if the system proper does not produce these characteristics corrections can be introduced during the modulation process.

Basically there are two types of transmitters, namely: low-level and high-level transmitters. Low-level is the one in which the output of the oscillator is weak in such a way that it cannot cover a long distance. For this reason an R.F power amplifier is being attached to the output of the oscillator so as to boost the power level of transmission. But on high-level transmitters, there is no need for power amplifier because the output of the oscillator is strong enough for effective transmission.

CHAPTER TWO

2.0   LITERATURE REVIEW.

James Clerk Maxwell at London University first conceived the electromagnetic waves in 1864. After constructing a brilliant new general theory of electromagnetism expressed in mathematical equation, he concluded that light consists of transverse waves of oscillatory electric and magnetic fields, at frequencies between 10^{14} and 10^{15} hertz, and suggested that similar waves having quite different frequencies might be created or discovered.

In 1879, George F. Fitz Gerald proposed that the oscillatory currents produced by a capacitor discharging through an inductor might generate Maxwell's waves. The oscillator discharge of a capacitor has been first noted by Joseph Henry in 1842, analyzed mathematically by William Thomson (Lord Kelvin) in 1853, observed oscillographically by Wilhelm Feddersen in 1861 and by Wilhemin Van Bezod in 1870 to produce electric waves on wires.

Similarly, Maxwell in 1865 stated that electric oscillation in a circuit produces electric waves or radiations in the surrounding space, which in turn travels with the speed of light. Scientists like Hertz and Marconi performed experiments to this effect and eventually, Heinrich Hertz was able to prove the existence of electric waves in space, hence verifying Maxwell's postulation on December 12, 1901.

Marconi later used the principle of electromagnetic radiation to successfully send radio waves across the Atlantic. Generally, all forms of communication that can send and receive information through space utilize electromagnetic radiation, which is in the form

of electrical energy that can travel through space and does not require any medium for transmission.

In 1877, Thomas Edison discovered electron movement in a vacuum cause by heating of a wire (Edison Effect), which later brought about the discovery of a vacuum tube. Two important developments took place in the radio receiver technology between the year 1914 and 1918, and they are:

The invention of the valve (diode and triode)

Development of super heterodyne principle by Major Armstrong in 1918.

As designers learned more about transistors and as better brands became available, tube-based transceivers began to disappear. In fact by 1970, transistorized transceivers commanded the consumer market.

Integrated Circuits (I.Cs) were the second technical breakthrough in consumer transceiver design. This development, more than anything else made high-quality portable transceiver possible. It allowed the designers to put more sophisticated circuits into a smaller package, permitting consumers to enjoy the benefits of F.M broadcasting without experiencing complications of F.M stereo. This move to a smaller, lighter, more powerful and efficient transceivers has led to fundamental changes in the way transceivers are built and serviced. In the days of vacuum tubes and transistor-based transceivers, the designers would build a transceiver out of individual stages that are interconnected to provide a working unit. However, today, Large Scale Integration (LSI) and Very Large Scale Integration (VLSI) techniques have permitted virtually all active circuits of an A.M/ F.M transceivers to be placed on one single I.C.

2.1 HOW RADIO WORKS

The information transmitted by radio is carried by electromagnetic wave system called "carrier wave". The carrier wave is modulated (varied) in some fashion by electrical signal regenerating the information to be transmitted. The modulated carrier wave is fed to a transmitting antenna, which launches the electromagnetic waves into space. At the receiver site a very small portion of the transmitted wave is captured by another antenna. This captured signal is fed to a radio receiver, which separates the desired information from the carrier. The information in then converted from different form into sounds, pictures, or other forms. Radio wave can carry speech and a wide variety of other information. In most cases suitable electronic receiving equipment is needed to convert the information, the modulated carrier wave to a few recognizable speeches to our senses. This conversion is needed because we can not perceive ordinary waves without the aid of the receiving equipment.

In this project, the transceiver (transceiver/receiver) was the principle of radio telegraphing, where electromagnetic waves are used to send and receive information with the form of voices messages and sound codes. This two-way communication device when transmitting and receiving messages uses an antenna to radiate and capture the radio signal.

2.2 CLASSIFICATION OF RADIO TRANSMISSION/ RECEPTION

2.2.1   Simplex Radio reception: - This is a one way reception. A single source

communicates with one or more receivers.

2.2.2   Duplex Radio Reception: - This is a two way receiver (dual). The device could

act as a source (transmitter or as a receiver).

The AM/FM utilizes the simplex form of reception or the simplex star configuration (fig

1.2) where a single transmitter feeds more than one receiver.

2.2.3   SIMPLEX STAR CONFIGURATION

Receiver is used to select a desired signal from all the other unwanted signals in the

atmosphere, amplifies, demodulates and then to display it in acceptable form. (1)

Different types of receivers that have been proposed and built include:-

- -   crystal regenerative

- -   super regenerative

- -   tuned radio frequency (TRF)

- -   super heterodyne

The last two attained suitable level of commercialization ie the tuned radio frequency

receiver during the pre-world war II and is today used for specialized purposes ie tuned

frequency receivers.

The super heterodyne receiver is used in this particular project. It comes from heterodyne

which means to mix or combine frequencies and the word super was used for commercial

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effect to help sell the radio when it first appeared on the market. The main advantage of the super heterodyne receiver is its constant bandwidth while tuning to different radio stations. Also, it has a very good sensitivity and selectivity and it is the most common form of receiver today. (1).

This super heterodyne is used in the construction of all the stages involved. This is to enhance better understanding of the whole radio operation and also to familiarize the student with all the component since utilizing the integrated circuit ie phrase locked loop would have simplified the whole circuitry and also cost less.
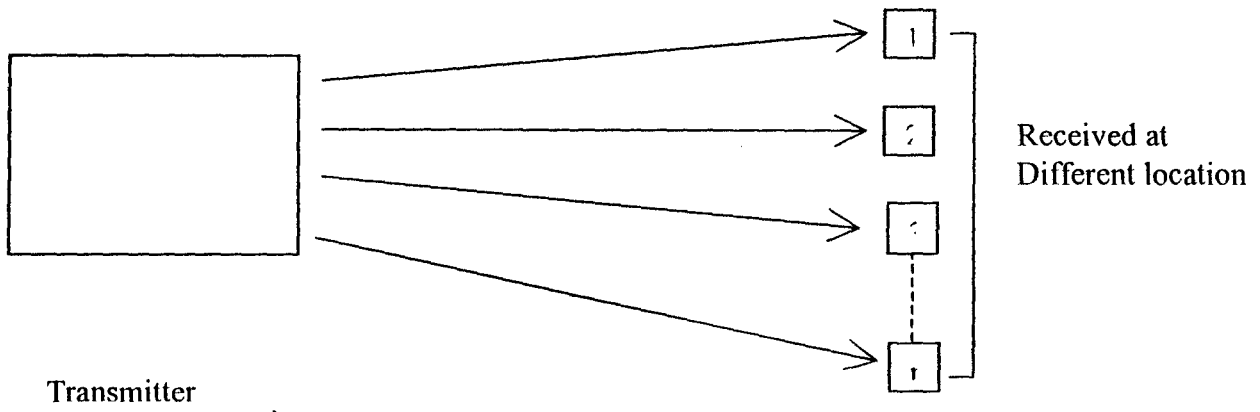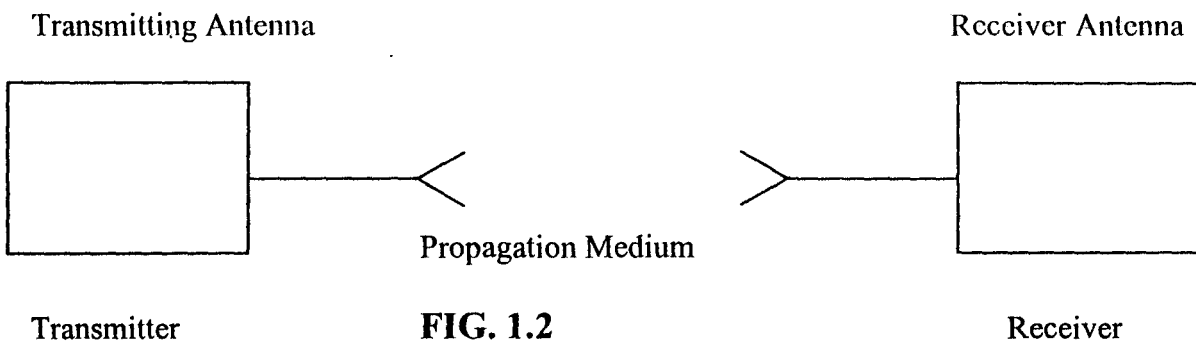
FIG. 1.1

SIMPLEX STAR CONFIGURATION

Where n is an integer

A BASIC COMMUNICATION SYSTEM

Receiver is required to intercept and decode a wide range of signals and the extent to which a receiver can be useful to the users is determined by the noise level picked up by the antenna on the desired frequencies and by noise generated within the receiver itself. Noise figure (in decibel) of a receiver compares the total receiver noise with the noise that would be present if the receiver generates no noise (internal noise). It is called the noise factor.

Furthermore, designer of the receiver have little or no control over the atmospheric noise picked up by the signal in transit but they do have control over the internal noise i.e. Noise generated by passive devices such as resistor, inductor and capacitor etc. This is as a result of internal thermal motion of the free electron i.e. Thermal noise.

However, semi conductors devices are the greatest source of internal noise in a receiver i.e. Transistor, diode, integrated circuit (I – C).

2.3   TRANSMITTER STAGE

A transmitter is a device for sending out intelligence means of radio wave from one point to another. (1) The dispersal of information over a distance is done through the process of modulation, which may be described as variation of some characteristic (amplitude, frequency or phrase angle etc) of a particular signal referred to as carrier.

2.3.1 AMPLITUDE MODULATION: Here, the message signal causes the amplitude of carrier wave to change.

2.3.2 FREQUENCY MODULATION: This is when the information/message signal causes the frequency of the carrier wave to change.

