DESIGN AND CONSTRUCTION OF A FREQUENCY MODULATION (FM) TRANSCEIVER

BY

ETUKUDO EMEM

REG. NO: 97/5995EE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING.

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY,

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CERTIFICATION

This is to certify that the project work title "Design and Construction of FM Transceiver" was carried out by Etukudo Emem under the supervision of Engr. J. Tsado and Engr. M. N. Ahmed, and submitted to the department of Electrical and Computer Engineering for the award of B.Eng in Electrical and Computer Engineering of the Federal University of Technology, Minna.

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Engr. J. Tsado Date

Project Supervisor

------------------------ 15/4/84

Engr. M. N. Nwohu Date

Head of Department

------------------------ ------------------------

Engr. M. S. Ahmed Date

Project Co-ordinator

------------------------ ------------------------

External Examiner Date

DECLARATION

I hereby declare that this thesis is my original work and has never been printed else where for award of any degree.

Information derived from published and unpublished work of others has been acknowledged in this project write up.

ETUKUDO EMEM 17-10-03

DEDICATION

To Jesus Christ the greatest influence upon me who has made living meaningful and rewarding.

And

To my beloved parents Elder and Late Mrs. E.J Etukudo and the entire family, thank you for co-operating with the purpose of God for my life. I love you all.

ACKNOWLEDGEMENT

I am very grateful to God Almighty, the author and finisher of my faith of his mercy and goodness bestowed on my family and I. May his name be exalted forever- Amen.

My special thanks goes to my caring father Elder E.J Etukudo and the entire family of Etukudos for their special love, care and support rendered to enhance my success in life. May I remain to be the true son of the family in Jesus name – Amen.

My profound gratitude goes to my able, diligent and kind hearted supervisor Engr J. Tsado for his absolute monitoring of this project work, his assistance in terms of knowledge and advice to make my degree course a success.

Special thanks also go to my caring and loving younger brother, John and my sisters Atimma and Ma-may for their concern and the part they played especially during my early University studies.

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Finally, my special appreciation is extended to all my friends – too numerous to mention that stood by me and encouraged me through out the degree course especially my project partner Student Engr. Kenneth Paul. May they ever be rewarded in Jesus name.

ABSTRACT

This project report is on design and construction of a Frequency Modulation (FM) Transceiver system. It involves both the transmitter and receiver for sending and receiving signal.

In FM, the AF energy coming from the Microphone or transducer is amplified to the required power level by low distortion amplified operating class A. The high quality audio thus produce is used to modulate the radio frequency carrier. The radio frequency "carrier" wave is generated by a stable oscillator usually lower power, which is usually LC controlled to achieve long distance coverage of transmission. That the carrier wave is only a constant amplitude, high frequency a.c wave until it is modified in some way to convey intelligence. When the power level is satisfactory, the radio frequency carrier is coupled to the antenna where the energy is radiated into the air. The radiated electromagnetic energy travels away from the antenna at the speed of light, approximately 186,000 miles per seconds or 300 million metres per second.

The receiving antenna picks up energy from the transmitter whose output passes through its intercept area. Selection of the desired signal or station is accomplished by resonant L-C circuits at receiver input. At the receiver we find a non-linear device producing some and difference frequencies, this time at very low power level. The stage which this "mixing" takes place is referred to as mixer or converter. The antenna furnishes one of the signals to be mixed and a "local" oscillator furnishes the other. The difference frequency signal from the mixer is referred to as the intermediate frequency (IF), which is the new carrier frequency. The IF is further demodulated and required audio is amplified which is the required signal through a transducer.

CHAPTER ONE

INTRODUCTION

Communication in its widest sense entails the exchange or sending of information from one person to another.

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.

Any communication process must have an INFORMATION SOURCE. This is the origin of the information to be communicated. Next, the information must be encoded or converted to an electrical signal. This second stage is often referred to as the transmitter. From the encoder or transmitter, the communication message is fed through some "channel". This can be electromagnetic waves, wires, air or some other mediums.

After this message is fed through the particular channel, it is to be decoded. This stage picks up the transmitter message and converts it into some intelligent form in sound or picture (video). Many times the decoder stage is called the RECEIVER.

Lastly, the information is fed to the destination, which could be a person or persons or machines. However, noise can interrupt or break communication. Noise in communication system can be defined as any unwanted or desired signal interfering with the reception and processing of the desired signal. It can be classified into two broad categories, depending on it source – internal or external noise.

Notably, the most common place where noise enters the communication process is in the message channel.

The application of this type of system covers a wide range, from broadcasting, public address system, to Walkie – talkie systems or transceivers. A simpler communication model is shown in fig. 1.0

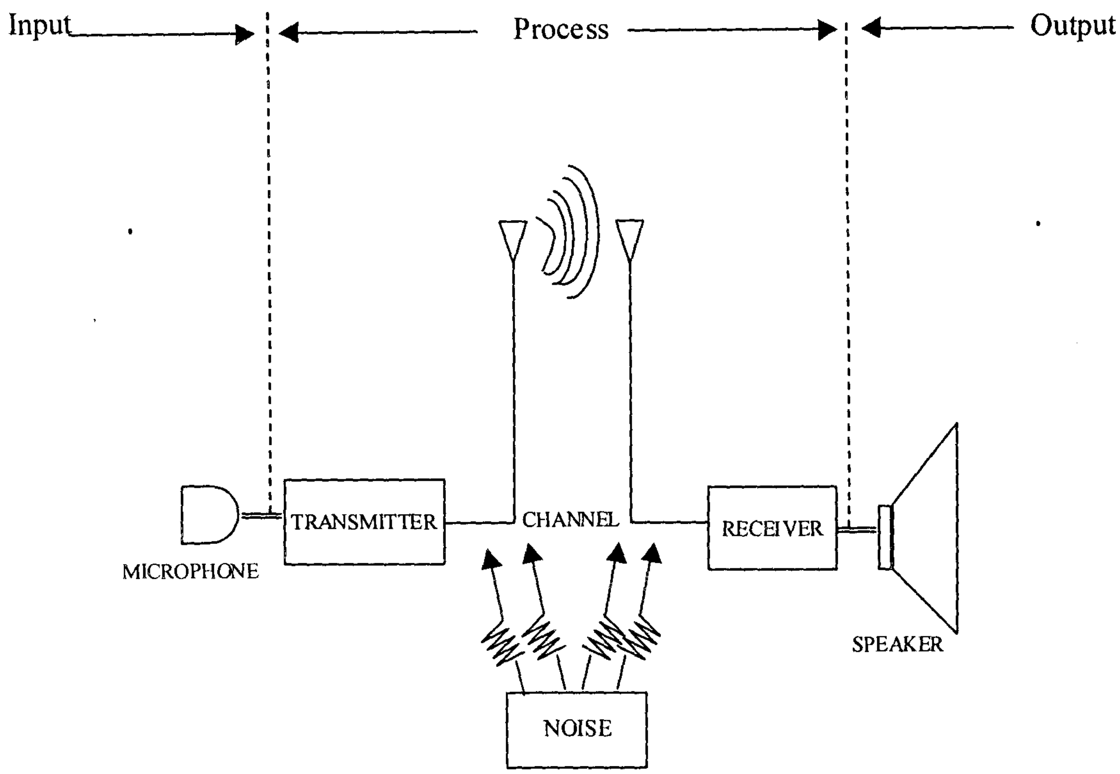

FIG 1.0: BASIC TRANSMITTER / RECEIVER COMMUNICATION MODEL

It must be remembered that the use of space in communication is rigidly controlled, not only by our own Federal Ministry of Communication, but also by organisation or union involving other countries. This must be assigned to satisfy the need of all the people for industrial, military and entertainment purposes and at the same time minimize any interface between the services.

