THE DESIGN AND CONSTRUCTION OF NIGERIA POLICE OPERATIONAL COMMUNICATION DEVICE

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2000/10939EE

A Thesis submitted to the Department of Electrical and Computer Engineering in partial fulfillment of the requirement of the attainment of Bachelor in Engineering.

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Dedication

To Almighty God, the source of my inspiration and to my wife, Ijeoma and my children, Naomi, Peter and Paul who will continue from where I shall eventually stop.

Declaration

I, EZEH KINGSLEY CHINEDU declare that this work was done by me and has never been presented elsewhere for the award of a degree. I hereby relinquish the copyright to the Federal University of Technology, Minna.

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Acknowledgement

I am grateful to Almighty God for making it all possible and to the following squadron commanders in Mopol 12, Minna who supported and encouraged my studies: Mr. Sumaila Atta (S.P), 24 /3 /2000- 7 /11/2001 ; Mr. Gazali (S.P) , 7/ 11 / 2001- 7 /12 / 2001; Mr. Kudu Nma (A.C.P), 7/12/2001-5/11/2003 ; Mr. Dibia Polycarp (S.P), 5/11/2003-24/9/2004 ; Mr. Femi Haruna (S.P), 24/9/2004- 15/5/2005 and Barrister David Abuo (S.P), 15/8/2005- date (date of writing this report).

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Abstract

This thesis reports the design and construction of a wireless transceiver that will enable ease of communication between a police operational commander and his men in the field. The aim is to create convenience in communicating with each other while wielding weapons in active combat. This device, unlike the ones in current use is easily worn on the body and can conveniently transmit and receive from anyone wearing a similar device. This way, active communication in combat is made possible without letting the enemy know anything of police combat plans. This will go a long way in making the police force more operationally efficient.

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1.5 Involvement Of Others

My consultation to realize this project was wide. Soldering was not learnt at school so I engaged with Mr Adebowale Alagbado, a road side electronics artisan who taught me soldering. I also consulted Mr Sado of FM Crystal, Minna who gave me a lecture on the project. Also fully involved was Dr. E.N.Onwuka, my project supervisor whose guidance was paramount in the success of the project.

1.6 Constraints To Achievable Performance

The main challenge of any radio device project is frequency-tuning. Due to limited experience in radio projects coupled with unavailability of high frequency meter and oscilloscope capable of measuring the high frequency FM involved in this project , there was considerable tuning difficulty coupled with difficulty in aligning the transmitting and receiving frequency without which establishment of communication is impossible.

Another inferable constraint of the project to achievable performance is un-availability of vital components in the market as [2] rightly pointed out that distributors are extremely hesitant to sell in small quantities and the consumer-oriented electronics stores (Radio shacks etc deal in small quantities and tend to stock an extremely limited range of parts, restricting the design to readily available components.

These constraints resulted in:

1. Low power of the transmission, which limited the range of operation
2. Operation of the device in analogue system rather than digital which would have given better security to signal and
3. Miniature IC which would have further miniaturized the device as was aimed could not be sought.

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CHAPTER ONE

INTRODUCTION

1.1 Objective

Nigeria police operations involve combating crime, especially violent ones as is common in Nigeria today. For effective crime combating, there should be effective communication link between operational commander and his team in the field. For instance, assuming a bank,"X" is being robbed and the police arrived to combat the robbers, the first thing the police will do is to cordon off the premises of the bank. Police field operational commander is known as a unit commander and his team is known as the unit. As a police control tool, no member of the police operational unit should open fire unless on the order of the unit commander, who might not, though have the complete view of the whole side view of the bank's premises so cordoned. Police operation should be "speed", "surprise" and "silent" [5]. That is to say speed for speedy and quick operation, surprise as a tool of confusion on the enemy which will therefore completely disarm the enemy and silence as a tool that will help police presence concealed to the enemy until he is completely rounded up [5].

Continuing with the above illustration assuming one of the robbers in bank "X" is escaping through a side view of the bank premises not visible to the police unit commander but visible to one of his men in the unit that cordoned off the bank, there is a need for a communication link to the unit commander for an order for action. Such communication, if made in human voice will give police away and there will no longer be element of surprise, nor silence in the operation. The communication is better via electronics communication means.

In today policing, the communication link between a unit commander and his unit via electronics means could be achieved using walkie-talkie. Walkie-talkie has been developed to a very high sophistication by great companies such as Motorola, Kenwood etc. However, walkie-talkie in itself can hamper police operation as an operational police officer should clutch his rifle on both hands and prepare for any eventuality, leaving no hand available for carrying a walkie-talkie. Wearing the walkie-talkie in the police belt is still not a better option because police operational exigency may require that a police officer crawl in thick shrubs which, due to the size and weight of available walkie-talkie could get stuck in the shrub hampering the crawling of a police officer. Moreover walkie-talkie exposes police cover in operation as its communication is audible to everybody close to the walkie-talkie, thus defeating the aim of silence and surprise in police operations.

The project is aimed at effectively constructing two devices that will work like a walkie-talkie but is far more compact than the walkie-talkie for portability and has the advantage of employing professional headphone attached with microphone for confidentiality of communication during police operations.

1.2 Methodology

The project involves two compact transceiver devices. They are designed such that when one device transmits at a given frequency (in the range of 60-70MHZ) the other device is enabled to receive at the same frequency and vice-versa.

The transmitter module involves a very simple circuit for compactness. A microphone (transducer) converts audio wave into electrical energy or signal. An amplifier, employing the transistor 2SC945 increases the weak current signal from the input, that is; audio signal amplification. The amplified signal is used to frequency modulate a carrier wave from a high frequency oscillator employing the 2SC930 transistor. The resulting modulated frequency signal is transmitted into space via the antenna. The receiver on the other hand is tuned through an RF LC circuit to align with the frequency of the transmitter. A current signal is induced into the antenna of the receiver.

The signal is amplified using LM386 OP-AMP and demodulated with the aid of KA2297 which is a non-adjustment single chip IC AM/FM DET coil for the transmitted audio signal to be realized at the earpiece of the head-phone of the receiver. Frequency modulation (FM) is attributed to both good reception and minimum interference.

1.3 Scope Of The Project

The project is bounded under frequency modulation below the normal frequency modulation (FM) range (88-168MHZ).The effective range of the device is aimed at about 15 meters. Therefore, radio communication could only be achieved within this range. The receiver involves a modern integrated circuits, the KA2297. The transmitter has no power amplifier due to tuning difficulty. Power is supplied from 9V battery. Both microphone and speaker are incorporated into a head phone with mouth piece in each device for ease in communication.

1.4 Source Of Materials Used

The sources of materials used in realizing the project include websites, text books like Police Operation Manuals, Electrical Technology by B.L Theraja and A.K. Theraja, Telecommunication principles by Engr. (Dr) Y.A. Adediran and related works from the library e.t.c. Details of source of materials are given in reference section.

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CHAPTER TWO

LITERATURE REVIEW/THEORETICAL BACKGROUND

2.1 Historical Background

The identity of the original inventor of radio at the time called wireless telegraphy is contentious [7]. The controversy over who invented the radio can be broken down as follows :

Spark gap radio was invented by Nikola Tesla who holds US patent for invention of radio. Amplitude modulation (AM) was invented by Reginald Fessenden and Lee de Forest, which allows more than one station to send signals (as opposed to spark gap radio where one transmitter covers the entire bandwidth of the spectrum.) Frequency modulation (which is of concern as regards this project) was invented by Edward H. Armstrong and Lee de Forest so that an audio signal can avoid "static" that is, interference from electrical equipment and atmosphere[7].

However, the theoretical basis of the propagation of electromagnetic waves was first described in 1873 by James Clerk Maxwell, British, in his paper to the royal society, "a dynamic theory of the electromagnetic field" which follows his work between 1861 and 1865 [9]. In 1875, Thomas Edison first observed what became known as the "Edison effect", or thermionic transmission. In a vacuum, a current of electricity will flow through space from a negatively charged filament (the cathode) to a positively charged metal plate (the anode) [9]. When William J. Hammer, an Engineer working for Edison observes it again in 1883, Edison patents the effect in a device he calls an electrical indicator. In 1878, David E. Hughes was the first to transmit and receive radio waves when he noticed that his induction balance cause noise in the receiver of his home made telephone.

However, it was Henrich Rudolph Hertz who between 1886 and 1888 first validated Maxwell's theory through experiment demonstrating that radio radiation had all the properties of waves, now called Hertzian wave and discovered that the electromagnetic equation could be reformulated into a partial differential equation called the wave equation. In 1887, British Oliver Lodge demonstrates Hertzian wave communication before the British association. In 1895, Russian Alexander Popov began transmitting wireless electrical signals through the air over 500 meters. Independently of Popov, Italian Guglilmo Marconi accomplished the same feat three months later. By the end of the year Marconi could send signals over a mile (1.6km).In 1896, Marconi building on inventions and insights by hertz, Nicola Tesla, Edward Branly, John Stone, Lodge and others, applied for first patent specifically for wireless telegraphy and begun process of starting a communication company founded in 1897 in Great Britain [7].