2.3.3 PHASE MODULATION: Takes place when the message signal varies the phase of the carrier.

The process of modulation entails superimposing on the carrier wave the message or information signal. The relationship between the carrier and the message signal is similar to that between a sheet of paper (information signal) which contain vital information and is to be sent over quite a long distance. It is not possible to throw the paper alone as it is too light hence it is wrapped around a stone (carrier) that is then thrown to cover the required distance. It would be observed that more energy is used in transporting the stone (carrier), which doesn't contain any useful information than the sheet of paper (modulating signal). This is the relationship between carrier and receiver signal.

AMPLITUDE MODULATION: As stated earlier, this is when the information or message signal causes the amplitude of the carrier to vary. It is achieved by making use of a non linear component i.e. diode and a resonant circuit which eventually give the AM waveform.

The output of the diode is the pulsating DC waveform which serves as the input to the the resonant circuit. The resonant circuit eventually has the AM wave envelope as it's output.

The modulation of carrier at greater than 100% is undesirable as it causes distortion of the recovered audio signal at receiver. It should be less than 100%. The amount of modulation could be measured by modulation factor (M).

$$M = \frac{B}{A}$$

B = Peak value of modulating signal

A = Peak value of unmodulated signal

If the carrier frequency is given by Cos Wct and it is in turn varied by a modulating signal of much lower frequency Cos Wmt,

Signal = (1+m Cos Wmt) Cos Wct

M = Modulation Index < 1.

Expanding gives

Modulated signal = Cos Wct + $\frac{1}{2}$ Mcos(Wc − Wm)t.

i.e. the modulated carrier has power at frequency Wc and at frequencies on either side of Wm.
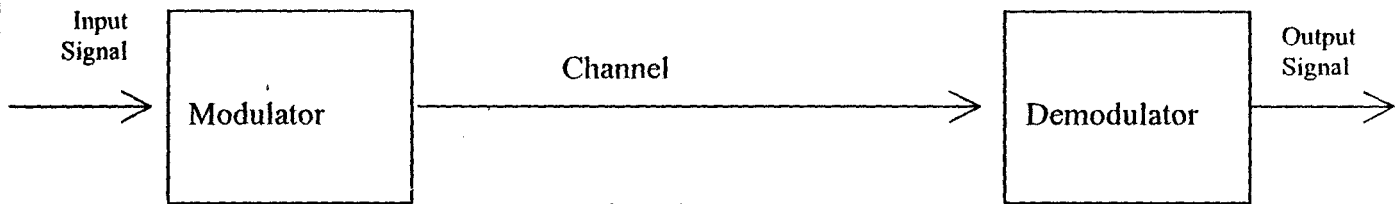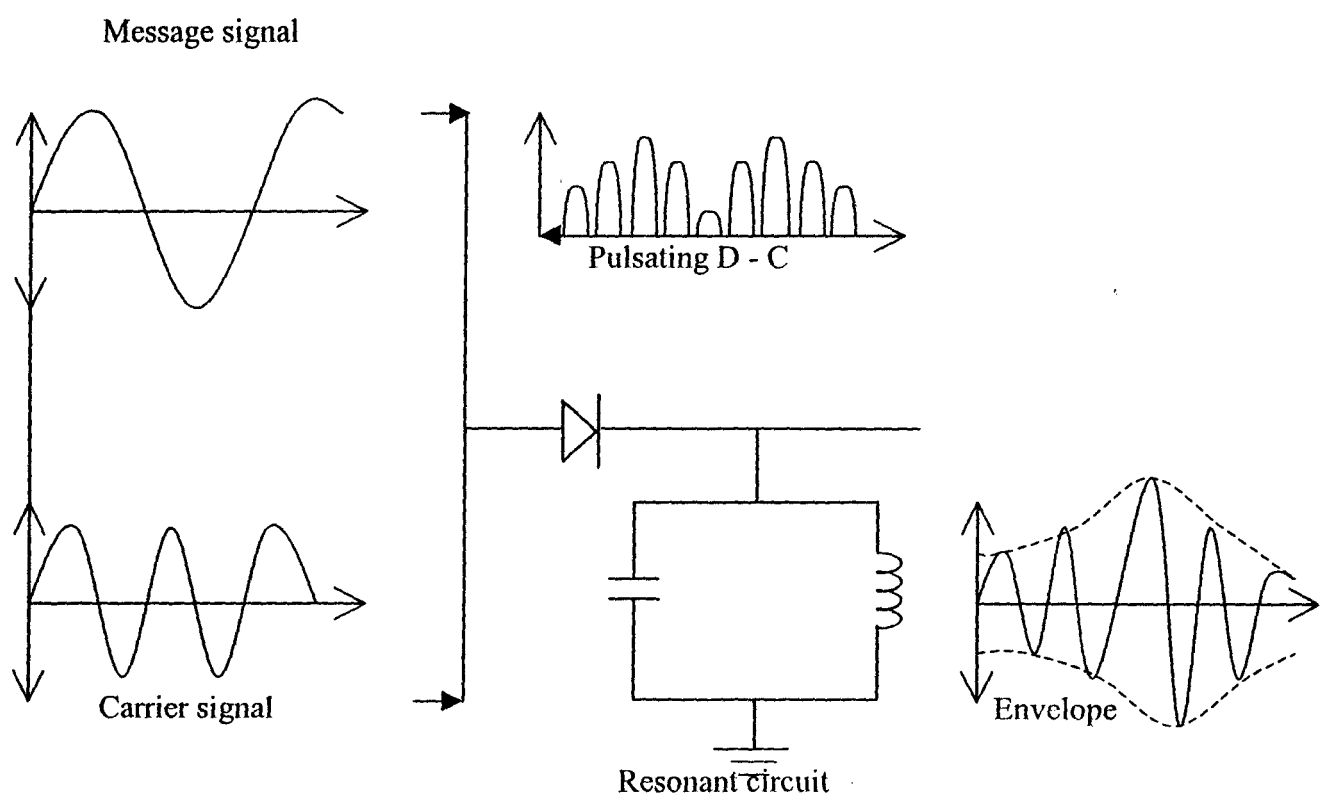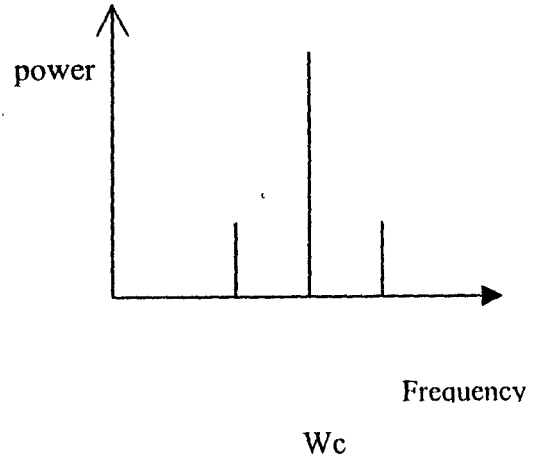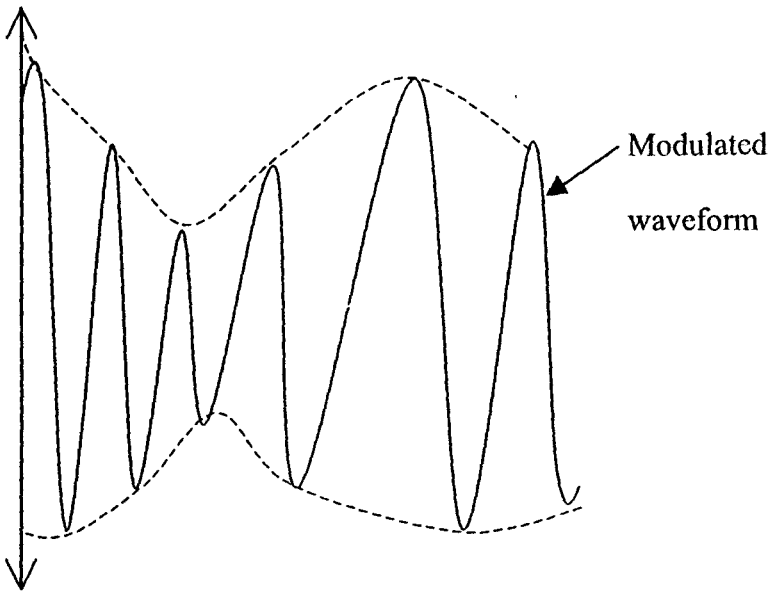
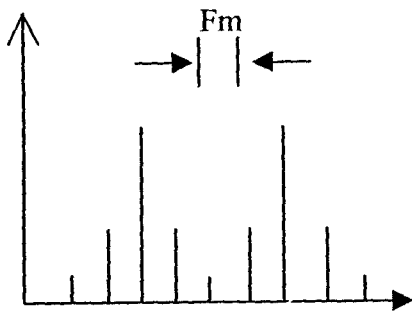Fig. 2.1

A TYPICAL TRANSMISSION SYSTEM

FIG. 2.2

OBTAINING THE AM WAVEFORM

Modulated
waveform

power

Frequency

Wc

(b)

Envelope

(a)

AMPLITUDE MODULATOR

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Power

Fm

FE   Frequency

FIG. 2.4

WIDEBAND FM SPECTRUM

FM has a quiet, background when tuned and it is this property that makes wide band FM preferable to AM for high quality transmission.

$$\text{Modulating index} = \frac{Frequency\ deviation}{Modulating\ index}$$

When frequency deviation >> modulating frequency, wide band frequency modulation is obtained as used in FM broadcasting.

FM has numerous side band spaced at multiples of modulating frequency from carrier. The number of significant side band is approximately equal to the modulating index. (6)

2.4   RECEIVER

Receiver is used to select a desired signal from all other unwanted signal, amplify demodulate and then display it in an audible and comprehensible form. Different type of modulation i.e. FM, AM, etc. require different types of demodulation and this gives rise to the difference in the classification of the receivers.

Demodulation is the process used in extracting information imposed on the carrier wave.

The different types of receiver existing include

-   Crystal Regenerative Receiver

-   Super Regenerative Receiver

-   Tuned Heterodyne frequency Receiver

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- Super Heterodyne Receiver

In general, the last two types of receiver listed above have attained suitable level of

commercialization.

Tuned Radio Frequency (TRF) receiver dominated the scene during the pre-world war II

and is currently still being used today.