Another general classification of waves is according to frequency (electromagnetic spectrum). This will prove useful when discussing ranges of frequencies.

FREQUENCY BAND	**CLASSIFICATION**
20 – 20,000 Hz	Audio Frequency
3 – 30 kHz	Very Low Frequency (VLF)
30 – 300KHz	Low Frequency (LF) or Long Wave
300 – 3000KHz	Medium Frequency (MF) or Medium Wave (MW)
3 –30 MHz	High Frequency (HF) or Short Wave (SW)
30 – 300MHz	Very High Frequency (VHF)
300 – 3000MHz	Ultra High Frequency (UHF)
3 – 30 GHz	Super High Frequency (SHF)
30 – 300GHz	Extra High Frequency (EHF)

AIM AND OBJECTIVE

The aim and objectives of this project is to design and construct a frequency modulation (FM) transceiver that will transmit and receive an audio signal. This means the speech or message signal will be transferred from a source to a medium or channel to a known destination.

Radio receivers and transmitters are part of devices used in communication systems.

Notably, the main function of a transmitter in the radio communication and broadcasting is to deliver enough radio frequency (RF) power for radiation by the transmitting antenna to a receiver which selects and recovers the original message from the various RF signals that arrives at the receiving antenna.

The transmitting process includes modulating a high frequency carrier with the message signal for ease of radiation while the 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.

PROJECT OUTLINE

In the preceding chapter effort was made to discuss and analyse what is communication, the process involved and it models to ranges of frequency band for each classification.

The purpose is to show case an example of modulation in the transmission of speech and its frequency which covers a band up to 10KHz, which is much too low for global transmission.

Consequently, we modulated a radio frequency signal (the carrier) with the speech frequency (the modulating signal) in order to broadcast it; the speech signal is finally demodulated in the radio receiver.

In chapter two, the system analysis and design is given its functional description from the transmitter, its frequency modulation to the receiver including their block diagrams.

In chapter three, a concise explanation on construction, testing and result was explained with development of the casing.

Presented in chapter four were conclusion, recommendations, references and appendix (ces) of the system.

RELEVANT LITTERATURE REVIEW

The development of radio in the late 1800's revolutionized communication. At that time, people used other means of quick, long – distance communication – telegraph and telephone. But the signals sent by both devices had to travel through wires. As a result, telegraph and telephone communication was possible only between places that had been connected by wires.

Radio signals on the other hand passed through the air. Thus, radio enabled people to communicate quickly between any two points on land, at sea, and – later in the sky, and even in space.

Prediction of radio existence was made in 1864 by James Clerk Maxwell (1831- 1879) the great English mathematical physicist.

In 1888, a German physicist Heinrich Hertz (1857-1894) demonstrated that waves do actually exist and they travel through space.

In 1871- 1937 an English physicist Ernest Rutherford succeeded in sending signal over a range of ¾ mile.

Another English man Oliver Lodge (1851-1940) developed the basic principle of tuning

Notably, in 1895, Guglielmo Marconi an Italian inventor, combined earlier ideas and his own ideas and sent the first radio communication signal through the air. He used electromagnetic waves to sent telegraph code signals a distance of more than 1 mile (1.6 kilometers)

There are many claims to the broadcast of human speech over the air.

Most historian gives credit to Reginald A. Fessenden, a Canadian – born physicist.

In 1906, Fessenden spoke by radio from Brant Rock, Massachusetts, to ships offshore in the Atlantic Ocean saying, "if you have heard this programme, write to R. A. Fessenden at Brant Rock".

An American inventor Edwin H. Armstrong did much to improve radio receivers. In 1918, he developed the super-Heterodyne circuit. In 1933, he discovered how to make FM broadcasts.

In 1904, the first vacuum tube was made by John Ambrose Fleming (1849-1945) an English electrical engineer.

This tube was a 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. This new vacuum tube was called triode or audion, it was much like vacuum used today.

The first practical use of the "wireless" which was then called, was for ship – to - ship and ship – to – shore communication.

The above great men and their respective effort was to come about how signal can be transmitted and received.The transmitter can be AM or FM.

FM transmitters are basically similar to AM transmitter while virtually all receivers AM, FM, TV, Short Wave and so on are termed superheterodyne because of the way in which they process the signal.

It is worth pointing out here that "tele" is derived from the ancient Greek word for "at a distance " "phone" means sound or speech, "graph" means writing or drawing. So the following well known terms have emerged:

(a) Telecommunication – communicating at a distance

(b) Telephone – speaking at a distance

(c) Television – seeing at a distance

(d) Telegraph – writing at a distance

CHAPTER TWO

SYSTEM ANALYSIS AND DESIGN

The design of this FM transceiver system is better presented in its function description, which is divided into two parts viz the transmitter and the receiver.

THE TRANSMITTER

Any radio communication system needs a device that will transfer information from one point to another. This device is known as a transmitter. Thus, a transmitter is a device used for the sending of intelligence by means of radio waves from one point to another. The transmission of intelligence involves the modulation of an audio signal by impressing on it a suitable carrier frequency so as to allocate to it a frequency spectrum and then amplified to the necessary power level.

Radio signals are transmitted and received by means of an aerial, but since no kind of aerial can operate at such low frequencies it is necessary to MODULATE – shift each signal to some higher frequency.

MODULATION

Modulation is the process of super imposing a low frequency (containing information) into a high frequency (carrier) which does not contain information before being sent over long distance as required.

It is necessary to modulate because the low frequency can not travel far but it carried the information while the carrier can travel very far and so carry the low frequency along. It is of course necessary to carefully choose the frequency bands to which the signals are moved in order to ensure that each service within a given geographical area operates at a different frequency. In practice, the frequency band which are used for particular purposes are allocated in accordance with the recommendations of the International Telecommunication Union (I.T.U)

Two methods can be used in this regard. These are Amplitude Modulation (AM) and frequency (FM). For this project work, we are interested in FM.

FREQUENCY MODULATION (FM)

Frequency modulation (FM) is the process by which we vary the frequency of the carrier wave with respect to the amplitude of the modulating signal.

In FM, the amplitude of the carrier wave is kept constant during modulation, and so the power associated with a FM wave is constant.

When the modulated signal amplitude is zero, the modulated signal has the same frequency as the carrier wave.

When the modulated signal voltage is positive, the frequency of the modulated signal is greater than the unmodulated carrier signal, and when the modulating signal is negative, the frequency of the modulated signal is less than that of the unmodulated carrier.

The maximum frequency of the modulated signal clearly occurs when the modulating signal is at its maximum positive value; the minimum frequency of the modulated signal occurs when the modulating signal is at its max. negative value.

Frequency modulation (FM) which is used for sound broadcasting occupies the 88MHz – 108MHz band.