2.2 Previous Works On Walkie-Talkie

A simple instance of a radio transceiver is the "Walkie-talkie" a hand-held portable bi-directional device. Before the World War II, the first walkie-talkie was developed for military use [9]. The typical physical format looks some what like a telephone handset, possibly slightly larger but still a single unit with an antenna sticking out of the top[9]. A walkie-talkie built in earpiece is loud enough to be heard by the user and those in his immediate surrounding [10]. One of the most successful early radio receiver/transmitters, nick named " Walkie-talkie ", was the back packed Motorola SCR-300 created by an engineering team in 1940 at the Galvin manufacturing company consisting of Dan-noble who conceived of the design using FM technology, same as in this project, Henryk Magnuski, who was principal RF engineer, Marion Bond, Lloyd

Morris and Bill Vogel. Motorola also produced the hand-held AM SCR-536 radio during the war and it was called the "handie-talkie" [6].

2.3 Theoretical Background

Radio is transmitted by, first the speech which consists of a series of compressions and rarefactions being translated into a tiny varying electric current with the help of a microphone. The frequency of variations of this current lies in the audio-range, hence, it is known as audio frequency signal. The audio frequency signal cannot be radiated out from the antenna directly because transmission at audio frequencies is not practical. For this purpose, oscillations of very high frequency or radio frequency are produced with the help of any one of the oscillator circuits. In this project, Hartley oscillator was employed with the transistor in common base mode. The electromagnetic waves so produced are of constant amplitude but of extremely high frequency. These waves, which are neither seen nor heard, travel through space with the velocity of light i.e. 3×10^8 m/s (approx).The audio-frequency signal which is to be broadcast, is then superimposed on the RF wave, which are known as carrier waves (because they carry A.F signal through space to distant places).The process by which A.F. signal or information is impressed on the carrier wave is known as modulation. The modulated wave travels through space. At the receiving end, it strikes the receiving aerial and enters the receiver which separates the A. F. signal from the carrier wave. The wave is returned and the audio-frequency signal is converted back into sound .This process which the R.F. waves and A.F. waves are separated is known as detection or demodulation (because it is the reverse of modulation) [1].

2.4 Frequency Modulation

As the name shows, in this modulation, it is only the frequency of the carrier which is changed and not its amplitude. The amount of change in frequency is determined by the amplitude of modulating signal, whereas rate of change is determined by the frequency of the modulating signal. Fig 2.1 illustrates this fact.

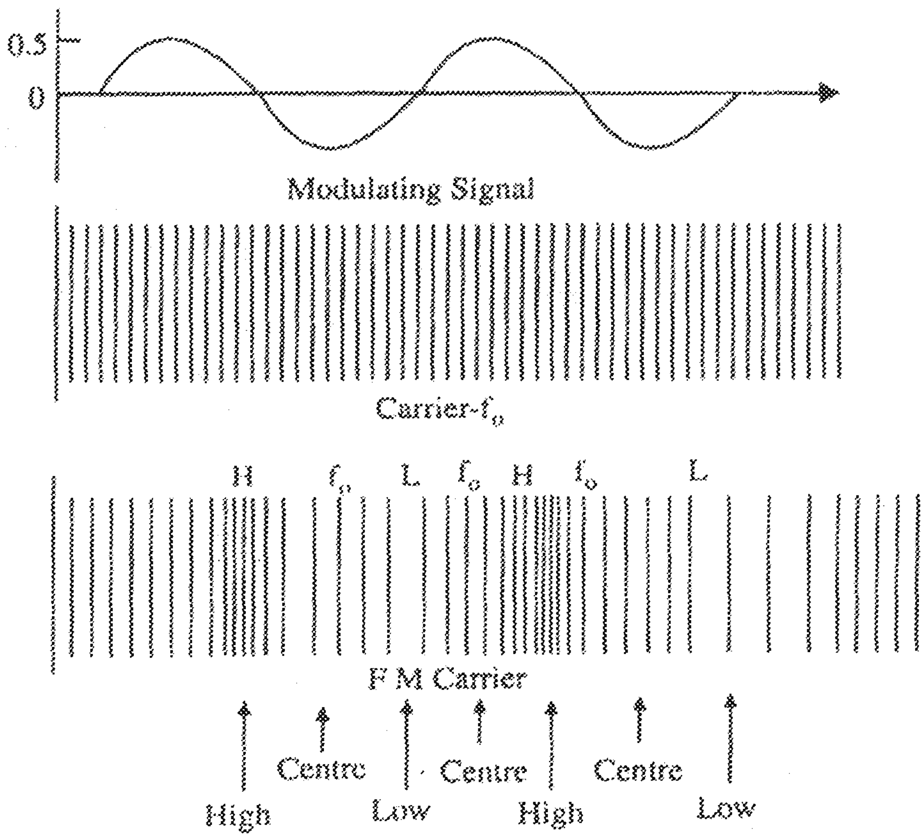


Fig 2.1 Representation Of How Intelligence Is Carried In Fm [1]

As shown in fig 2.1 above, in an FM carrier, information (or intelligence) is carried as variations in its frequency. As seen, frequency of the modulated carrier increases as the signal amplitude increases but decreases as the signal amplitude decreases. It is at its highest frequency (point H) when the signal amplitude is at its maximum positive value and is at its lowest frequency (point L) when signal amplitude has maximum negative value. When signal amplitude is zero, the carrier frequency is at its normal frequency fo (also called resting or center frequency.)

The fact that amount of change in frequency depends on signal amplitude is illustrated in fig 2.2, where R stands for resting frequency.

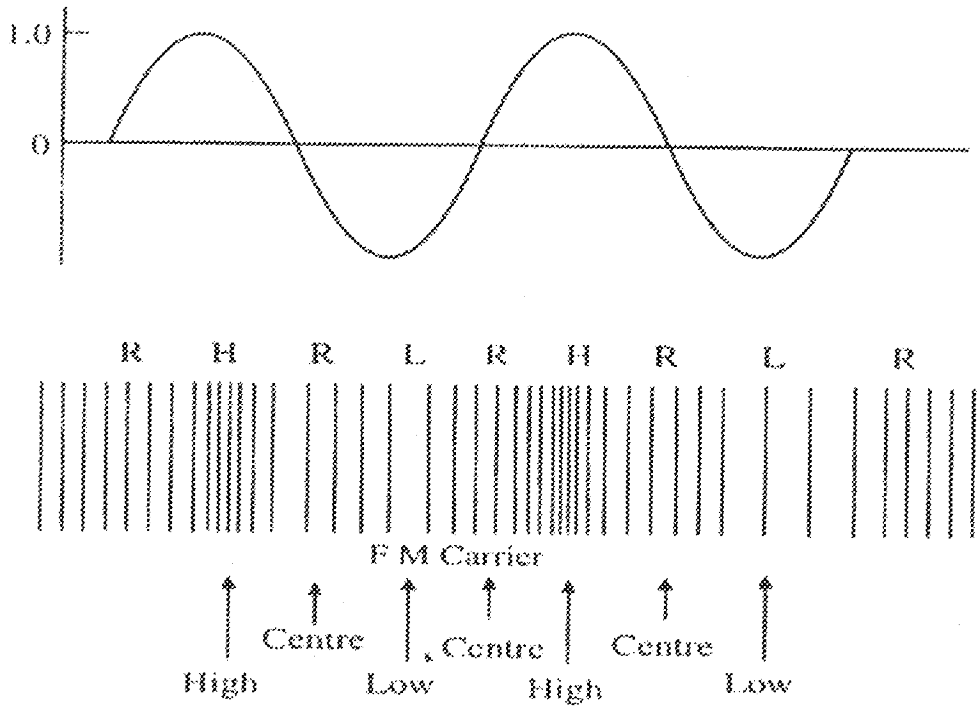


Fig 2.2 Relationship Of Signal Amplitude And Frequency[1]

Here, signal amplitude is almost double of that in fig 2.1 though its frequency is the same. Thus, louder signal causes greater frequency change in modulated carrier as indicated by increased bunching and spreading of the waves as compared with relatively weaker signal of fig 2.1.