Tuned receiver is simple in design, very sensitive and fairly easy to align, however, it has

the following disadvantages.

- Instability problem

- Band width variation

- Low sensitivity

2.4.1 SUPER HETERODYNE RECEIVER

Super heterodyne receiver replaced the tuned receiver in 1927. The word super

heterodyne id from heterodyne which means to mix or combine frequency while super

was used for commercial effect to help in selling the radio when it first appeared in the

market. The main advantage of the super heterodyne receiver is its constant band width

while tuning to different radio stations. It also have a very good sensitivity and

selectivity, hence it is the most common type of receiver in use today.

Automatic gain control (AGC) is a method use to keep use to keep the gain of the

receiver constant as station of different signal strength are received. The super heterodyne

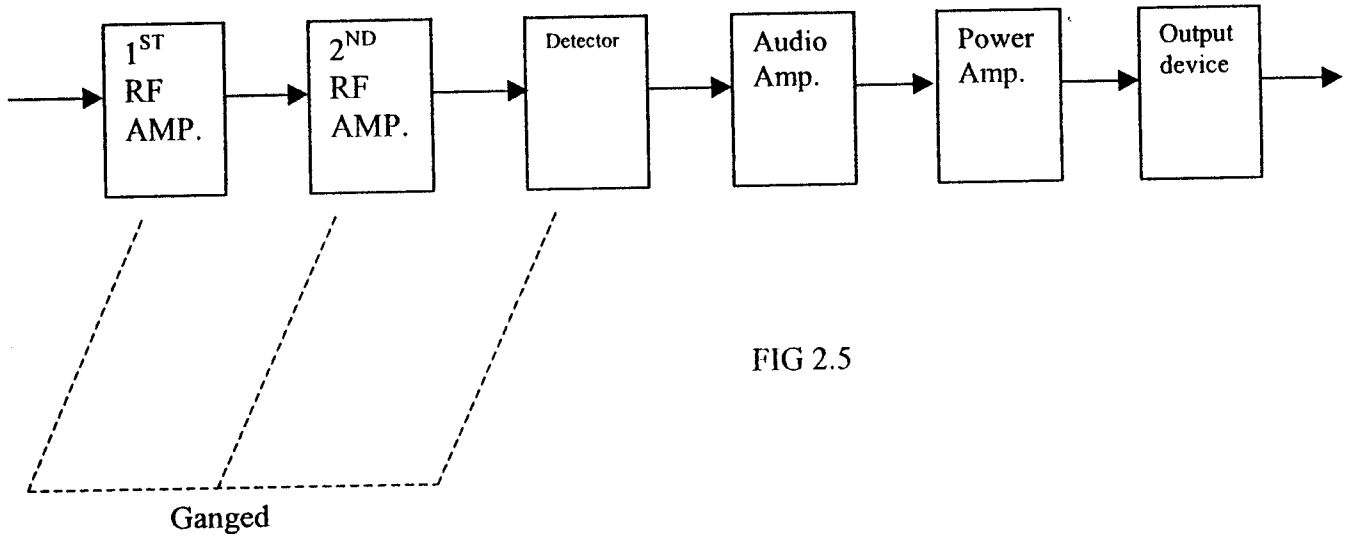maintain constant band width by keeping the tuned circuit used by amplifier tuned

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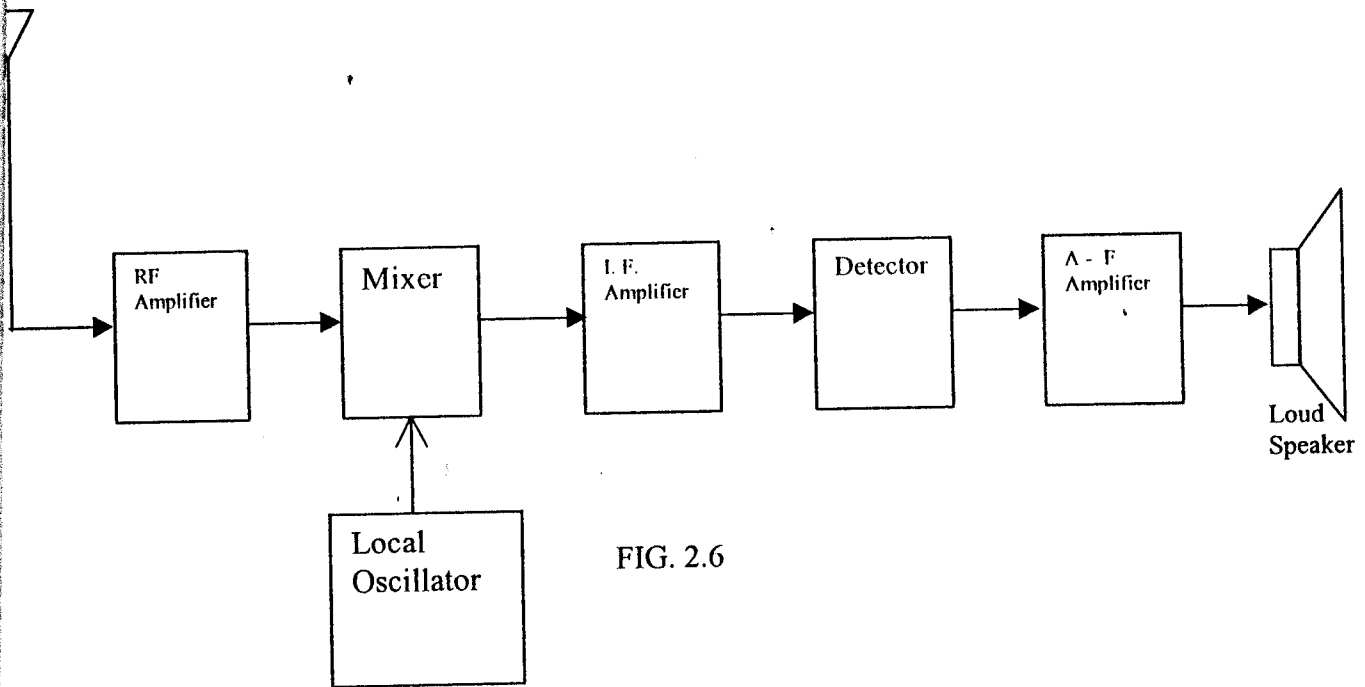
FIG 2.5

BLOCK DIAGRAM – TUNED RADIO FREQUENCY RECEIVER.

FIG. 2.6

A SUPER HETERODYNE RECEIVER (1)

to the same frequency, which in turn is accomplished by intermediate frequency (IF)

amplifiers. IF amplifiers are always tuned to the same frequency regardless of the

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incoming frequency. They are called IF amplifier because the frequency they amplifying is between the frequency of the received signal and the frequency of the audio that will eventually operate the loudspeakers. (1)

2.4.2 AM RECEIVER (SUPER HETERODYNE)

Radio frequency amplifier stage could be omitted in AM receivers. The block diagram principle of an AM heterodyning principle with the input radio signal of 1000KHz is shown on the next page.

When two frequencies are mixed together in a non linear device, the result is the two original frequencies, the sum of the two frequencies and the difference between the two frequencies. For commercial AM receivers, the IF amplifier stage is 455 KHz. If the received radio signal is 1000 KHz, then the local oscillator will have a frequency of 1, 455 KHz.

An oscillator is a circuit that creates its own frequency. In the receiver, it is called local because it is contained locally in the receiver. The received signal and the local oscillator signal come together in the mixer to give the intermediate frequency (IF) i.e. the difference between the local oscillator frequency and the incoming radio signal frequency.

Local oscillator frequency must always be greater than the frequency of the received station by 455KHz. This is achieved by physically connecting (ganging)
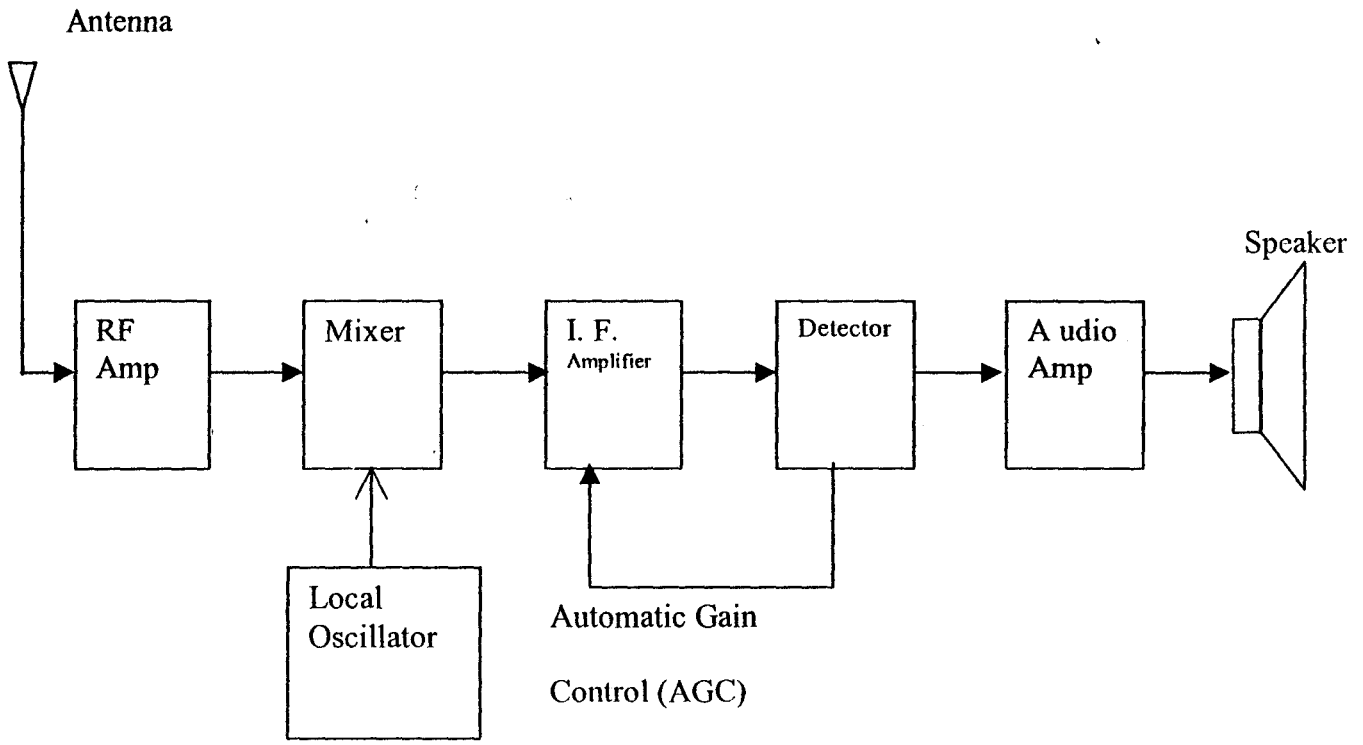
Antenna