The wave forms is illustrated below:

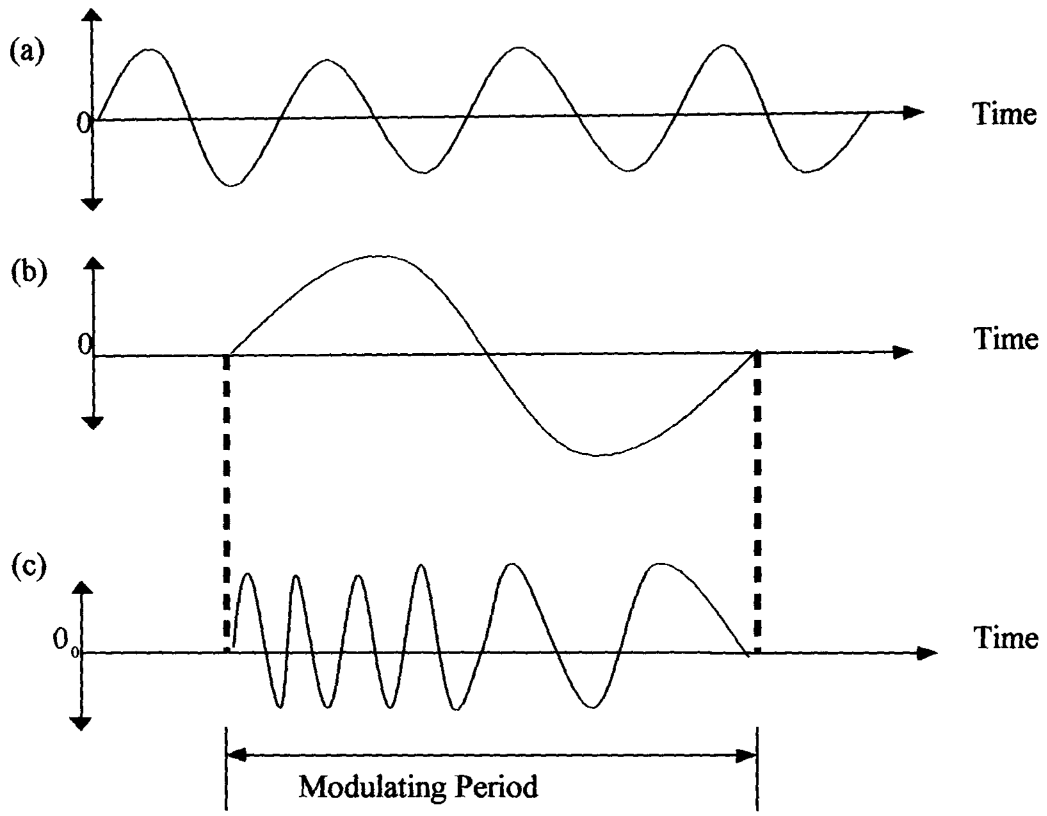

FIG 2.1:

(a) the carrier signal

(b) the modulating signal and

(c) Modulated signal.

From Fig 2.1 (a), (b), and (c) it can be seen that as the amplitude of the modulating signal increases positively, the frequency of the modulating signal carrier increases, as can be seen by the closing together of the waves and as the amplitude of the modulating signals decreases, the frequency decreases. This can also be observed by the spacing of the waves.

ANALYSIS OF FM

Let the instantaneous wave carrier be

$$V_C = A_C Cos\,(w_c t + \Phi)$$
$$= A_C Cos\,(2\pi f_C t + \Phi)$$

$$f_d(t) = KfV_m(t) = \frac{1}{2\pi}\frac{d\Phi(t)}{dt}$$

Where $f_d(t)$ is instantaneous frequency deviation and it is proportional to the message or modulating signal Kf is the frequency deviation constant.

$$V_C(t)/_{Fm} = A_c Cos\left[w_c t + 2\pi kf \int_0^t V_m(t)dt\right]$$

SPECTRUM OF THE FM SIGNAL

For tone modulation,

$$V_m(t) = A_m Cosw_m t$$

$$Then \quad V_C(t)/_{FM} = A_C Cos\left[2\pi f_C t + 2\pi K_f A_C \int_0^t Cosw_m tdt\right]$$

$$= A_c Cos\left[2\pi f_C t + 2\pi K_f A_m \int_0^t Cosw_m tdt\right]$$

or $V_C(t)/_{FM} = A_c Cos\left[w_c t + \frac{K_f A_m}{fm} Sin\, w_m t\right]$

The product $K_f A_c$ is the maximum or peak frequency deviation and is given the symbol Δf

So that, $V_C(t)/_{FM} = A_c Cos\left[w_C t + \frac{\Delta f}{fm} Sin\, w_m t\right]$

$$= A_C Cos[w_c t + \beta Sin\, w_m t]$$

where, $\beta = \frac{Frequency\ \ deviation}{Modulating\ \ Fequency} = \frac{\Delta f}{fm}$

is the modulation Index define for tone modulation. Expanding the above, we have:

from SinA – SinB = Sin(A-B)

$$V_C(t)/_{Fm} = A_C[Cos\, w_C t\ Cos(\beta\ Sin\ w_m t) - Sin\ w_C t Sin(\beta\ Sin\ w_m t)]$$

The product Cos(Sin) and Sin(Sin) which represents the power series maybe expressed in terms of Bessel functions as follows:

$$Cos(\beta Sin\, w_m t) = J_o(\beta) + 2\sum_{n=1}^{\infty} J_{2n}(\beta) Cos\ (2nw_m t)$$

$$J_0(\beta) + 2\sum_{n\ even}^{\infty} J_n(\beta) Cos\ (nw_m t)$$

$$Sin\ (\beta Sin\ w_m t) = 2\sum_{n=0}^{\infty} J_{n+1}(\beta) Sin(2n+1) w_m t$$

$$= 2\sum_{n\ odd} J_n(\beta) Sin(nw_m t)$$

$$J_n(\beta) = \sum \frac{(-1)^m (\beta/2)^{2m+n}}{m!(m+n)!}$$

≡ Bessel functions of the first kind, of order n, and argument β

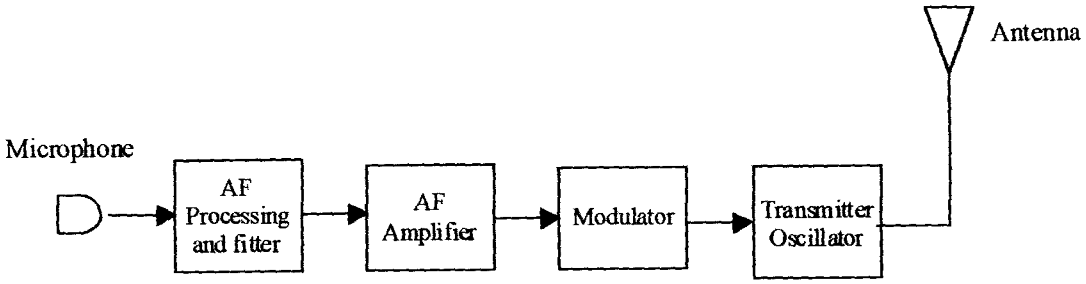

FIG. 2.2: BLOCK DIAGRAM OF A FM TRANSMITTER

MICROPHONE

Microphone is a device that converts the variation in air pressure produced by voice or musical instrument into an electrical voltage or current of the same frequency and corresponding amplitude.