The rate at which frequency shift takes place depends on the signal frequency as shown in fig 2.3

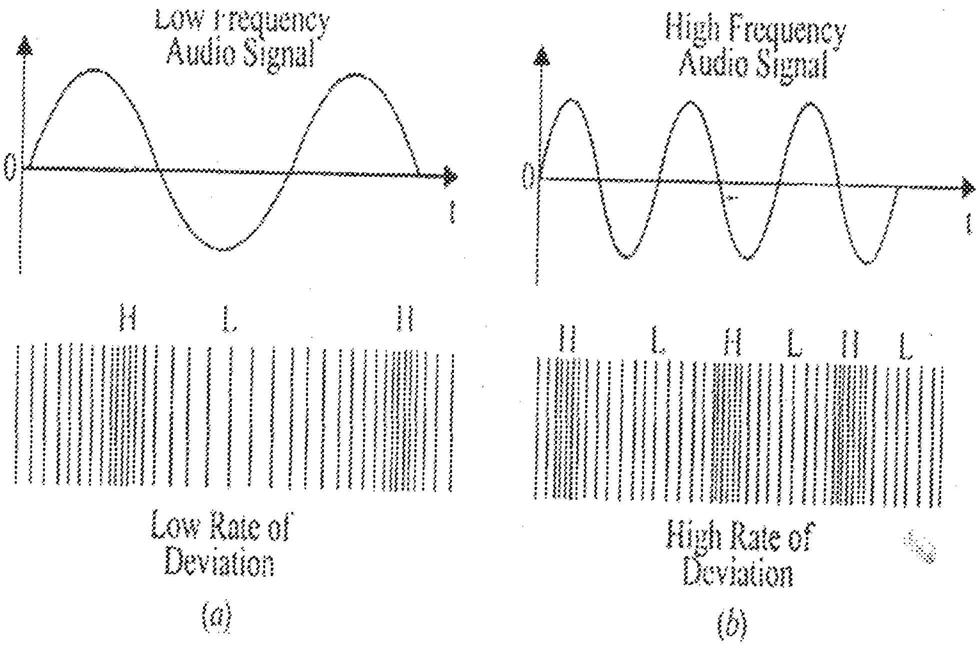


Fig 2.3 Rate Of Frequency Deviation [1]

For example, if the modulating signal is 1 KHz. Then the modulated carrier will swing between its maximum frequency and lowest frequency 1000 times per second. If fm = 2 KHz, the rate of frequency swing would be twice as fast. In short, two important points about the nature of frequency modulation has been established: (i) the amount of frequency deviation (or shift or variation) depend on the amplitude (loudness) of the audio signal. The louder the sound the greater the frequency deviation and vice-versa. However, for the purpose of FM broadcasts, it has been internationally agreed to restrict maximum deviation to 75 KHz on each side of the center frequency for sounds of maximum loudness. Sounds of lesser loudness are permitted proportionately less frequency deviation. (ii) The rate of frequency deviation depends on the signal frequency.

A maximum frequency deviation of 75 kHz is allowed for commercial FM broadcast stations in 88 to 168 MHz band. Hence, FM channel width is 2 x 75 = 150 kHz. Allowing a 25 kHz guard band on either side, the channel width becomes 2(75 + 25) = 200 kHz. (fig. 2.4)[11]

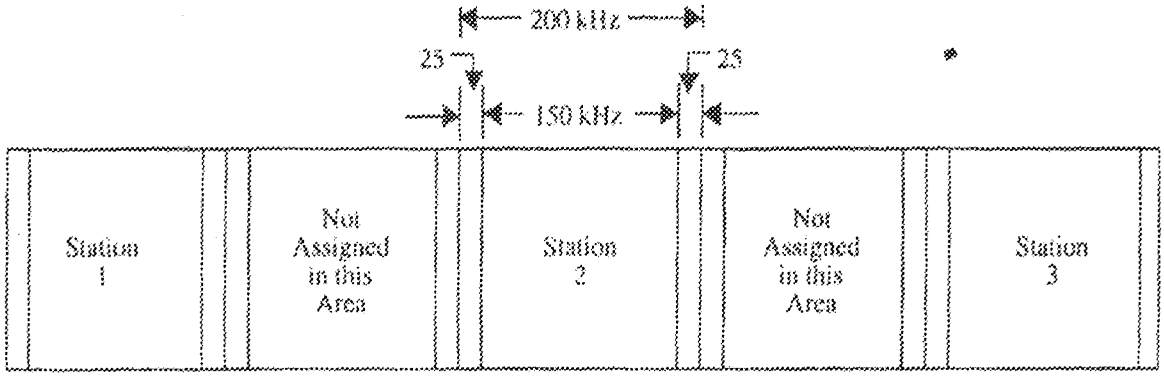


Fig. 2.4 Fm Guard band

2.5 Mathematical Expression For Fm Wave

The unmodulated carrier wave is given by $e_c = A \sin 2\pi f_o t$ .The modulating signal frequency is given by $e_m = B \sin 2\pi f_m t$ .The modulated carrier frequency swings around the resting frequency thus $f = f_o + \Delta f \sin 2\pi f_m t$ .Hence, equation for the frequency modulated wave becomes

$$e = A \sin 2\pi f t = A \sin [2\pi(f_o + \Delta f. \sin 2\pi f_m t)t]$$

$$= A \sin (2\pi f_0 t + \Delta f/f_m + \cos 2\pi f_m t) = A \sin (2\pi f_o t + m_f \cos 2\pi f_m t)[1]$$

2.6 Demodulation Or Detection

When the RF modulated waves, radiated out from the transmitter antenna, after traveling through space, strike the receiving aerials, they induce very weak RF currents and voltages in them. If these high-frequency currents are passed through headphones or loudspeakers, they produce no effect on them because all such sound-producing devices are unable to respond to such high frequency due to large inertia of the vibrating discs etc. Neither will such RF currents produce any effect on human ear because their frequencies are much beyond the audible frequencies (20 to 20000 Hz approx).Hence, it is necessary to demodulate them first in order that the sound-producing devices may be actuated by audio-frequency current similar to that used for modulating the carrier wave at the broadcasting station. This process of recovering AF signal from the modulation carrier wave is known as demodulation or detection [1].

Demodulation of an FM wave involves three operations

i) conversion of frequency changes produced by modulating signal into corresponding amplitude changes [3].

ii) rectification of the modulating signal and [3].

iii) elimination of RF component of the modulated wave. This was achieved with the help of KA2297 single chip IC in the project [3].

2.7 Fm Detection

FM carrier signal contains information (or intelligence to be conveyed) in the form of frequency variations above and below the center frequency of the carrier. For recovering the information, the FM signal must first be converted in such a way that it appears as a modulated RF voltage across the diode. A simple method of converting frequency variations into voltage variations is to make use of the principle that reactance of (coil or capacitor) varies with frequency. When an FM signal is applied to an inductor, the current flowing through it varies in amplitude according to the changes in frequency of the applied signal. Now, changes in frequency of the FM signal depends on the amplitude of the modulating AF signal. Hence, the current in the inductor varies as per the amplitude of the original modulating signal. In this way, frequency changes in FM signal are converted into amplitude changes in current. These changes in current when passed through a resistor produce corresponding changes in voltage. Hence, frequency variations in FM signal are converted into voltage changes. Also, there exists a linear relation between the two –something essential for distortion-less demodulation.[1]

To detect FM, superheterodyne receiver is used. The final stage of IF amplification includes a limiter and the subsequent detector has to convert frequency deviation into amplitude. Method of detection includes:[2]

i. A balanced quadrature detector[2]

ii. ratio detector[2]

iii. phase-locked-loop (PLL)[2]

iv. frequency discriminator.[2]

v. slope detector[2]

We shall consider quadrature detector method here because it was employed in this project.

2.7.1 Quadrature Detector

This detector depends on the frequency/phase relationship of a tuned circuit. It uses only one tuned circuit and is becoming increasingly popular in the integrated FM strips. Let us first consider the general principle. A sinusoidal current is given by the equation

$i = I_m \sin \phi = I_m \sin wt$

Suppose, it flows through a circuit shown in fig 2.5(a).The voltage across the inductor (assumed pure) leads the current I by 90°

$V_L = V_L \cos wt$

The voltage Vz across the parallel tuned circuit will be in phase with I at resonance. However, at frequencies slightly different (+/- 1) from the resonant frequency, the phase angle f will be given by

$\tan \phi = yQR/R = yQ$ assuming $f_o/f = 1$

Here $\frac{\omega}{\omega_0} - \frac{\omega_0}{\omega} = \frac{f}{f_0} - \frac{f_0}{f} \equiv \frac{2\Delta f}{f_0}$

where $\Delta f = f - f_0$

f_0 = resonant frequency

f = slightly off resonant frequency

Hence, equation for Vz is given by $V_z = V_z \sin(\omega t - f)$[1]