FIG. 2.7

BLOCK DIAGRAM OF AM SUPER HETERODYNE RECEIVER
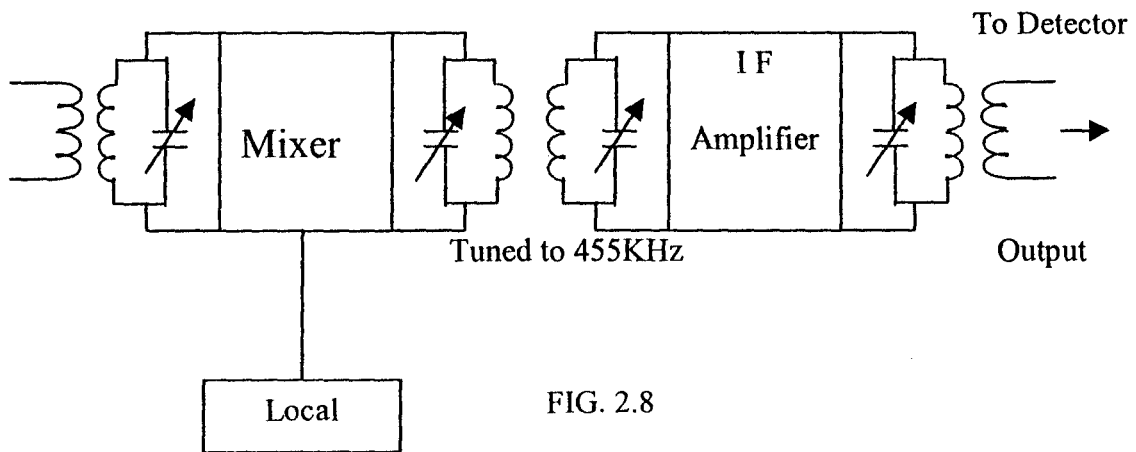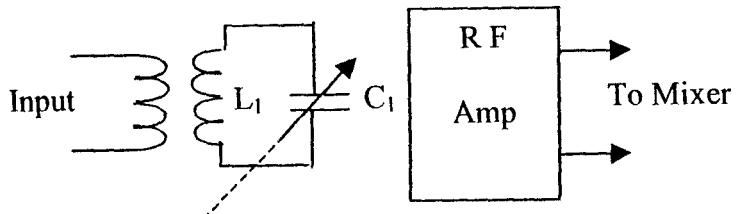

Tuned to 455KHz
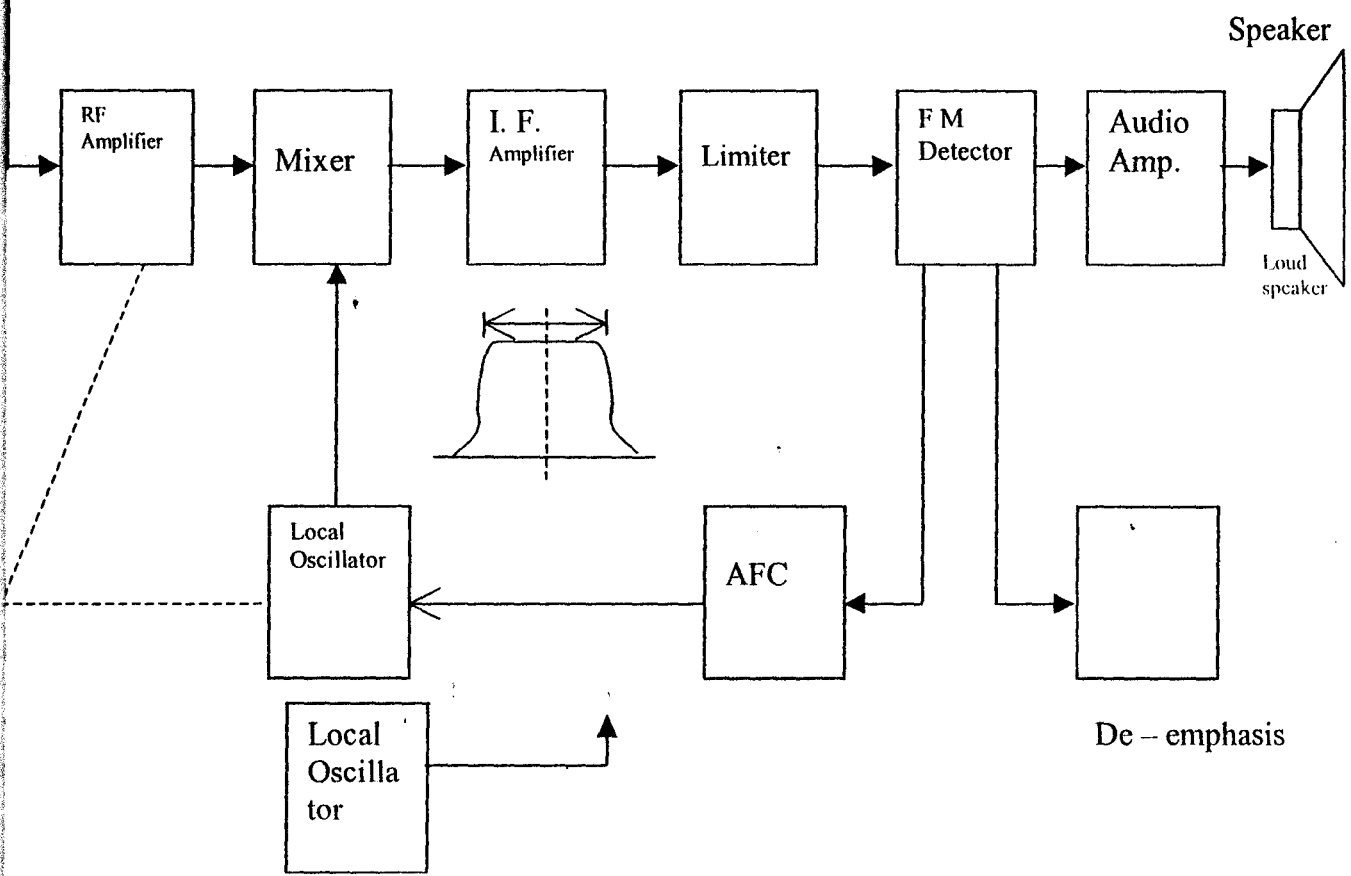
Output

FIG. 2.8

FIG 2.9
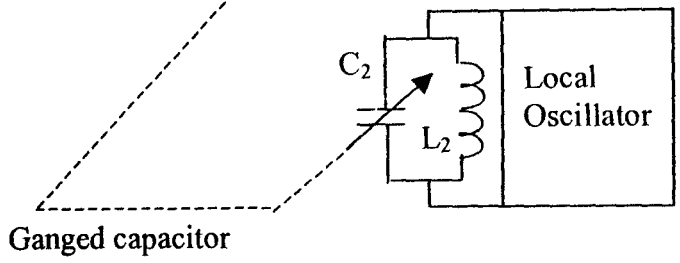
Ganged capacitor

GANGED CAPACITOR IN A SUPER HETERODYNE RECEIVER

Speaker

RF Amplifier → Mixer → I. F. Amplifier → Limiter → F M Detector → Audio Amp. → Loud speaker

Local Oscillator

Local Oscillator

AFC

De – emphasis

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the variable capacitor in the tuner to the variable capacitor in the tuned circuit of the oscillator.

$$F_{LO} = F_R + F_{IF}$$

F_{IF} = Intermediate frequency

F_{LO} = Local oscillator frequency

F_R = Radio frequency

2.4.3 FM RECEIVER

It is also a super heterodyne receiver but is different from the AM in the following ways.

    i. It has a higher operating frequency

    ii. It requires limiter and de-emphasis network

    iii. It requires different method of demodulation.

    iv. Different method of obtaining automatic gain control (AGC)

The RF stage is a must in the FM receiver as it improve the noise figure of the system. Ratio detector is used because of the possibility of a change in amplitude in the receiver signal and the need to use limiter to arrest amplitude changes.

Intermediate frequency (IF) for the FM is 10.7MHz. (7)

Fig 2.11 is the block diagram of the basic FM receiver which is also similar to the IF frequency value, limiter, de-emphasis network, automatic gain/frequency control and wider band width requirement.

The purpose of each stages include

2.4.1 RF AMPLIFIER

To select the desired signal and reject all others. It amplifiers the selected signal

2.4.2 MIXER/FREQUENCY CHANGER

A mixer is a circuit whose function is to translate a signal from one frequency band to another. If a mixer incorporates an oscillator, it is called a frequency changer. There are two methods via which mixers operate; either the signal and the output of a local oscillator are added together and then applied in series with a square law device, or two signal are multiplied together in a dual-gate M.O.S.F.E.T.

To generate a sine wave that id the IF frequency above the incoming radio signal, i.e. 10.7MHz.

The frequency changer of the incoming signal (radio) with the local oscillator signal and produces the sum and the difference of the two signal.

2.4.3 IF AMPLIFIER

Intermediate frequency amplifier amplifies the intermediate frequency. In commercial FM, the IF amplifier are tuned to 10.7MHz.

2.4.4 LIMITER

The noise output of a frequency modulation receiver will be minimized when the receiver

does not respond to amplitude variations of the incoming signal. This could be achieved

by arranging the circuit so that the output of the intermediate frequency amplifier

undergoes limiting or radio detector or by combination of the two.

Limiting action can be introduced by means of a crystal diode or grid limiting in the final

intermediate frequency amplifier stage (4).