There are different types of microphone base on applications ranging from public address system, telephone handset, and transmitter, broadcasting to scientific measurement and recording.

Microphones are rated in terms of frequency response, directivity, impedance and sensitivity.

PRE – AMPLIFICATION

The intelligence signal coming from the microphone is being amplified at this stage to an appreciable level. At this stage, a linear amplification is necessary so as to prevent the distortion of the message signal.

To achieve this, a class A biasing transistor configuration is used due to its linearity properties.

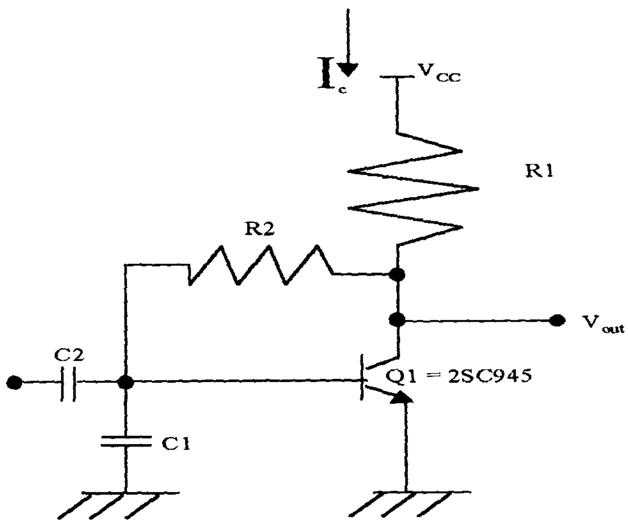

FIG.2.3: PRE – AMPLIFICATION CIRCUIT DIAGRAM

BIASING CALCULATION

From the above diagram fig 2.3;

$I_c = 4.5mA$

$H_{FE} = 120$

$V_{cc} = 9V$

$V_{CE} = ½\, V_{cc}$

$= ½ \; x\, 9 = 4.5V$

$R_cI_c = V_{CE}$

$\therefore R_1I_c = V_{CE}$

$$R_1 = \frac{V_{CE}}{I_C} = \frac{4.5}{4.5x10^{-3}}$$

$R_1 = 1000\Omega$

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

$$I_B = \frac{I_C}{h_{FE}} = \frac{4.5 x 10^{-3}}{120} = 37.5 \mu A$$

$$I_B = 37.5 x 10^{-6} A$$

For Silicon transistor $V_{BE} = 0.7V$

$$VR_2 = V_{CE} - V_{BE}$$

$$= 4.5 - 0.7$$

$$= 3.8V$$

$$R_2 I_B = VR_2$$

$$R_2 = \frac{VR_2}{I_B} = \frac{3.8}{37.5 x 10^{-6}}$$

$$R_2 = 101 K\Omega$$

F = 20KHz (for speech frequency)

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

$$C_2 = \frac{1}{2 x 3.142 x 20 x 10^3}$$

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

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

$$C_1 = \frac{1}{2 x 3.142 x 101 x 10^3 x 20 x 10^3}$$

$C_1 = 79 \times 10^{-12} F$

$C_1 \approx 100 \times 10^{-12} F$

FM MODULATOR STAGE

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

The diode (D) used below as shown in the circuit, is acting as a buffer that blocks the emitter current from the oscillator stage from affecting the operation of the oscillator.

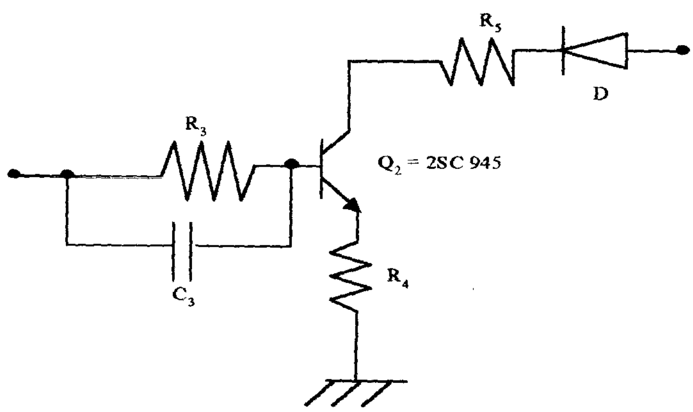

FIG. 2.4: MODULATOR CIRCUIT DIAGRAM

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.

$h_{FE} = 120$

$I_C = 96mA$

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

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

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

$$R_3 = \frac{VR_3}{I_B} = \frac{4.5}{800x10^{-6}}$$

$$R_3 = 5.625\,K$$

$$R_3 \approx 5.6K\,\Omega$$

$$C_3 = \frac{1}{2\pi R3F}$$

$$C_3 = \frac{1}{2x3.142x5.610^3x2010^3}$$

$$C_3 = 1.42x10^{-9}F$$

Then $VR_5 = V_{CC} - V_{CE}$

$$= 9 - 0.7$$

$$= 8.3V$$

$$R_5 = \frac{VR_5}{I_C} = \frac{8.5}{96x10^{-3}}$$

$$R_5 = 89\Omega$$

$$R_5 = 100\Omega$$

Applying the approximation (junction resistance)

$$r'e \approx \frac{26mV}{I_E}$$

$$I_E \approx I_C$$

The input resistance to the transistor in the CE configuration is

$$hie \approx \beta r'e \approx \beta \frac{26mV}{I_E}$$

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

$$hie = 32.5\ \Omega$$

For dynamic values of input and load resistance

$r_{in} \approx hie\ //\ R_3$

$$r_{in} = \frac{32.5x5.610^3}{32.5+5.6x10^3}$$

$$r_{in} \approx 32.3\Omega$$

OSCILLATOR STAGE/ANTENNA

Oscillator is an electronic circuit that has been designed to produce an alternating emf of a known frequency and waveform. Oscillator is an amplifier that generates its own input signal, which is derived from the output signal.