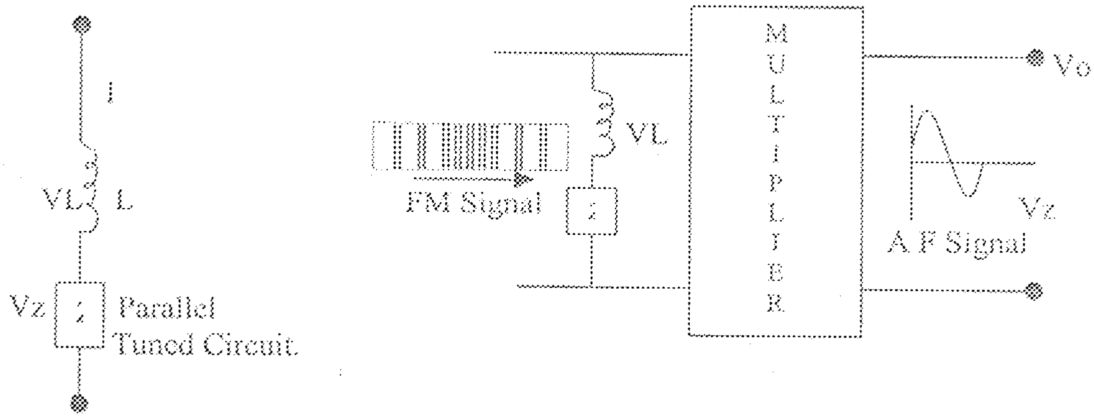


Fig 2.5 Multiplier Module [1]

When the two voltages V_L and Vz are applied as inputs to a multiplier, the output voltage

is found to be proportional to their product as shown in

$V_o \infty v_L, v_z \infty \cos wt . \sin(wt - \phi)$

$\infty \sin(2wt + f) + \sin \phi$

A low pass filter is used to reject the double frequency component

$\sin(2wt + \phi)$ and select only the low frequency $\sin \phi$ component

$V_o \infty \sin \phi \infty \tan \phi$ ....since ϕ is very small

$\infty\ y\ \phi\ \infty\ y\ \infty$ ....where V_m is the modulating AF voltage

Now, $\Delta f = f - f_0 \infty kV_m$

it shows that output voltage Vo proportional to the original modulating signal voltage

2.7.2 Frequency Conversion

It is very difficult to design amplifiers which give uniformly high gain over a wide range of radio frequencies used in commercial broadcast stations.However, it is possible to design amplifiers which can provide high-gain uniform amplification over band of comparatively lower frequencies called intermediate frequencies (IF).Hence, it is necessary to convert the modulated RF carrier into modulated IF carrier by using a frequency converter. This IF signal is then amplified by narrow-band IF amplifier and passed on to the FM detector. The frequency conversion can be achieved by utilizing the heterodyne principle. For this purpose, the modulated RF signal is mixed (in a mixer) with an unmmodulated RF signal produced by local oscillator as shown in fig 2.6

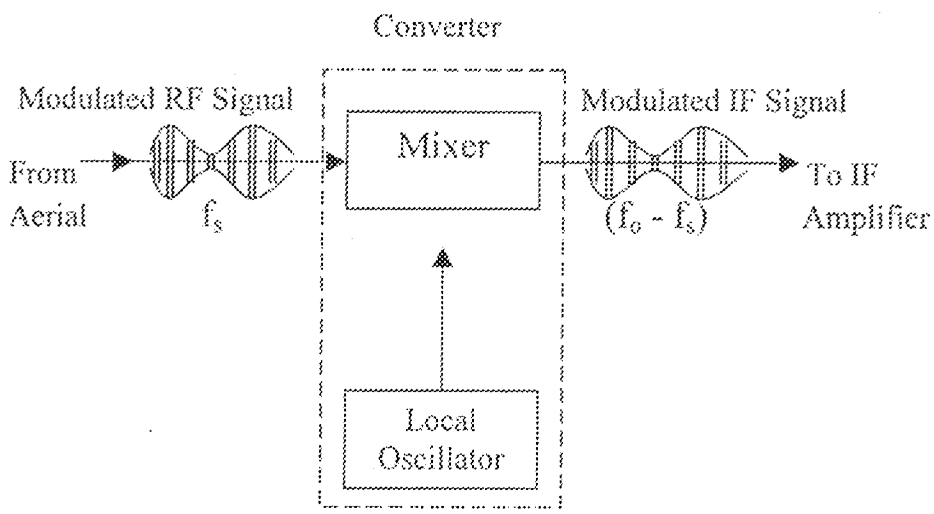


Fig 2.6 Frequency Conversion Module [1]

The oscillator and the mixer may be either two separate devices or may be combined into one device called converter. The process of combining two ac signals of different frequencies in order to obtain a signal of new frequency is called heterodyning action.

2.7.3 Heterodyning Action

Suppose the carrier signal; of frequency fs is heterodyned with another signal of frequency fo then two additional signals are produced whose frequencies are: (i) $fo + fs$ - the sum component [1] (ii) fo .. fs - the difference component[1].

Usually, the sum frequency is removed by bandpass filtering. The difference (also called beat frequency) is retained and forms the IF frequency in receivers. Suppose, a carrier signal of frequency 1500KHz is mixed with an unmodulated carrier (produced by local oscillator) of frequency 1955KHz.Then, the following two frequencies are produced

(i).3455KHz

(ii).455KHz

The higher frequency is generally filtered out leaving behind the difference frequency of 455KHZ which forms the IF freq1uency [1]

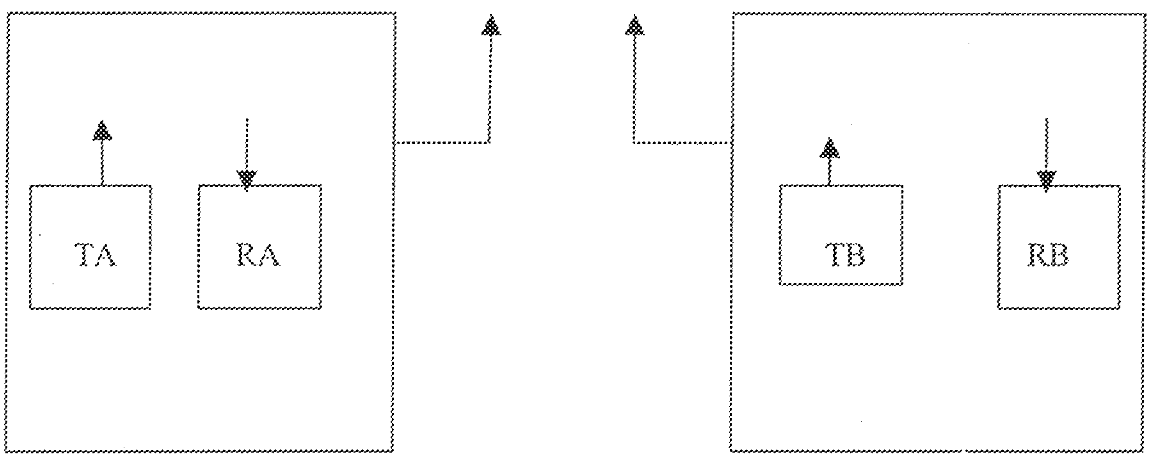
Subsequently, the IF signal so produced is amplified in order to obtain sufficient gain, passed to a limiter (sort of clipping circuit) to remove amplitude variations (caused by noise) passed to a detector circuit which rectifies the IF signal and thus, filters out RF signal, leaving audio signal which is passed to a de-emphasis circuit to reduce the amplitude of high frequency in the audio signal which was earlier increased by the pre-emphasis circuit at the transmitter. The recovered audio signal is fed to audio section where it is amplified until it is large enough to drive a loud speaker which reproduces the original message signal.[1]

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 Circuit Design Analysis

The project involves two communication devices, each containing FM transmitter and a receiver. The two devices are meant to establish communication link with each other. The frequency of operation (60 – 70 MHz), which is below the traditional commercial FM band (88 – 168MHz), was selected deliberately to enable the devices operate with minimum or no interference from commercial broadcasting stations.



TA ≡ transmitter A
RA ≡ Receiver A

TB ≡ transmitter B
RB ≡ receiver B

Fig 3.1: Block Diagram Of The Communication Devices

3.1.1 The Radio Transmitter

The radio transmitter is designed to generate a carrier wave which is modulated by the audio signal. The modulation type employed is frequency modulation. The radio transmitter circuit comprises a very high frequency Hartley oscillator operating in the common base mode, FM modulation circuit and audio amplifier.

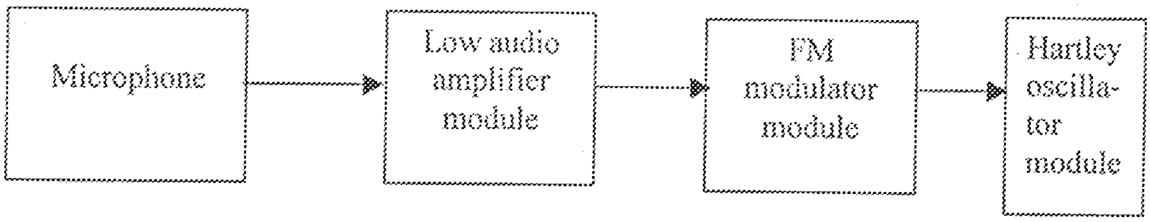


Fig 3.2 Block Diagram Of The Radio Transmitter

3.1.2 The Microphone And Low Audio Amplifier

A microphone transducer converts audio signal into corresponding electrical signal. The resulting weak signal can not be used directly and is thus, amplified by the low audio amplifier modular circuit of fig. 3.3 Transistor Q, is coupled directly to the microphone through a 1µf 16v capacitor C1. Q is configured in the common emitter mode. The transistor employed is 2SC945 used for low frequency amplification and speed switching. It has a maximum operating current and voltage of 100mA and 500V respectively [8]. Its typical hfe or current gain is 80 [8].