It clips the peak of the FM waveform thus eliminating the amplitude changes by noise.

2.4.5 DETECTOR STAGE

This is the process of recovering the intelligence from a frequency modulated carrier

wave. It entails stripping the modulating signal form the carrier. There are several

methods depending on the form of modulating i.e. AM, FM etc. (6).

Detector of AM signal is the generation of a voltage proportional to the instantaneous

amplitude of the RF signal carrying the modulation. Simple diode detector has the

advantage of working over an enormous range of frequencies but it is non linear at low

levels.

Pre – amplifying the signal before rectification is use to improve the situation. The active

rectifies by contrast is highly linear, but is also works at low frequencies.

2.4.6 DE-EMPHASIS NETWORKS

The audio of a frequency modulation receiver must be proportioned to reduce the higher audio frequencies in direct proportion to the amount of pre-emphasis employed at the transmitter.

2.4.7 AUTOMATIC FREQUENCY CONTROL (AFC)

AFC circuit is used to prevent the local oscillator from drifting. Unlike the AM receiver the local oscillator frequency of an FM receiver is very high i.e. 88MHz + 10.7 MHz at the lower end.

A drift of 0.1% would cause a frequency change of at least 98.7KHz hence the local oscillator frequency is checked by noting the amount of FM detection caused by small change in the frequency of the local oscillator and the change is feed back by the AFC circuitry to bring the local oscillator to the required frequency.

2.4.8 AUTOMATIC GAIN CONTROL (AGC)

Signal arriving at the input terminal of a receiver are subject to continual fading and unless AGC is used, the volume control will require continual adjustment to keep the output of the receiver more or less constant.

The function of the AGC is to vary the gain of a receiver to maintain a reasonably constant output power even though there are large variation in the input signal level i.e.

the gain of the receiver must be reduced by the AGC system when a large amplitude input signal is received and increased for a small input signal.

Variation of gain also serves to prevent the output level changing over much as the receiver is tuned from one station to another and also afford and it also afford it also avoid audio frequency amplifier distortion caused by its overloading as a result of larger input signal. (3).

2.4.9 AUDIO AMPLIFIER

It is made up of one or more amplifier which brings the reconstructed audio signal to a level that can operate the receiver speaker system.

2.4.10 AUDIO AMPLIFIER POWER AMPLIFIER

This could be either class A, B, or C amplifier.

Class A Amplifier: It experience little or no signal distortion. It has a maximum signal distortion of about 50% and a low efficiency.

Class B Amplifier: It is also called the push pull amplifier. Its output is distorted and hence only use in circuit that can replace or restore the missing half cycle i.e. Tuned radio circuit and has a maximum efficiency of about 78.5%.

Class C Amplifier: The output here are narrow pulses that is less than half the periodic time of the input signal waveform. It is use in radio frequency power amplifier as well as in some oscillator circuit.

2.4.11 LOUD SPEAKER

It converts the changes in electrical energy to change in air pressure thus reproducing the original sound.

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3.0 DESIGN AND ANALYSIS OF FM TRANSCEIVER

THE DESIGN STAGE.

PRE - AMPLIFICATION

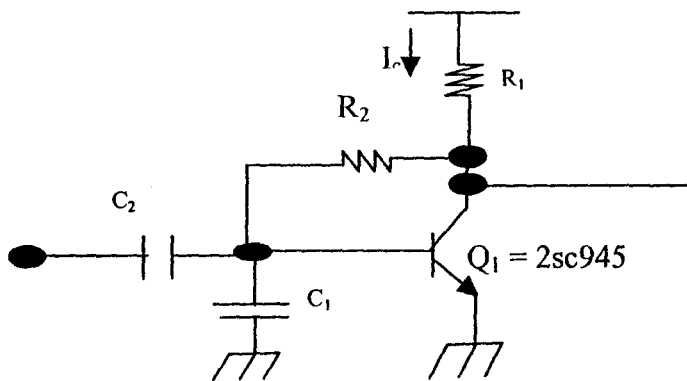Fig.3.1 pre-amplification circuit diagram

BIASING CALCULATION.

From the above diagram fig. 3.1:

$I_C = 4.5$ mA

$h_{FE} = 120$

$V_{CC} = 9v$

$V_{CE} = \frac{1}{2} V_{CC}$

$= \frac{1}{2} \times 9 = 4.5V$

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$R\, I_C = V_{CE}$

$\therefore R_1 I_C = V_{CE}$

$R_1 = \dfrac{V_{CE}}{I_C} = \dfrac{V.5}{4.5x10^{-3}}$

$R_1 = 1000\Omega$ (ohms)

$h_{FE} = \dfrac{I_C}{I_B}$

$I_B = \dfrac{I_C}{h_{FE}} = \dfrac{4.5x10^{-3}}{120} = 37.5\mu\,A$

$I_B = 37.5x10^{-6}\,A$

for silicon transistor $V_{BE} = 0.7V$

$V_{R2} = V_{CE} - V_{BE}$

$\qquad = 4.5 - 0.7$

$\qquad = 3.8V$

$R_2 I_B = V_{R2}$

$R_2 = \dfrac{VR_2}{I_B} = \dfrac{3.8}{37.5x10^{-6}}$

$R_2 = 101K$ ohms

$F_2 = 20\ KH_Z$ (for speech frequency)

$C_2 = \dfrac{1}{2\pi\ f}$

$$C_2 = \frac{1}{2x3.142x20x10}$$

$$C_2 = 8x10^{-6}F$$

$$C_1 = \frac{1}{2\pi R_2 F}$$

$$C_1 = \frac{1}{2x3.142x101x10^3 x20x10}$$

$$C_1 = 79x10^{-12}F ,$$

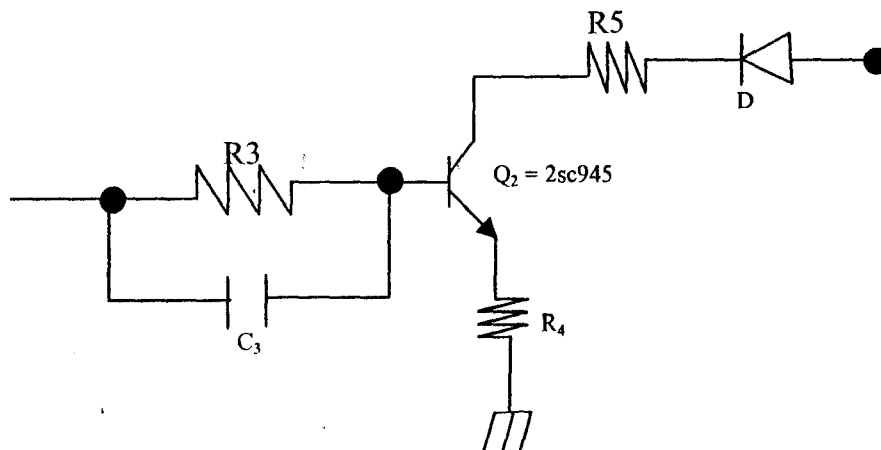$$C_1 \approx 100x10^{-12}F$$

FM MODULATOR STAGE

Fig. 3.2: MODULATOR CIRCUIT DIAGRAM

In the biasing, consideration was made so that the collector current is not too much to over modulate and not too low to under modulate the carrier.

$h_{FE} = 120$

$I_c = 96$ mA

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$$I_B = \frac{I_C}{h_{FE}}$$

$$I_B = \frac{96 \times 10^{-3}}{120}$$

$$I_B = 800 \times 10^{-6} \, A.$$

$$R_3 = \frac{VR_3}{I_B} = \frac{4.5}{800 \times 10^{-6}}$$

$$R_3 = 5.625 \, k\Omega$$

$$R_3 \approx 5.6 \, k\Omega$$

$$C_3 = \frac{1}{2\pi \, R_3 F}$$

$$C_3 = \frac{1}{2 \times 3.142 \times 5.6 \times 10^3 \times 20 \times 10^3}$$

$$C_3 = 1.42 \times 10^{-9} \, F$$

then VR5 = V_{CC} - V_{CE}

$$= 9 - 0.9$$

$$= 8.3V$$

$$R_5 = \frac{VR_5}{I_C} = \frac{8.5}{96 \times 10^{-3}}$$

$$RS = 89\Omega$$

$$RS \approx 100\Omega$$

Applying the approximation (junction resistance)

31

$$r'e = \frac{26mv}{IE}$$

$$I_E = I_C$$

The input resistance to the transistor in the CE configuration is

Hin Rr'o=R26mV

$$Hie = \quad 120\left(\frac{26x10^3}{96x10^{-3}}\right)$$

For dynamic values of input and load resistance

rin $\approx$ $hie = 32.5\Omega$ hie//R$_3$

$$rin \approx \frac{32.5x5.6x10^3}{32.5 + 5.6x10^3}$$

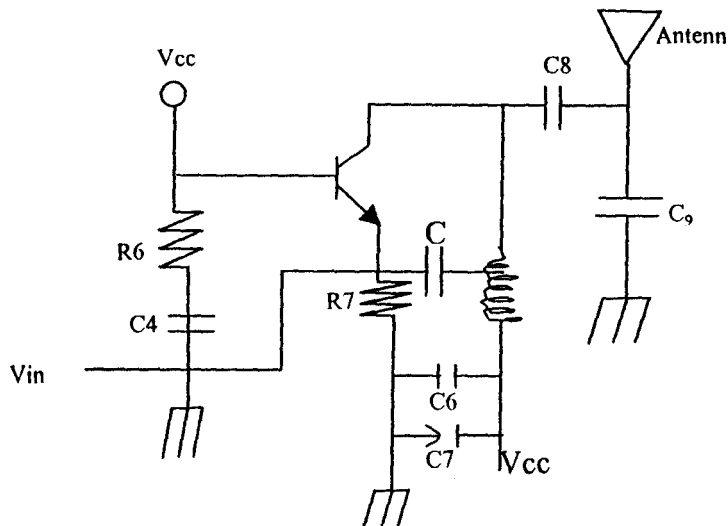$$rin \approx 32.3\Omega$$

OSCILLATOR STAGE

Fig. 3.5 oscillator circuit/antenna diagram

The common-base amplifier and dynamic signal condition

$$V_{EE} = I_E R_E + V_{EB}$$

$$V_{EE} = I_E R_7 + V_{EB}$$

$$V_{EB} = 0.7 \text{ Silicon transistor}$$

$$I_C \approx I_E = 8 \times 10^{-3} A$$

$$R_7 = \frac{V_{EE} - V_{EB}}{I_E}$$

$$= \frac{9 - 0.7}{8x10^{-3}} = \frac{8.3}{8x10^{-3}} = 1038\Omega$$

Determining the value of Rl which is inductive

$$\therefore R_7 = 1kohms$$

$$V_{CB} = 1/3 \, V_{cc}$$

$$= 1/3 \times 9$$

$$= 3V$$

$$V_{EE} = V_{CB} + V_{RL}$$

$$V_{RL} = 9 - 3 = 6V$$

$$I_C R_L = V_{RL}$$

$$8 \times 10^{-3} RL = 6$$

$$R_L = \frac{6}{8x10^{-3}} = 750\Omega$$

$$R'_L = 750\Omega$$

At this point, we have calculated the values off R_7 and R_L necessary to establish proper

D.C. Conditions so that amplification can take place.