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

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

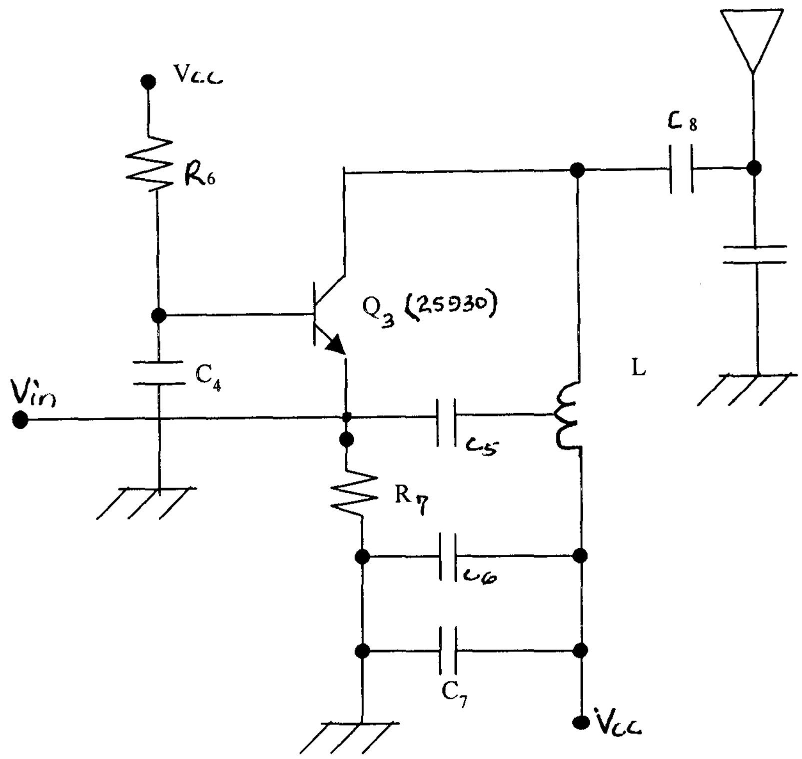

FIG.2.5 OSCILLATOR CIRCUIT/ANTENNA DIAGRAM

The common – base amplifier and dynamic signal condition

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

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

$V_{EB} = 0.7$ Silicon transistor

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

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

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

$$\therefore R_7 = 1K\ \Omega$$

Determining the value of R_L which is inductive

$V_{CB} = 1/3\ V_{CC}$

$= 1/3 \times 9$

$= 3V$

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

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

$I_C \approx I_E$

$I_C R_L = V_{RL}$

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

$$R_L = \frac{6}{8 \times 10^{-3}} = 750\Omega$$

$$R_L = 750\Omega$$

At this point, we have calculated the values of R_7 and R_L necessary to establish proper d.c conditions so that amplification can take place.

DYNAMIC SIGNAL CONDITION

To find input signal current (ie), firstly, we determined the value by the signal source.

Applying the approximation (junction resistance)

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

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

where,

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

$$r'e = 3.25\Omega$$

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

Then $r_{in} \approx r'e \,//\, R_7 \approx r'e$

$$r_{in} \approx \frac{3.25x1038}{3.25+1038}$$

$$r_{in} \approx 3.2\Omega$$

$$i_{in} = \frac{V_{in}}{r_{in}} \approx \frac{3.5mV}{3.2}$$

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

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

$$I_{in} = I_e \approx I_c \text{ (or } I_{out}) \approx 1mA_{pp}$$

But the dynamic load $\approx R_L \,//\, R$

where R is the resistance of the antenna ($R = 75\Omega$)

$$r_L \approx 750 \,//\, 75$$

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

$$r_L \approx 68\Omega$$

Finding output signal voltage

$$V_{out} = i_C r_L$$

$$1 x 10^{-3} x\, 68$$

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

Voltage gain $= \frac{V_o}{V_i} \approx \frac{0.068}{3.5 x 10^{-3} V} = 19$

Voltage gain $\approx$ 19

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

$\approx$ 1 in CB configuration

Power gain = Current gain x Voltage

$\approx$ 1 x 19 = 19

The total capacitance, C_t, of the Hartley Oscillator,

$C_t = C_5 + C_8 + C_9$

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

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

To calculate the value of inductor used in the oscillating task.

F = 103.7MHz

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

$$L = \left(\frac{1}{2\pi F}\right)^2 x \frac{1}{C}$$

$$L = \left[\frac{1}{2 \; x \; 3.142 \; x \; 103.7 \; x \; 10^6}\right]^2 x \frac{1}{14x10^{-12}}$$

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

FUNCTIONAL DESCRIPTION

FM Receiver contain an antenna connected to the local Amplifier which is followed by a mixer and local oscillator, I.F Amplifier, a demodulator, AF amplifier and a speaker. This can be seen in the diagram below.

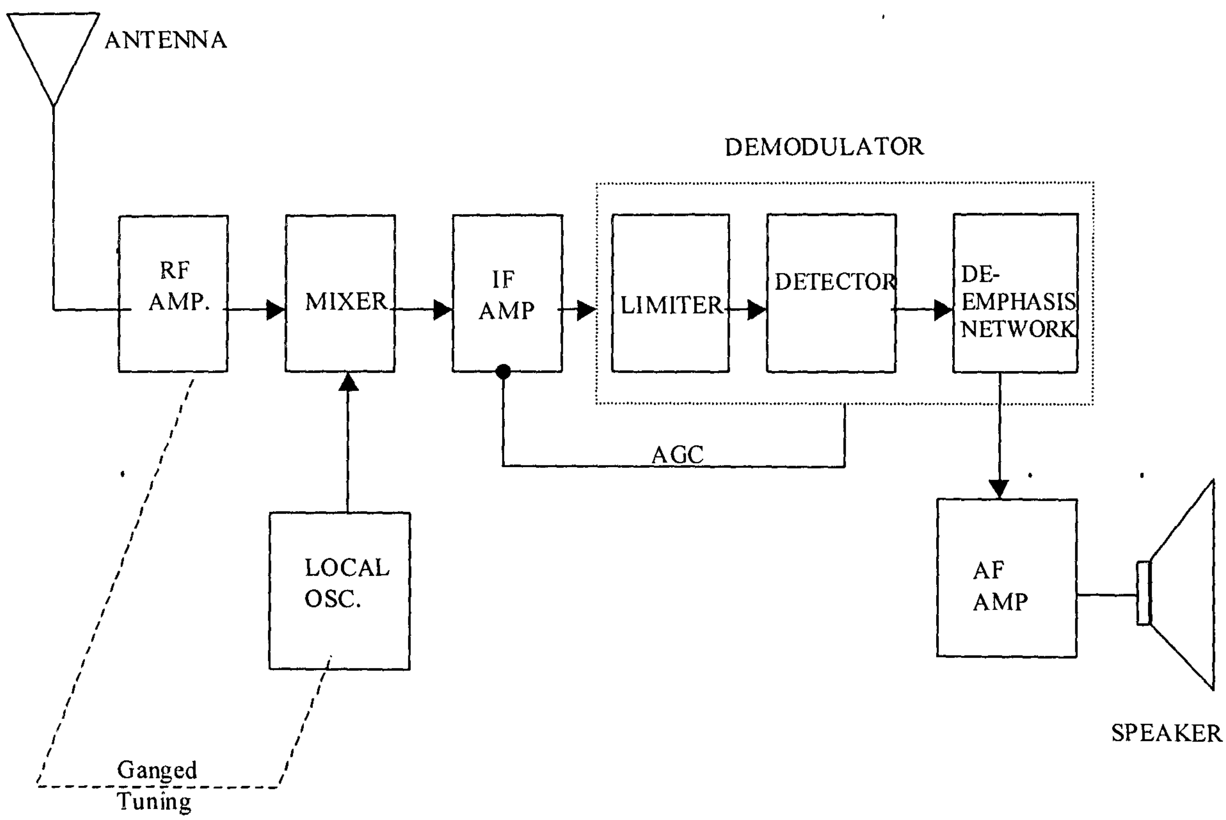

FIG. 2.6 BLOCK DIAGRAM OF AN FM RECEIVER

RF AMPLIFIER

First of all, the receiving antenna picks up energy from the transmitter whose output passes through its intercept area. Consequently, it receives and amplifies the frequency of the incoming signal.