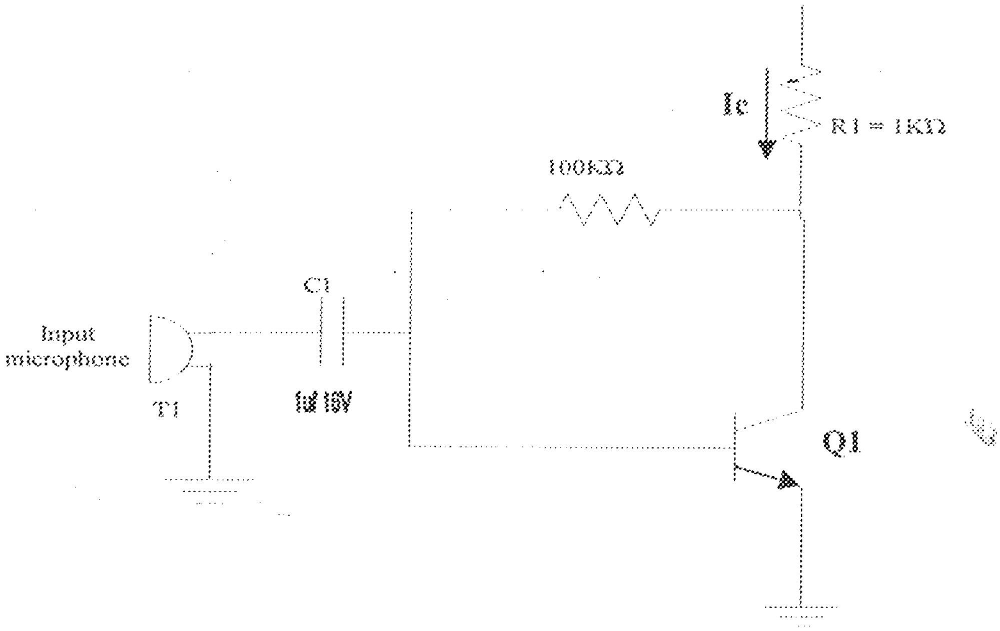


Fig 3.3 Low Power Audio Amplifier

For maximum undistorted output voltage swing, VCE is biased to half the supply voltage,

i.e. $VCC/_2$ = 0.5 VCE.

On a 5v supply, VCE = 0.5 x 5 = 2.5V

VCE = VCC – IcR1

2.5 = 5 – IcR1

IcR1 = 2.5V

With a 1 kΩ collector resistance R1

IcRc = 2.5 .

Ic = (Vcc-Vce)/R = (5 – 2.5)/1000

= 2.5mA

For the transistor used, hfe is typically = 80

Since Ib = $IC/_{hfe}$; Ic = (2.5×10^{-3}) / 80 = 3.125mA

I B = (VCE – 0.7)/RB

$$:- RB = \frac{VCE - 0.7}{IB} = \frac{2.5 - 0.7}{3.125x10} = 592000\Omega$$

This gives the minimum value of RB needed to maintain the quiescent collector voltage at $VCC/2$. This resistor also determines the magnitude of amplification provided by the circuits. A 100 KΩ feed back resistance was selected for high sensitivity. Thus, the maximum amplification provided by the circuit is -100 (inverting amplification). The amplified output is fed into a pre-emphasis circuit to accentuate the high frequency audio signal. The pre-emphasis circuit is shown below.

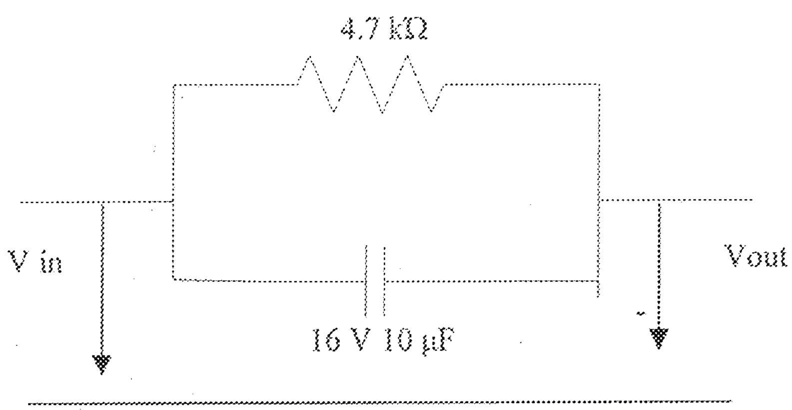


Fig 3.4 Pre-Emphasis Circuit

It has a time constant of T = RC = (4700 x 10^{-5}) S = 47m second

This is different from the standard 50 ns pre-emphasis used for radio transmission and reception.[3]

3.1.3 FM MODULATOR

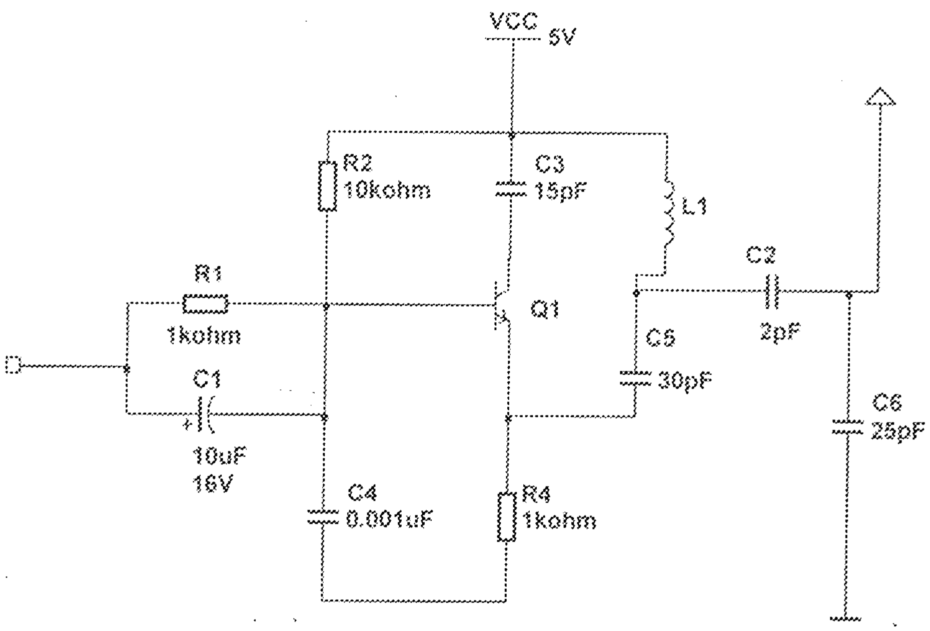


Fig.3.5 Fm Modulator Circuit

The 2SC945 NPN high frequency transistor is wired as a common – base oscillator. Capacitor C_4 provides an ac short circuit from the base to earth at signal frequencies and capacitor C_5 provides the required positive feedback from the collector to the emitter, thus sustaining oscillation. The effective capacitance of the tuned circuit can be visualized as C_3 in parallel with CcE, CoE, and CRB.