DYNAMIC SIGNAL CONDITIONS

To find input signal current (i.e.), firstly, we determine value by the signal source.

Applying the approximation (function resistance)

$$rj \approx \frac{26mV}{I.d.c.}$$

becomes $\quad r'e = \frac{26mV}{I_E}$

where $r'e = \frac{26mV}{8x10^{-3}}$

$r'e = 3.25\Omega$

To the signal source, r'e and R_7 appear to be in parallel.

Then rin $\approx$ r'e // R_7

$$rin \approx \frac{3.25x1038}{3.25 + 1038}$$

$rin \approx 3.2\Omega$

$$i_{in} = \frac{v_{in}}{rin} \approx \frac{3.5mV}{3.2}$$

$i_{in} = 1x10^{-3} = A_{pp.}$

Since the signal is applied to the emitter, we can say that

I_{in} = i.e. $\approx$ ic (or I out) $\approx$ 1mA$_{pp}$

But the dynamic load $\approx R_L$//R where R is the resistance of the antenna (R=75Ω)

$r_L \approx$ 750//75

$$r_L \approx \frac{750x75}{750 + 75}$$

$r_L \approx 68\Omega$

Finding output signal voltage

Vout = icrl

= 1x10^{-3} x68

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$V_{out} = 68 \times 10^{-3} V$

Voltage gain $= \dfrac{Vo}{Vi} \approx \dfrac{0.068}{3.5 \times 1010^{-3}} = 19$

Voltage gains ≈ 19

Current gain $= \dfrac{i_{out}}{i_{in}} = \dfrac{i_c}{i_e}$

≈ 1 in CB configuration

Power gain = current gain x voltage gain

≈ 1 x $19 = 19$.

The total capacitance, C_t of the Hartley oscillator

$C_t = C_5 + C_8 + C_9$

$C_t = 7 \times 10^{-12} + 5 \times 10^{-12} + 2 \times 10^{-2}$

$= 14 \times 10^{-12} F$

To calculate the value of the inductor used in the oscillator tank.

$F = 103.7 mHz$

$F = \dfrac{1}{2\pi \sqrt{Lct}}$
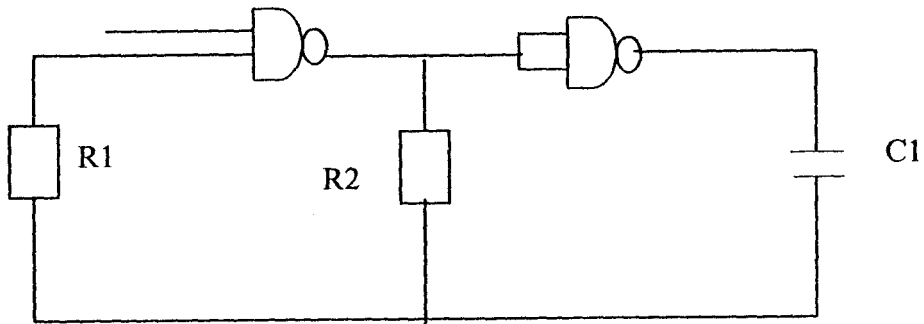
$L = \left(\dfrac{1}{2\pi F}\right)^2 . \dfrac{1}{c}$

$L = \left(\dfrac{1}{2 \times 3.142 \times 103.7 \times 10^6}\right)^2 \dfrac{1}{14 \times 10^{-12}}$

$L = 168 \times 10^{-9} H$

CODING PART

C MOS OSCILLATOR 1

Oscillator frequency f1

$$F_1 = \frac{1}{2.2RC_1}$$

But $R = R_1 + R_2$

$R_1 = 100k\Omega$

$R2 = 33\ k\Omega$
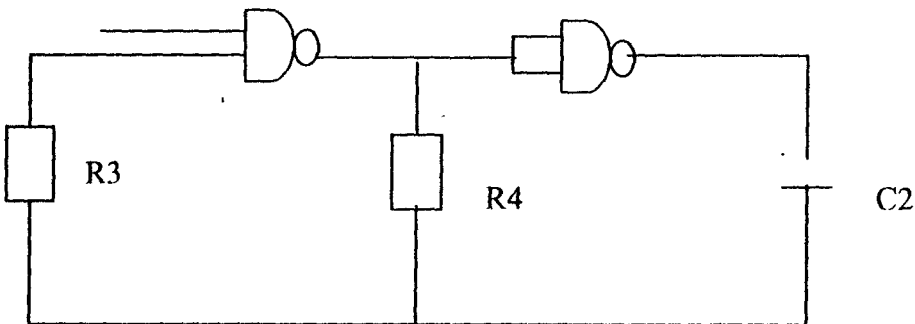
$C1 = 0.01\mu f$

$R = 100 + 33 = 133\ k\Omega$

Hence

$$F_1 = \frac{1}{2.2 \times 133 \times 0.01 \times 10^{-6}} = 341.8 Hz$$

CMOS OSCILLATOR 2

Oscillator Frequency, F2

$$F1 = \frac{1}{2.2RC_2}$$

But R = R$_3$+ R$_4$

R$_3$ = 100kΩ

R4 = 33 kΩ

C2 = 0.01μf

R = 33+ 33 =66 kΩ

Hence

$$F_2 = \frac{1}{2.2x66x10^3 x0.047x10^{-6}} = 146.5Hz$$

3.1 CONSTRUCTION

Components required for the construction were sourced for and those that are unavailable were replaced by their substitute. Ideally, these transceiver is to operate a single station which implies that the exact frequency of the station to be received should be utilized i.e. but considering the fact that the clarity of reception varies i.e. day and night, this give rise to the necessity for the station to be fine tuned in order to get a good reception and this lead to the circuitry not being on a fixed frequency nut ranging between two fixed frequency (upper and lower to the required frequency). This implies the station could be fine-tuned till the best reception is obtained.

After getting all the required component, the prototype of the construction was built on the breadboard. While arranging on the breadboard, the input and output of each stages was tested. This include

RF – AMPLIFIER STAGE

The RF amplifier is use in communication system to increase the sensitivity and selectivity of the receiver. A typical RF amplifier will have tuned resonant circuit on its input and output to help in selecting the desired signal.

A single RF amplifier could be used at once, also the RF amplifier could be connected in cascade i.e. more than one RF could be use (MULTI-STAGE) with the output of one connected to the input of another. This is done to increase the receiver sensitivity, and is

attained by ganging the circuit. Input to the RF stage is the incoming radio signal and the output is the amplified version of the received radio signal.

LOCAL OSCILLATOR STAGE

An oscillator is use to generate waveform or output signal without an input signal. They can generate different types of the waveform. For continuous oscillation of the oscillator, it must have the following:

1.   A source of energy i.e. power supply, battery etc.

2.   An amplifier i.e. transistor, integrated circuit (IC)

3.   Frequency determining circuit which could consist of i.e. tuned LC circuit, RC time constant circuit etc.

4.   Feed back circuit (positive feedback) - feedback is a method of transferring energy from the output of oscillator to the input so that the output and input signal are in phase it may be carried out via a wire, optical link, electromagnetic radiation etc.

The different type of oscillator in use include

-    The Colpitt oscillator.

-    Clamp oscillator

-    Crystal oscillator etc.

Here, the local oscillator is use to generate a sine wave which is mixed with the incoming signal. It does not have any input as stated but the output equal i.e.

Received signal frequency + 455KH$_z$ for AM

Received signal frequency + 10.7MH$_Z$ for FM.

MIXER STAGE

In some circuitry, the mixer and the local oscillator are combined together

(FREQUENCY CHANGER) and in others they are separated. Local oscillator generates

a frequency equivalent to (F_{LO}). This is mixed with the amplified received radio signal

(F_{RF}) to give the intermediate frequency (F_{IF}) as one of the output, the intermediate

frequency serves as the next stage i.e.

For the FM, the IF value is 10.7MH$_Z$. the* input to this stage is the intermediate

frequency (F_{IF}).

THE DETECTOR STAGE

The input signal to the FM detector is 10.7MH$_Z$. The output in turn is the restored audio

signal.

In FM, noise increases with frequency and is greatest at the extremely high frequency end

of the audio range. This particular stage is very important in the FM receiver circuitry and

its non-implementation delayed this particular project for almost a week as the FM

receiver frequency was to high to give a comprehensible output.

This is due to the fact that transmitters the magnitude *of the high frequency of the

modulating voltage was increased (PRE-EMPHASISED) so that distortion is not

introduced. In the receiver, the exact opposite of the pre-emphasis is done to bring the

frequency back to the required level. The exact opposite of the pre-emphasis is the de-

emphasis and it is done by means if a simple R – C filter as show in the receiver circuit.

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As the greatest noise is produce at the extreme high frequency which implies that in FM, the noise produce reduce with the frequency, the idea is based on the fact that in general, the magnitude of the high frequency voltages produced by music or speech are small compared to those at low level hence when the de-emphasis stage is introduced, it reduces the frequency hence the noise considerably. After the de-emphasis stage was introduced, the FM started giving a clear output.