MIXER AND LOCAL OSCILLATOR

The amplified signal enters a mixer circuit, which is so designed that it can conveniently combine two radio frequencies – are fed into it by RF Amplifier and the other by local oscillator. The mixer, which is a non-linear device, produced sum and difference frequencies, this time at very low power levels.

The local oscillator is designed so that its frequency will always be a certain fixed amount different from the frequency of the incoming signal. Usually, the oscillator operates at higher frequency than the incoming signal from the antenna.

"Beathing together", "mixing", or "heterodyning" (which means to beat together the antenna signal and the oscillator produces sum and difference frequencies. The difference frequency is referred to as the intermediate frequency, IF, which is the new carrier frequency.

The local oscillator frequency of oscillation can be controlled by varying the capacitance of its capacitor.

In fact, the tuning capacitor of the oscillator ganged with the capacitor of the input in the circuit so that the difference in the frequency of the selected signal and oscillator frequency is always constant.

As said earlier, the output of the IF Amplifier is demodulated by a detector which provides the audio signal.

LIMITER

The function of the limiter is to eliminate amplitude modulated noise from IF signal which might have crept into the FM signal. This removal of amplitude variations is necessary for distortionless demodulation.

FM DETECTION

As discussed earlier, a FM carrier signal contains information (or intelligence). For recovering the information, the FM signal was converted in such a way that it appears as a modulated RF voltage. A simple method is to make use of the principle that reactance (coil or capacitor) varies with frequency. When an FM signal is applied to an inductor, the current flowing through it varies with amplitude according to the changes in frequency of the FM signal which depends on the amplitude of the modulating signal.

DE – EMPHASIS NETWORK

This reduces the amplitude at high frequencies in the audio signal which was earlier increase by the pre – emphasis stage at the transmitting section.

It serves to re- establish the tonal balance of speech or music etc lost in the FM amplifier. Without it, the sound signal would have a heavy treble effect.

LOUD – SPEAKER

As a transducer, it convert electrical impulses into acoustical energy. Hence, in the circuit it brings out the amplified sound waves.

FM RECEIVER

Receivers as earlier mentioned or discussed are designed to provide the following basic functions, among others:

1. Selection, via some tuning mechanism, the desired carrier signal from other unwanted signals in the electromagnetic spectrum.
2. Amplification and demodulation or decoding of selected signal.
3. Display of modulation signal in the desired form.

We see that demodulation is just one of many functions of a receiver, but the fact that receivers are frequently classified in terms of the modulation scheme (for example, AM, FM, SSB receivers) suggested that it is a most important function.

Different types of receiver have been developed over the years. These include the crystal, regenerative, super – regenerative, tuned – radio – frequency (TRF), and super heterodyne types.

Most radio receivers are of the super- heterodyne (superhet) type and this form the focus of this project presentation. The block diagram of the superhet receiver is as shown in fig 2.6. The RF stage incorporates the front end-tuning circuits. The combination of the mixer and the local oscillator is called the converter. Frequency translation takes place both in the converter and demodulator. This may explain why the converter is some times called first detector and the demodulator, the second detector.

The Local Oscillator (LO), which provides the mixer frequency, is adjusted in synchronism with the RF stage so that the difference between the selected RF carrier frequency Fc, and the LO frequency f_{LO}, is always equal to some standard frequency, referred to as intermediate frequency (IF or f_{IF}). This ensures that either

$$f_C - f_{LO} = f_{IF}$$

or $$f_{LO} - f_C = f_{IF}$$

Usually, the second condition applies, and the relative spectral positions under this setup are shown in Fig 2.6.1.

By choosing $F_{LO} > F_C$, the fractional change in F_{LO} (and by implication, in the value of the tuning capacitor), required to accommodate a given range of RF frequencies is smaller than would be the case if $F_C > F_{LO}$.

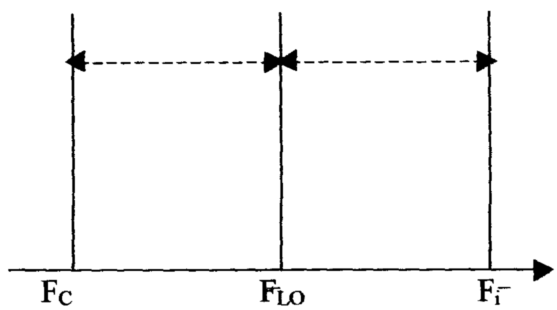

Fig 2.6.1: RELATIVE POSITIONS OF F_C, F_{LO} and F_i

Suppose the receiver receives, in addition to the desired signal at F_C, another signal at $f_I = f_C + 2f_{IF}$, then the frequency difference between f_i and f_{LO} constitutes f_{IF}.

Therefore, there is the possibility of simultaneous reception of two different signals if their signal separation is $2f_{IF}$.

The frequency f_i, is referred to image frequency because it is removed from f_{LO} the same frequency margin as the frequency of the desired station f_C. The image signal causes mutual interference. This effect is minimized by placing a tuned RF amplifier, centred at f_C, before the mixer and by having a higher value of f_{IF}, in order to ensure wide separation of f_i and f_C and thereby facilitate the elimination of f_i.

For a single - tuned RF circuit, the attenuation or rejection of image frequency, or the ratio of gain at f_C to the gain at f_i is given by

$$\propto = \left[1 + Q^2 P^2\right]^{1/2}$$

$$where \quad p = \frac{f_i}{f_c} - \frac{f_c}{f_i}$$

and Q is the loaded circuit Q.

When f_i/f_C is large as in MW broadcast band, the use of the RF stage is not essential for good image rejection. However, it becomes important in the SW(short wave) band and above, and is always used in FM receivers. In all case, MW and above, inclusion of the RF stage generally improves performance.

Apart from the image signal rejection, the RF stage must also

1. Provide effective coupling of the receiver to the antenna – a most crucial function at VHF and above.
2. Reject input signals at IF and unwanted signals from adjacent stations.

The term, selectively, is used to describe the ability of the receiver to reject adjacent unwanted signals or receive signals a comparatively narrow frequency band. The higher the selectivity, the lower will be the interference setup in the receiver by signals from other stations. Selectivity of receivers is usually presented in the form of resonance or selectivity curves, which show the attenuation the receiver offers to signals at frequencies adjacent to the one tuned. Excessive selectivity causes too narrow a pass – band and this results in signal distortion.

Another very important term used to describe receivers is sensitivity. Sensitivity is the ability of the receiver to pick up and reproduce weak signals. The lower the input RF voltage necessary for normal output power, and reception, the higher the sensitivity. Sensitivity of modern receiver is of the order of several μV and mV, and depends mainly on the level and quality of the IF amplification stages.

The IF stage is a fixed – frequency amplifier which provides most of the gain and selectivity of the receiver. The down conversion of the RF signal to a lower IF frequency at which it is more convenient to provide big gain and critical filtering, is one the merit of superhet receiver. However, the choice of f_{IF} is often not easy because of the following conflicting factors among others:

1. The lower the value of f_{IF}, the higher the selectivity of the amplifier and the greater the rejection of the adjacent channel.
2. However, as already discussed, a good image rejection requires large f_{IF}.
3. When F_{IF} is too low, f_{LO} tends to be pulled into the signal frequency and the output will be lost as there will be no output at f_{IF}.
4. When f_{IF} is too high, we have poor selectivity, and poor adjacent channel rejection.
5. The f_{IF} is normally selected to be outside the tuning range of the receiver to avoid the RF and IF receivers operating at the same frequency with likelihood of instability. Also, the

IF circuit will not be able to separate the signal and IF; the result will ~~not~~ be unwanted bent frequencies.