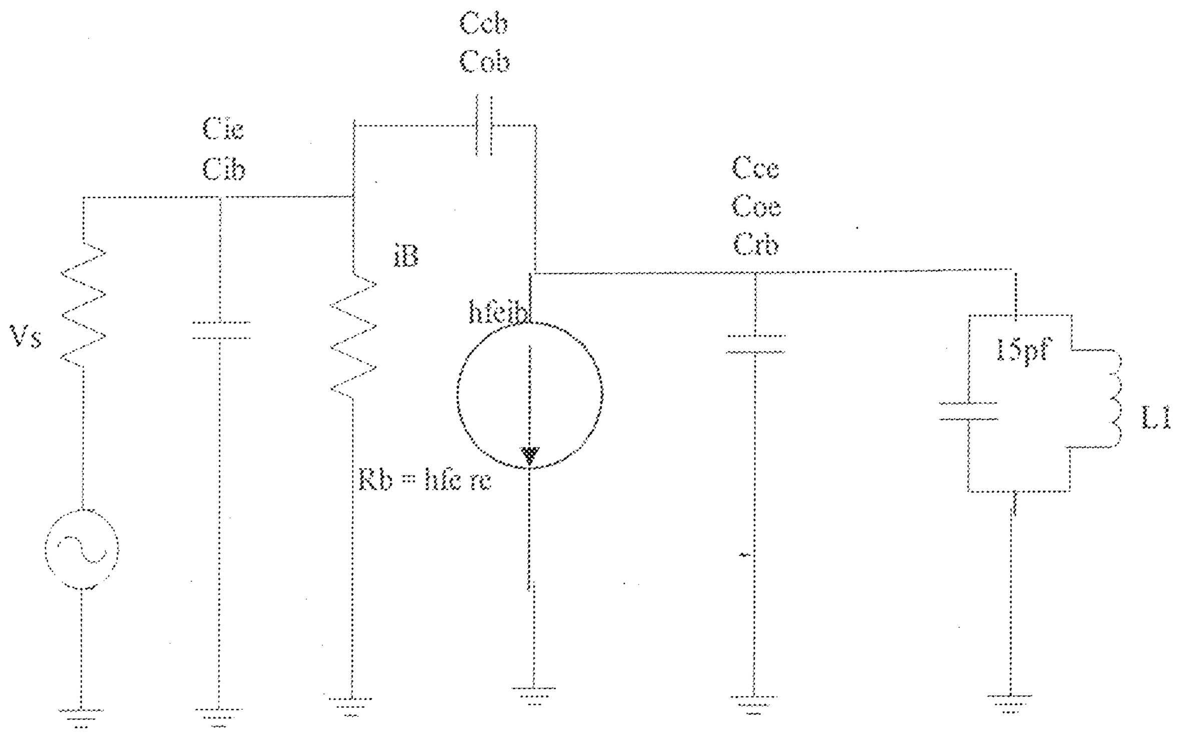


Fig 3.6 High Frequency Analysis Of A Common Base Amplifier

Cie ≈ 1 / 2∏fтre

Alternatively;

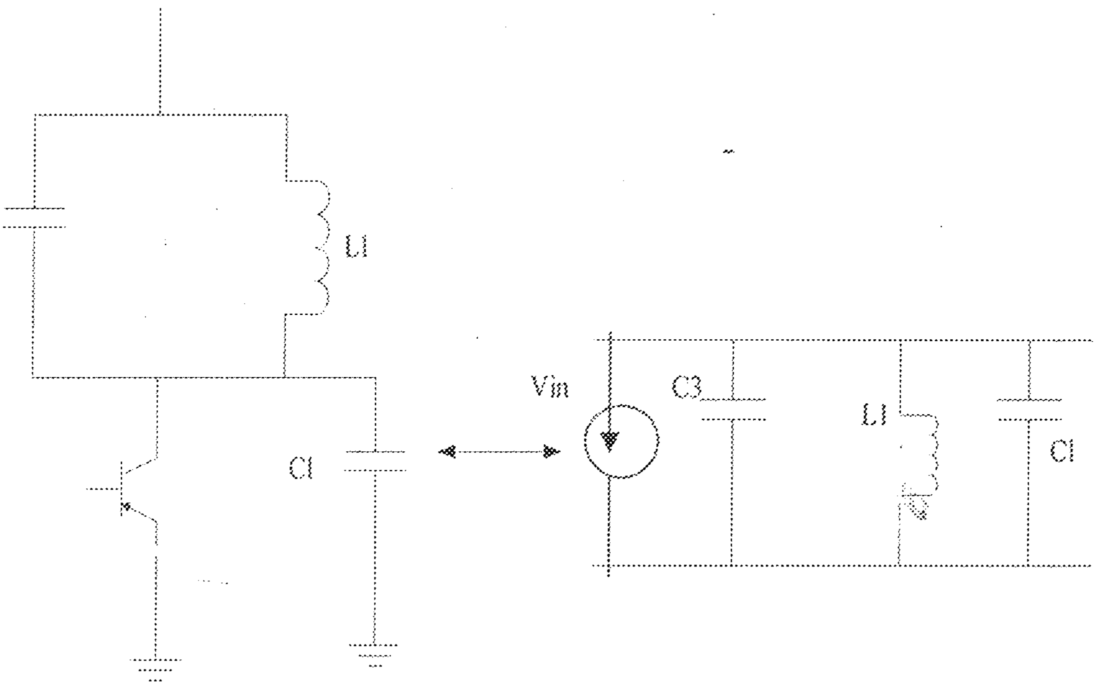


Fig 3.7 Equivalent Circuit Of High Frequency Fm Modulator

Cc varies with Vin, gm remaining constant. Therefore, the variation in the capacitance of the tuned circuit is strongly dependent on Vin. The tuned circuit generates an unmodulated carrier frequency given by the expression:

$F = 1/2\Pi\sqrt{(LC)} = 1/2\Pi\sqrt{(15\times10^{-12})}$ The desired frequency of interest was chosen to the between 60 and 70 MHz . Substituting the values of F and C in the above expression yields the value of L as: 0.4uH this value was approximately obtained by winding 10 turns of 24 gauge enameled copper wire around an air former.

The modulator output was corrected to an antenna for radiation of the radio waves across space.

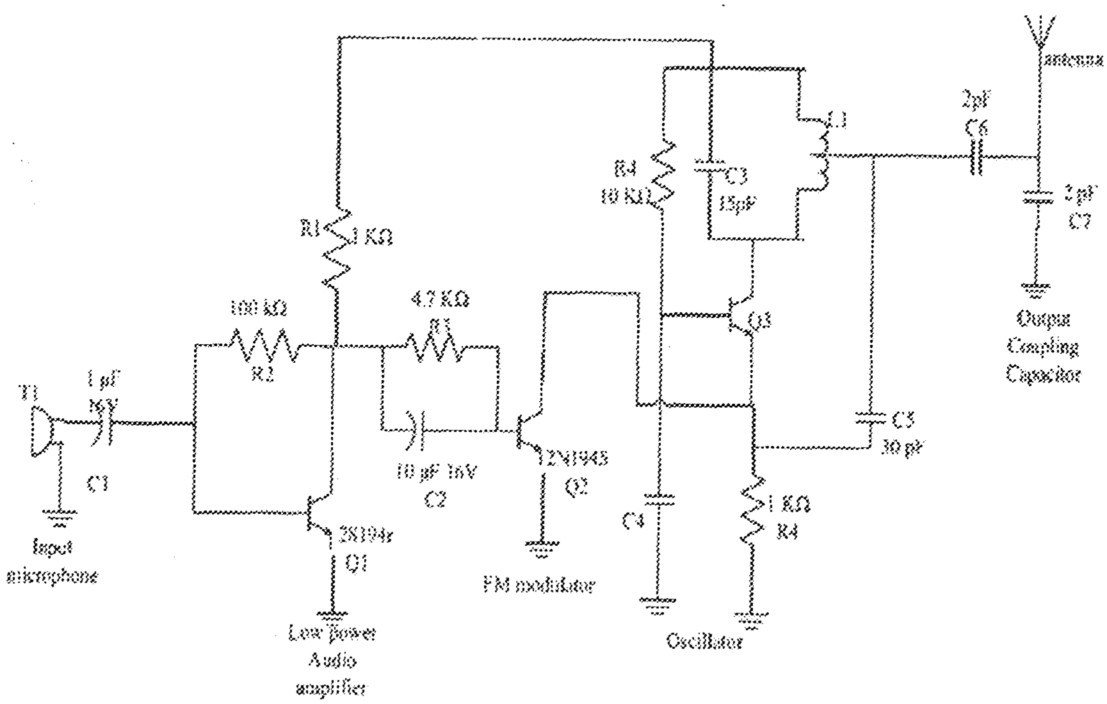


Fig 3.8 The Circuit Diagram Of The Radio Transmitter

3.2 Reception

The receiver portion is designed with an integrated FM/AM RF/mixer/detector chip, the KA2297 RF IC.

This chip provides all the basic requirement demanded of a super heterodyne receiver, that is;

1) Amplification of incoming radio frequencies,

2) Generation of beat frequency with the help of a local oscillator

3) Generation 0f a difference signal, $F_{osc} - F_{IF}$ by heterodyning the local oscillator frequency with the incoming radio frequency.

This heterodyning process produces a signal at a fixed intermediate frequency (IF), for fm (10.7MH$_z$) The IC also selectively amplifies the difference frequency before detection in a quadrature fm detector stage. A critical adjustment of the LO is needed otherwise the beat difference frequency is entirely rejected by the band pass IF filter of the IC if it falls outside of its pass band i.e. when $F_{Lo} - F_{IF} \neq 1O.7$ MHz

Since a (60 to 70) MHz transmission on frequency was chosen and a standard FMIF of 10.7m0H$_z$ used, the local oscillator frequency must be (60 x 10 .7 MHz to 70 x 10.7 MHz) The 10 is chosen higher than the OCF and not lesser to prevent image frequencies from being received and demodulated alongside the desired RF channel. The receiver system is wired as shown on page 25.