AUDIO AMPLIFIER AND LOUDSPEAKER STAGE

It could be a single amplifier or more. This stage (audio amplifier) is use to bring the signal from the detector stage (audio signal) to a level that can operate the receiver speaker system (LOUD SPEAKERS).

Loud speaker in turn is use to convert the variation in electrical signal from the audio-amplifier stage to changes in air pressure hence producing sound which is audible and comprehensible.

After verifying that each stage is working very well, the component were then transferred to the Vero-board, where they were soldered permanently. Along the line, some component had to be desolder and resoldered. Disoldering is the process of removing solder from the circuit board. It must be done rapidly. One method used in doing this is via the lead sucker and it is use to pull the hot melted lead off the board. Some of the

equipment used in soldering and disoldering include-soldering iron, bush, lead sucker, soldering lead.

3.2 CASING OF THE WORK

The completed project was encased in a wooden container/compartment. These include all the circuitry of the receiver i.e. power-supply, coding unit, transmitter receiver circuitry e.t.c. Also, all the necessary aperture where made on the casing for ventilation, and to enable the powering of the device, and the switching from transmitter to receiver to be done with ease.

CHAPTER FOUR

4.0 OPERATION

This section gives the description of each stage of the circuit. References could be made to the previous chapters in order to obtain an overall picture of the operation.

TRANSMITTER FUNCTION (See appendix A)

Sound waves sent to the microphone are converted into electrical signal. The audio signal from the microphone is amplified at this stage to an appreciable level and then fed to the modulator. A linear amplifier is necessary at this stage so as to prevent the distortion of the message signal.

To achieve this, a class A biasing transistor is employed due to its linearity properties. The emitter-base of the transistor is forward biased with it resistance very low and the collector-base circuit is reversed biased with its résistance very high.

The common element of the transistor is at ground potential. The D.C. input signal from the battery or between emitter and the base varies the forward bias by the alternatively adding to, and subtracting from the fixed bias. The increase and decrease current in the emitter-collector circuit produces the amplified voltage thus, avoiding signal inversion.

The modulator circuit super-imposes a low frequency voice information components on a higher frequency carrier signal, which is generated by the oscillator. The diode (D) is

acting as a buffer that blocks the emitter current from the oscillator stage from affecting the operation of the transistor.

In biasing of the modulator transistor, consideration was made so that the collector current is not too much to over modulate and not too low to under modulate the carrier. The oscillator is an electric circuit that has been designed to produce an alternating emf of a known frequency and waveform. The oscillator is an amplifier that generates its own input signal, which is derived from the output signal.

A Hartley oscillator circuit is adopted for the fact that the amplified output is connected to one end of the tuned circuit, and the feedback is taken from the other end. There is also a tap on the coil to establish an a-c ground nearest the end where the feedback is connected.

The transceiver will not operate effectively unless the antenna has been properly cut to resonance.

In the middle of the radio transceiver sits two antennae, one from the transmitter and one from the receiver. In order to transmit the modulated radio signal, an electric current passes through the antenna, inducing a magnetic field, which oscillate at the given frequency. The variations in the current create slight variations in the radio frequency. These radio waves radiate outwards from the antenna in a "beam" according to antenna's design.

On the other end, when the radio is in receiving mode, the antenna is passive. The electromagnetic radiation from the originating antenna passes across the receiving antenna. This creates a magnetic field, which, in turn, induces an electric current through the antenna. The current passes through the radio receiver and is demodulated back into an electrical signal with same form as the original electrical signal from the first transmitter.

A switch normally switches the transceiver into the transmitter mode when the button is pressed.

CODE PART (See appendix B)

It consists of two CMOS oscillators, one for each frequency, one-two-input diode resistor logic (DRL) or gate, and a low-pass filter for coupling to the transmitter.

A common CMOS controlled oscillator embodies two NAND gate, two resistors and a feed back capacitor. They are responsible for the output frequency of the oscillator i.e. the higher the resistance, in the circuit, the lower the output frequency and the lower the resistance, the higher the operating frequency. Therefore, the frequency is inversely proportional to the resistance. Also, the higher the capacitance, the lower the frequency and the lower the capacitance, the higher the frequency.

Push button is used to control the oscillator. When the button is pushed, the oscillator is switched ON. But when undisturbed, the oscillator remains OFF. The control is accomplished by the careful use of the truth table of the NAND gate.

```
A
                        ⊐D⊃o                C
B
```
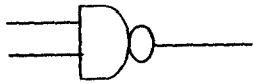
TRUTH TABLE OF A NAND GATE

A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

A NAND gate is an active low logic device. And this is satisfied whenever the inputs A and B are high. Therefore, when the oscillator is OFF one of its input is low, so the push button set the input high which activates the oscillator.

The high frequency oscillator represents logic 1 for the coding and low frequency represent logic 0

The Or- gate adds the two inputs so as to make a common input, which passes through the low-pass lifter to the transmitter.

COMPONENTS SELECTION

FM TRANSMITTER

RESISTORS

R_1 Loading resistor

R_2 Feed back resistor

R_3 RC coupling

R_4 Current limiting resistor.

CAPACITORS.

C_1 Amplifier coupling capacitors

C_2 RC coupling capacitor

C_3 (f) biasing capacitor

C_4 Oscillator feedback

C_5 Smoothening capacitor

C_6 Coupling capacitor

C_7 Filter capacitor.

DIODE

D_1 Coupling diode (forward biased)

COMPONENTS SELECTION FOR THE CODING CIRCUIT.

$R_1 = 100 \ k\Omega$

$R_2 = 33 \ k\Omega$

$R_3 = 33 \ k\Omega$

$R_4 = 33 \ k\Omega$

$R_5 = 33 \ k\Omega$

$R_6 = 1 \ k\Omega$

$R_7 = 33 \ k\Omega$

$R_8 = 33 \ k\Omega$

CAPACITORS

$C_1 = 0.01 \ \mu F$

$C_2 = 0.047 \, \mu F$

$C_3 = 1.\mu F$

$C_4 = 0.001 \mu F$

SWITCH

SW$_1$ For higher frequency   → 1(+)

SW$_2$ For lower Frequency   → 0(-)

RECEIVER FUNCTION (See appendix C)

Signal arriving from the antenna is passed through the C_8 and C_9 including the L_3 circuit

for effective coupling into the main receiver circuit through pin no. 1 and pin No. 2 of the

KA2297 mixer IC. The circuit of C6 and L1 are connected to pin N. 15 and 14 for the

radio frequency selection. Close to the effective coupling is the first leg of amplifier tuner

crystals T x TL1 and T x TL2 connected to pin No. 3, 6, 8 and 10 sequentially to the

KA2297iC.

The C 10 connected to pin No. 5 serves as an internal circuit filter to the I.C.. the choke

L3 prevent the RF from entering into power supply unit.

The C7 and L2 circuit is the local oscillator circuit that functions with the RF selector

circuit to maintain the intermediate frequency at 10.7mHz which is the strongest

amplitude frequency (bits) fit for amplification by the audio speaker.

The mixer circuit is a component of the KA2297IC connected to pins outwardly. C2 C3

and C4, R1, R2 and R3 constitute the circuit for the automatic gain control (AGC) for

proximity effect control by the audio amplifier as well as noise removal. C5 serves as

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coupling capacitor to the audio amplifier, while C11 and C12 serves as power smoothening capacitors.

The amplifier amplifies the intermediate frequency signal. The audio signal stage uses the IC LM386, which is a power amplifier, designed for use in low voltage applications. The gain is internally set to 20 to keep external part count low. The addition of external resistor and capacitor between pins1 and 8 will increase the gain to any value from 20 to 200.

The power supply is the pin 6 of the IC . Pin 2 and 3 are the inputs, which uses a 1000 uF capacitor to filter the incoming signal. Pin 5 is the output that is connected to the loud speaker through the coupling and filtering capacitor that filter off noise.
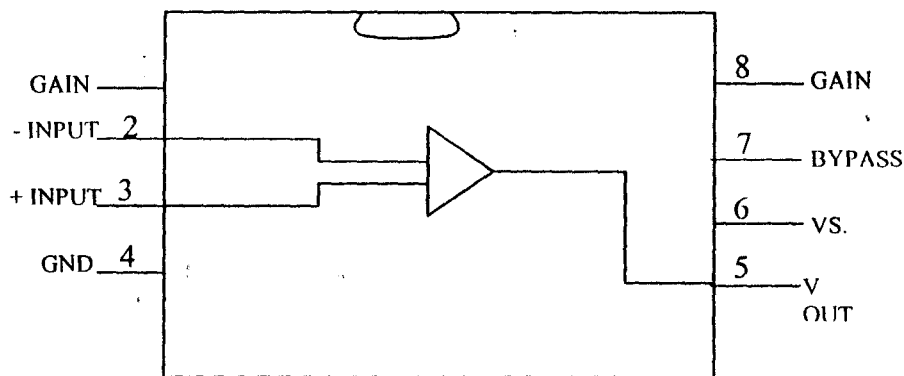

Fig IC LM386 (AUDIO IC)

The audio amplifier consists of a non-inverting amplifier, which shows that the waveform of the signal sent will be the type it will produce as the output. For instance, the sinusoidal signal fed in will produce a sinusoidal signal wave output.

Both inputs are biased to the ground with a 50kilo ohm resistor. The base current of the input transistor is bout 150nA. so the inputs are about 12.5mv when left open.

The resistor and capacitors are chosen in such a way that they will not limit the operational capability of the LM386 integrated circuit.

FEATURES OF THE LM386 AUDIO IC

Battery operation

Minimum external parts.

Wide supply voltage range 4v-12v or 5v-18v

Low quiescent current drain 4 mA

Voltage gains from 20-200

Available in 8 MSOP package.

Applications

AM-FM radio amplifiers

Portable tape player amplifiers

Intercoms

TV sound system

Power converters

Etc.

FM RECEIVER

COMPONENTS SELECTIONS

CAPACITORS

C_1 = 0.01 μF for smoothing the circuit.

C_2, C_3, C_4 0.001 μF, 0.022 μF, 0.1 μF for soothing and noise removal.

C_5 = 0.1 μF coupling capacitor to the audio amplifier

C_6 = 22pf for the FM oscillator circuit

C_8, C_9, 20 pF for antenna circuit, ensure the effective coupling of the antenna to the device.