6. f_{IF} is required to be higher when the input signal band width is high.

The standard frequency band for FM IF receivers is 10.7MHz. The FM receiver as seen in the block diagram Fig 2.6, often incorporate a limiter between the IF stage and the Fm detector. Also, a de – emphasis filter is often interposed between the FM detector and the AF (audio frequency) stage FM receivers typically incorporate an AFC (automatic frequency control) to correct for frequency drift of the local oscillator.

Traditionally, many of the function of the receiver as described above were implemented using a single chip (integrated circuit) and part using discrete components.

CHAPTER THREE

CONSTRUCTION PROCEDURE

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

The electronics part consist of audio amplifier, modulator and the oscillator at the transmitter's section, and Radio frequency amplifier, mixer, oscillator, intermediate frequency, demodulator network, the audio frequency amplifier to the transducer at the receiver's section. All these were constructed one after the other as designed and analyzed in the design aspect of the project in chapter two.

After all the calculation, and the design completed, the components with the preferred values were bought, then the components were arranged on a breadboard starting with the crystal microphone which is the first stage. Then up to the antenna stage, which launches the signal to space thereby, intercepted the receiver circuit whose stages of signal processes were constructed one after the other.

While on the breadboard, the output of the transmitter part was tested with digital multimeter and with conventionally general receivers in the market. The oscilloscope available in the school laboratory could not be use to display the output waveform because of high frequency response needed in the work.

Similarly, the receiver part was subjected to the same test with digital meter and we try to use it to receive any nearby transmitting FM station example 91.2 Crystal FM Minna.

After the whole connection on the breadboard, the system was tested and it function well, the stages in both transmitter and receiver were transferred and soldered on Vero – board using soldering iron and soldering lead

COMPONENTS SELECTION (TRANSMITTER)

R1	-	Resistor, 1K ohms
R2	-	Resistor, 33K ohms
R3	-	Resistor, 5.6K ohms
R4	-	Resistor, 100 ohms
R5	-	Resistor, 100 ohms
R6	-	Resistor, 10Kohms
R7	-	Resistor, 1K ohms
C1	-	Capacitor, 100PF
C2	-	Capacitor, 1μF, 16v
C3	-	Capacitor, 47 μF, 16v
C4	-	Capacitor, 0.01 μF
C5	-	Capacitor, 7PF
C6	-	Capacitor, 0.01 μF
C7	-	Capacitor, 100 μF
C8	-	Capacitor, 5PF

C9 - Capacitor, 2PF

Q1 – Q2 Transistor, NPN silicon (2SC945)

Q3 Transistor, NPN silicon (2SC930)

Diode L1-coil oscillator type

Speaker / Mic

Frequency of operation 103.7MHZ

COMPONENTS SELECTION (FM RECIVER)

RESISRORS

R1 - 100k ohms

R2 - 100k ohms

R3 - potentiometer 50kg

CAPACITORS

C1 - 20PF

C2 - 20PF

C3 - 33μF, 16v

C4 - 15PF

C5 - 5-75PF

C6 - 20PF

C7 - 10PF

C8 - 5PF

C9 - 0.0473 μF

C10 - 0.022 μF

C11 - 0.001 μF

C12 - 1 μF, 50v

C13 - 0.01μF

C14 - 100 μF, 10v

C15 - 100 μF, 10v

C16 - 100 μF, 10v

C17 - 470 μF, 10V

INDECTORS

L1 = 4T

L2 = 4T

L3 = 3T

I.C'S

KA2297

TA7368P

CRYSTALS

10.7MHZ (2)

CASING OF THE WORK

After the construction was completed and tested and the workability of the Transceiver ascertained, the circuitry board was cased using wooden materials as a box. The reason for this was because it was cost effective. The casing was also perforated for proper passage of the speech signal to the transducer inside for effective communication. However, antenna switch which connect the system one at a time to Transmitter or Receiver mode as well as the volume control and power switch where used on the side panel.

Portability and easy handling was considered during casing design. Hence, the hole for the elongation of the antenna was also drilled.

Testing in the box gave a satisfactory result.

CHAPTER FOUR

CONCLUSION

This project work was a complete success. Effective communication can be achieved while transmitting from the constructed transmitter to the receiver. However, this project work is simply a model.

RECOMMENDATION

1. The circuit of the fm transmitter shown in chapter 2 can be modified by providing more amplifier stage at output, thereby making the out put sound to be more louder.
2. This project can be used in two-way communication systems.
3. Application of this write up is highly recommended to any body who wishes to carry out test or repair on the circuit of the FM transceiver.
4. Finally, interested researcher can modify the design and construction of this project in the future.

PROBLEMS ENCOUNTERED

1. Scarcity of some of the components used necessitated the travelling from one place to the other in search of those components.
2. Resistors: from the calculated value or data and stated value of resistance obtained, the actual values were not available only but few.
3. Replacements of burnt components.
4. Unavailability of the required oscilloscope to determine the frequency signal.

RESULT AND DISCUSSION

The deign and construction of an FM transmitter and receiver given to us was completed and the test result was fairly adequate.

Although the sound level of the loudspeaker was not all that high, this is traceable to the fact that most of the components used were approximate. Hence, the distance covered by the transmitter is small.

TESTING

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

However, because of unavailability of a high rage frequency oscilloscope, proper oscillation frequency for transmission could not be determined as a result, a little distance was covered. This problem would have been partly averted if the one (oscilloscope) in the laboratory is of the required frequency range.