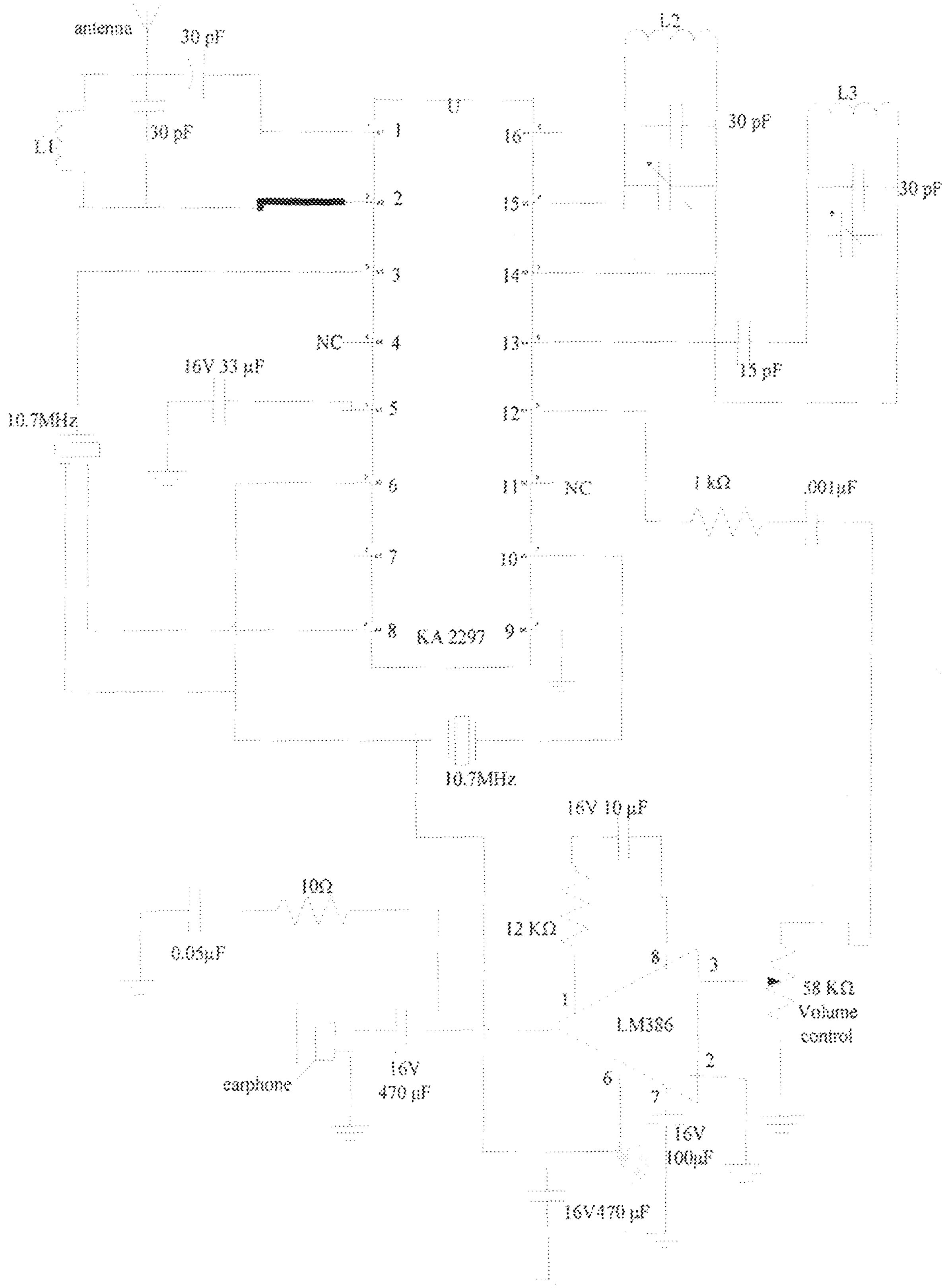


Fig 3.9 Receiver Circuit

Radio frequency reception and demodulation is effected using the KA 2297 RF IC. The antenna tuned circuit (ATC) and the local oscillator (LO) are ganged for easier alignment. The beat frequency is passed through a 10. 7MH$_2$ band pass surface acoustic wafer (SAW) filter to allow only the true difference frequencies as beating the LO (local oscillator) against the incoming RF which generates not only the IF but a whole lot of other frequencies and sub harmonics.

Thus the 10.7MHz SAW filter separates the desired IF from interference IFs. The IF is amplified, demodulated, and fed into an LM 386 low power audio amplifier to raise the received audio voltage to a level sufficient to drive a head phone. The KA2297 IC has specification as represented below.

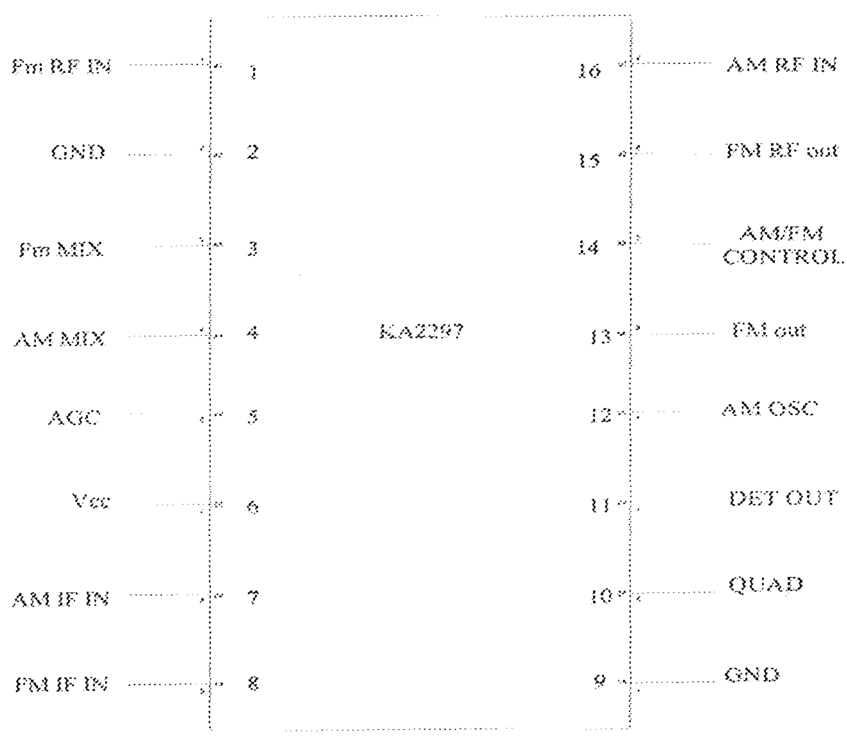


Fig 3.10 The Pin Assignment Of KA2297

The LM386 audio amplifier is a power amplifier designed for use in low voltage consumer of application. It has a gain of 20. However, the addition of an external resistor and capacitor between pins 1 and 8 results into ten times gain (200) for the device. The inputs are ground referenced while the output is automatically biased in one half the supply voltage. The quiescent power drain is only 24 mill watt when operating from a 6 volt supply, making the LM 386 ideal for battery operation.