C_{10} = 33 μF internal circuit switching capacitor

C_{11}, C_{12}, = 0.01 μF, 100μF power smoothing capacitors.

INDUCTORS

L1 = 4T for RF LC circuit

L2 = 3T for oscillator circuit

L3 = 4T for Antenna choke

Their diameter is 0.5m or 50cm

XTAL2 = 10.7MHz crystal for separating the intermediate frequency from other unwanted frequencies turning.

XTAL1 =10.7MHz Crystal for the internal tuned intermediate frequency

RESISTORS

R1= 100KΩ

R2 = 100kΩ

R3 = 1kΩ

4.1 PROBLEMS ENCOUNTERED

1. Some of the components needed were not readily available; this gave rise to moving from one place to another and at times the eventual replacement of the component with their close substitute.

2. Closure of school due to student unrest and ASUU strike.

3. In availability of higher capacity oscilloscope for tuning the crystal to achieve better coverage

4. Replacement of burnt component.

4.2 CONCLUSION.

It is worth noting that despite the constraint the project was tested and confirm working in accordance with the desired objective following the project lay out plan and procedure.

4.3 PRECAUTIONS

i. Each of the component used were selected with care

ii. The continuity of the breadboard and Vero-board was checked.

iii. The initial arrangement of component on breadboard and the eventual transfer to the Vero-board was done with care.

iv. The soldering of the component was done with care to avoid short-circuiting.

4.4 SUGGESTIONS

1 I suggest that adequate provision should be made for acquisition of practical knowledge

2 More lecturers should be employed I the department to reduce the pressure on the few ones available.

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3   Also the laboratory should be equipped with more practical equipment so that the program could be appreciated better.

4.7 RECOMMENDATION

Based on the limitation of this project work I do recommend that coming generation should improve on it subject to the availability of tools and materials.
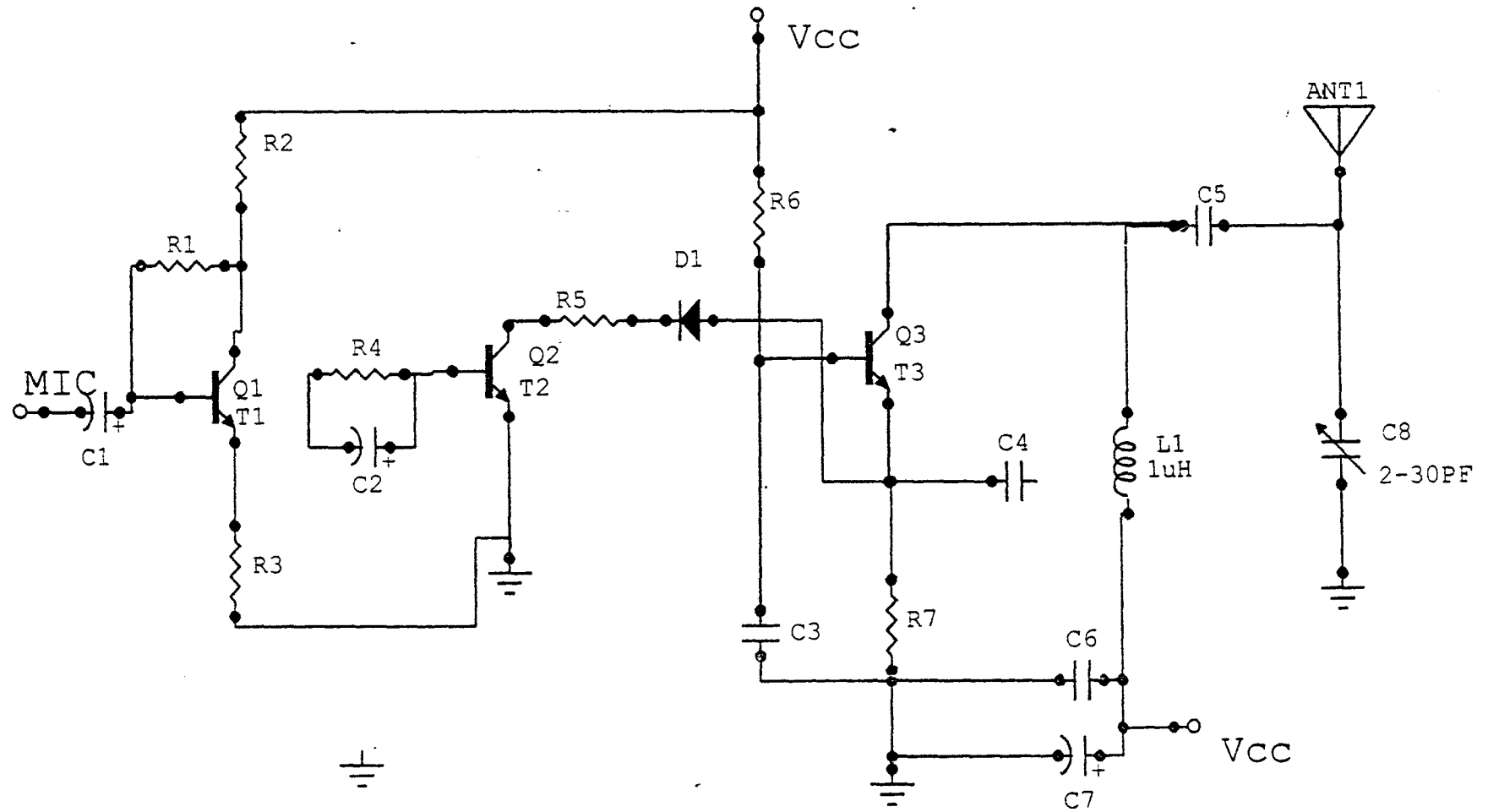
4.8 REFERENCES
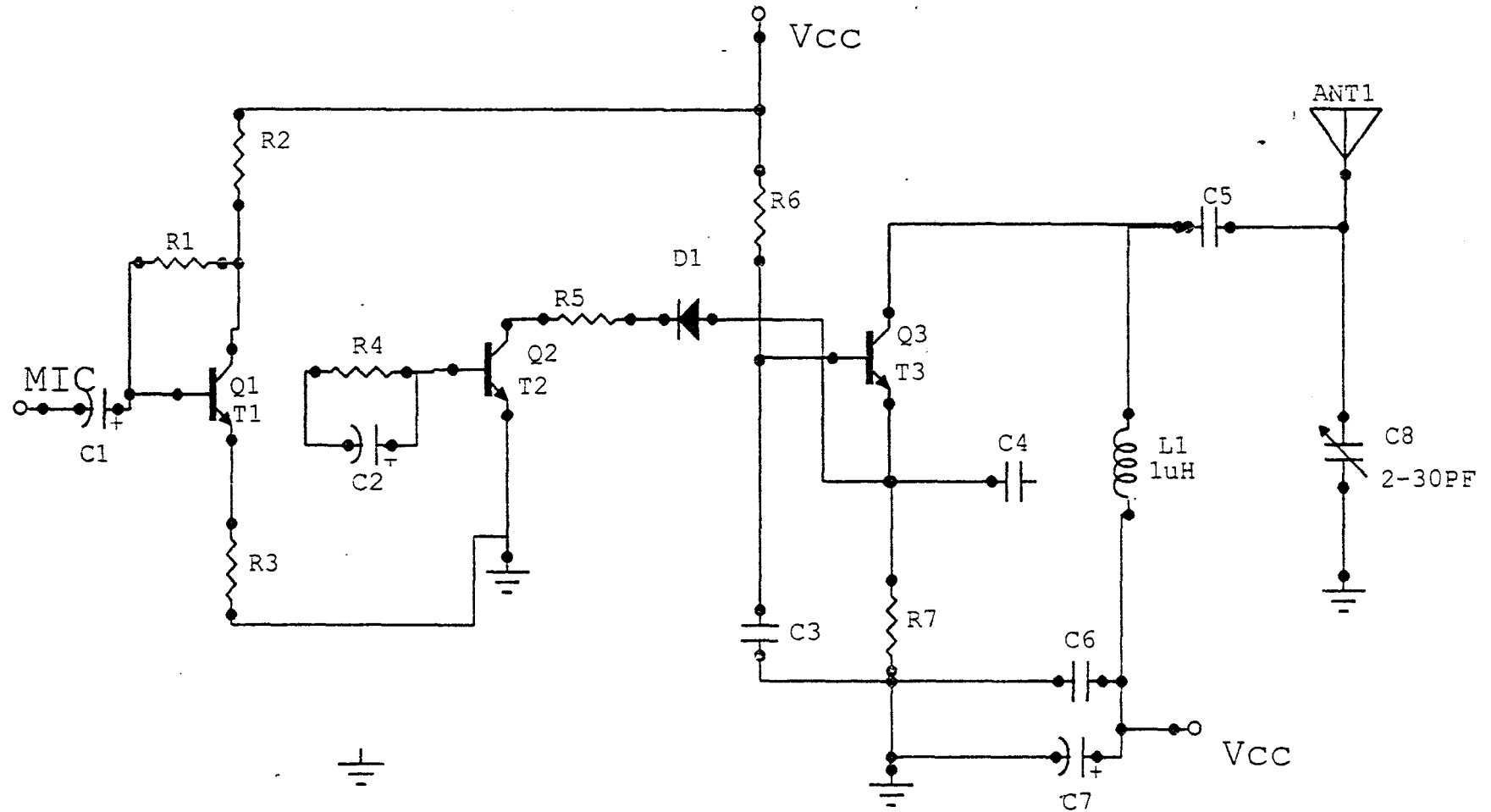
Art of electronics by Paul Horowitz

Telecommunication principle by Dr. Y.A Adediran

IEEE student journals   May 2001 edition

Design and construction of electronics movement chart with transceiver by Gloria Idumije

Vcc

ANT1

MIC

R1

R2

R3

Q1
T1

C1

R4

C2

Q2
T2

R5

D1

R6

Q3
T3

C4

C3

R7

C5

L1
1uH

C6

C7

C8
2-30PF

Vcc

FM TRANSMITTER CIRCUIT DIAGRAM.

FM TRANSMITTER CIRCUIT DIAGRAM.