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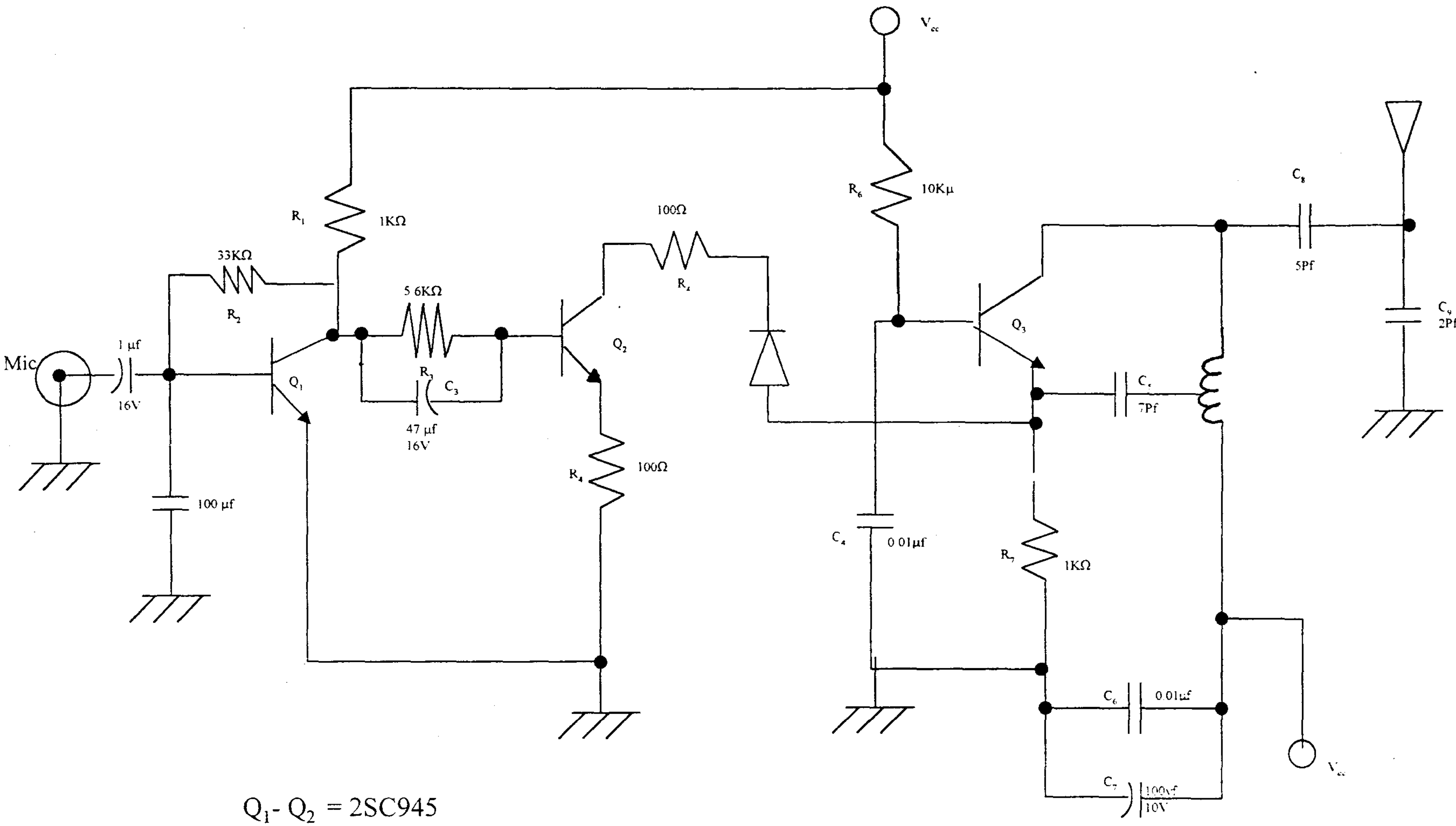
APPENDIX 1

MINI FM TRANSMITTER

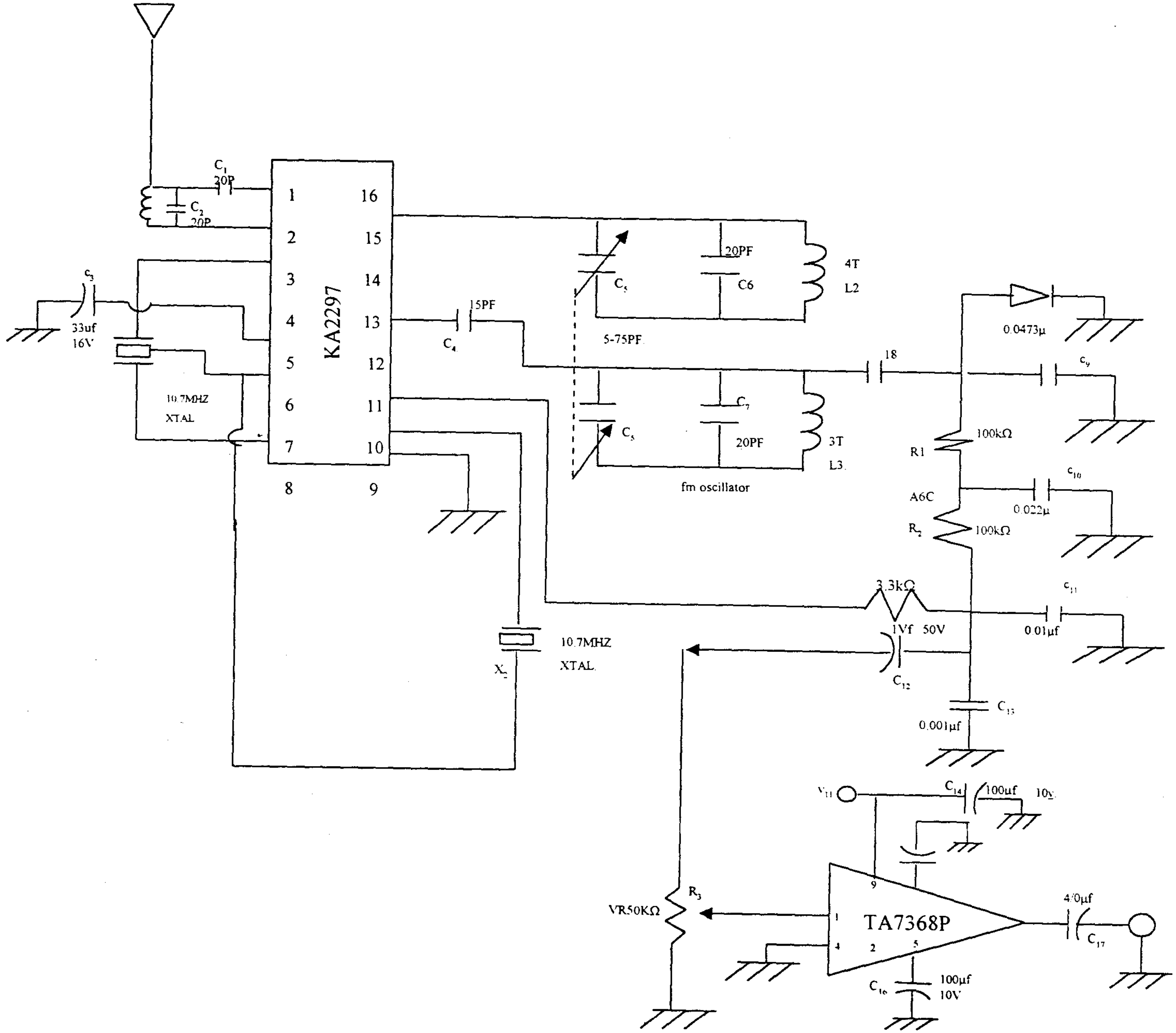


Q_1- Q_2 = 2SC945

Q_1 = 2SC930

COMPLETE CIRCUIT DIAGRAM OF THE FM TRANSMITTER

APPENDIX 2



KA2297
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
C1
20P
C2
20P
C3
33uf
16V
10.7MHZ
XTAL
15PF
C4
C5
C6
20PF
4T
L2
5-75PF
C7
C5
20PF
3T
L3
fm oscillator
18
0.0473μ
C9
R1
100kΩ
A6C
C10
0.022μ
R2
100kΩ
3.3kΩ
C11
0.01μf
1Vf 50V
C12
C13
0.001μf
10.7MHZ
XTAL
X2
V11
C14
100uf
10v
TA7368P
VR50KΩ
R3
470μf
C17
C16
100μf
10V

APPENDIX 3 COMPLETE CIRCUIT DIAGRAM OF FM TRANSCEIVER