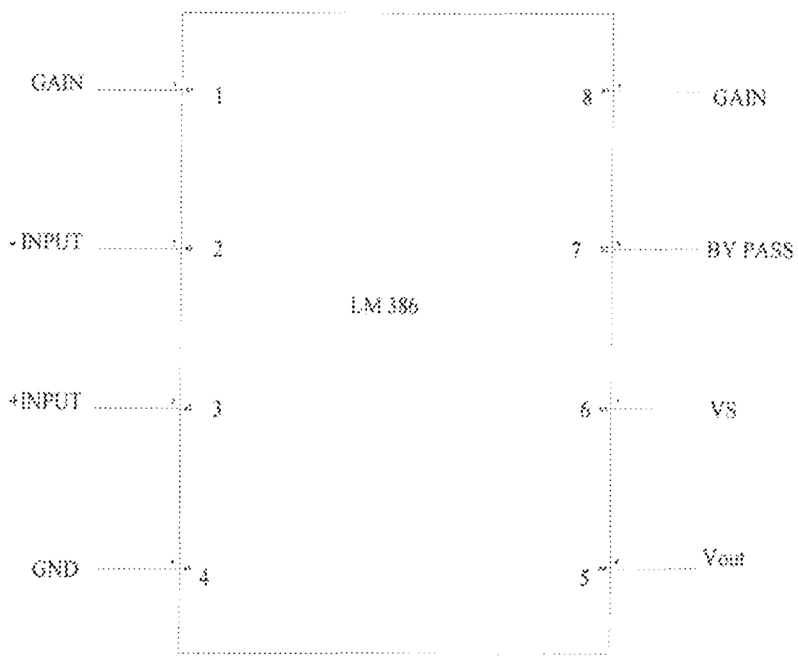


Fig 3.11 The Pin Assignment Of LM386

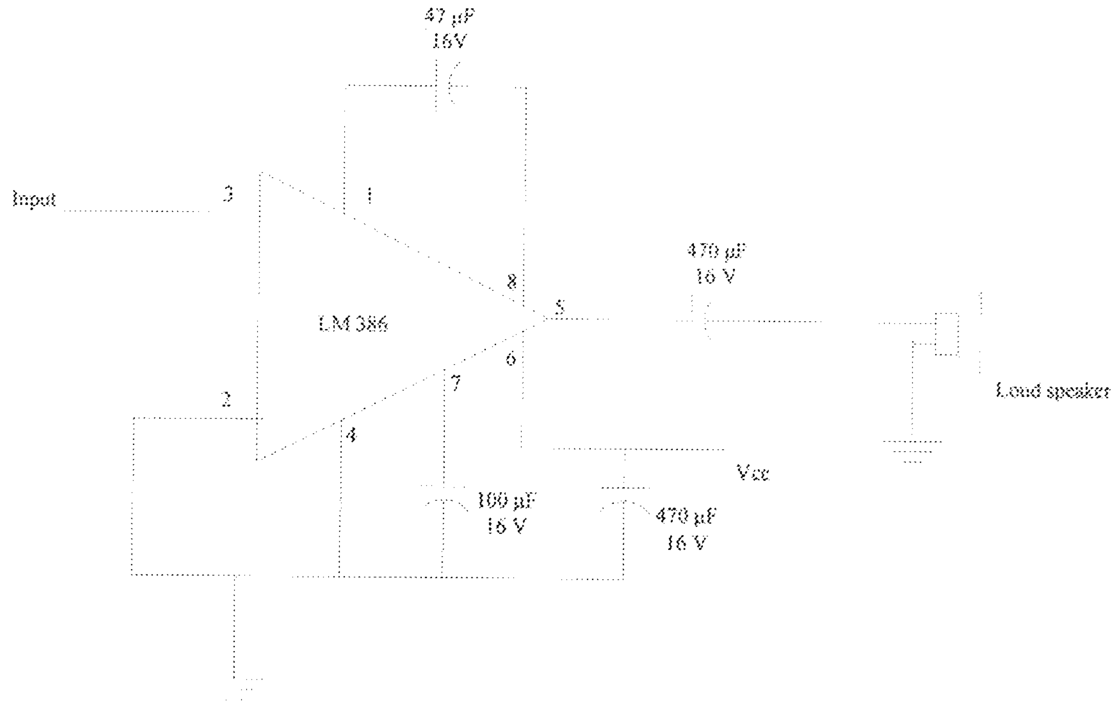


Fig 3.12 A Typical Circuit Of LM386

Operating supply voltage: 8 -18V

Output power: 1W typical (8Ω)

Voltage gain: 26dB typically

Band width: 300KH$_2$

Total harmonic: 0.2%. at 0.125W

Distortion:

Power supply: 50dB (typically

Rejection ratio

Input resistance 50K2 (RM)

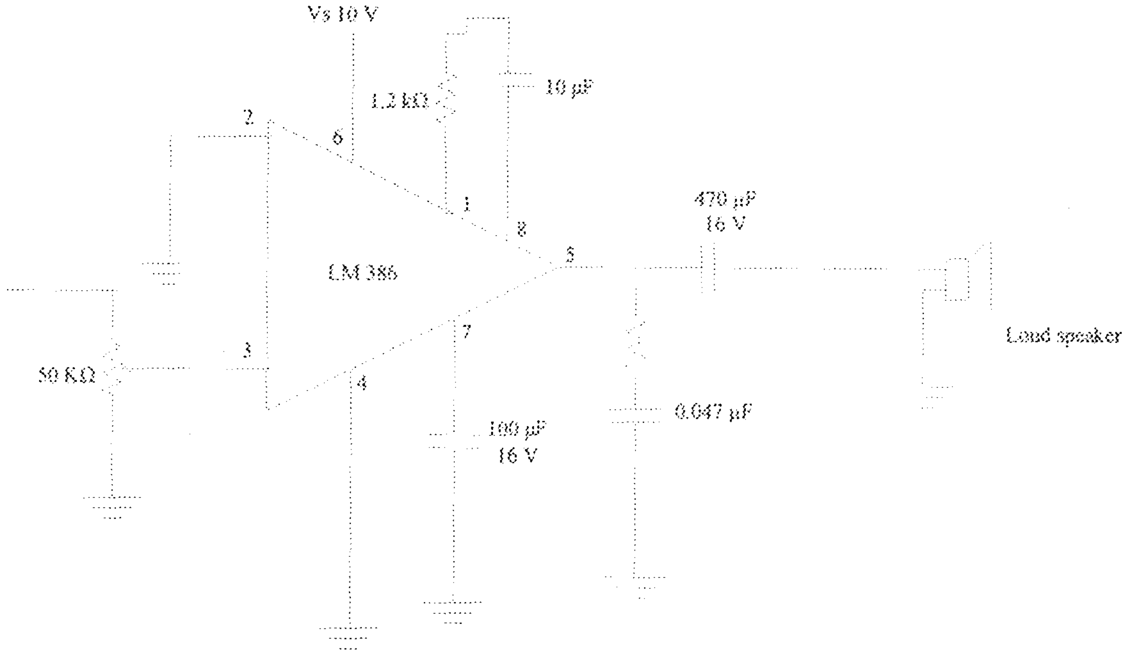


Fig 3.13 Audio Amplifier Of The Receiver Circuit

The LM 386 is a versatile power amplifier configurable for different voltage gains. Pins 1 and 8 are provided to allow higher gains for increased performance. With pins 1 and 8 open a 1.35KΩ internal resistance sets the gain at 20. If a capacitor is connected between pin 1 and 8, by passing the 1.35KΩ resistor, the gain goes up to 200.

If a resistor is placed in series with the capacitor the gain can be set to any value from 20 to 200. Gain control can also be effected by capacitively coupling a resistor (or FET) from pin 1 to ground. The LM386 was configured with fixed gain of 50, providing about 0.4w drive into an 8Ω head phone

3.3 Choice Of Antenna

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

$\lambda = V/F$

For this project, $L < \lambda$ is used which is for frequencies between 10 KHz – 1 GHz

Velocity of electromagnetic wave

$= 3 \times 10^8$ m/s

F= frequency at which signal is to be radiated and received.

λ = wave length of the signal

$$\lambda = \frac{3x10}{70x10} = 4.29m$$

To obtain better efficiency, the antenna must be able to radiate large fraction of the supplied power hence, there is a need for the antenna to approach a quarter wave length of working frequency.

Length of antenna, $L = \lambda/4 = 4.29 = 1.1m = 107cm$.

Therefore, at frequency of operation antenna required will be of length 1.1m

3.4 Implementation

The circuit was first implemented on a bread board. It was then tested for proper operation. There was problem initially as any variation in inductor affects frequency generated by the tank circuit. It was rectified when transferred to a Vero board and soldered. A Vero board is a special kind of printed circuit board specially designed for practical operations. It has tiny holes which are evenly spaced, and through which components can be inserted and soldered. On one face of the board are copper strip which run in rows such that all the components legs of a particular row are connected together. The legs of each component are pushed through the holes from the top of the board and are then soldered on to copper strips under the board. The orientation of the components on the board is such that they are only a few millimeters above board.

After a firm attachment has been made, the excess wires are then cut off for neatness and uniformity, using a long nose pliers or cutter.

3.5 List Of Component Used

1. KA 2297
2. LM386
3. Resistors of various values
4. Capacitors of different values
5. Inductors

CHAPTER FOUR

TEST, RESULTS AND DISCUSSION

The resistors capacitors and transistor were all tested using multimeter and were in good condition. After mounting components on the bread board in accordance with the circuit diagram, it was discovered that when audio signal is transmitted, reception was not stable. However, computer simulation using multisim package confirmed the workability of the project.

Trouble shooting was done and it was found that any variation in inductor in the LC tank circuit varies the transmitting frequency, and thus, affecting the alignment of frequency between the receiver and transmitter.

When components were soldered in Vero-board, initially, the problem persisted. However, after properly packaging in a plastic casing, screwing the Vero board to the plastic casing and carefully tuning the variable capacitor reception was made.

The reception was very clear. The testing was done by giving each of the devices to two individuals who stood five meters apart and continually communicated with each other. Reception was made and, thus the distance between the two individuals was further increased to ten meters apart. Reception was clear at ten meters apart and also at fifteen meters apart beyond which the communication was not clear. Maximum reception was made at about 15 meters apart.

4.1 Results

When the microphone of the transmitter of one device was spoken to, reception was made in the receiver of the second device at about 15 m apart and vice versa thus confirming the project works.

4.2 Discussion of Results

I had problem aligning the receiver with the transmitter due to tuning difficulty. However, careful and painstaking tuning resulted in alignment as reception was clearly made.

4.3 Troubleshooting

Troubleshooting an electronic circuit involves; observing the symptoms, analyzing the possible causes, and limiting the possibilities [4]. It is possible to observe the following; no output, reduced amplitude, unstable frequency and frequency error when troubleshooting oscillators [4]. A system could go wrong due to faulty power source, bad connectors and loose connectors, open cables and cables connected incorrectly, input signal missing, incorrectly set controls, component failures, network problems [4].

A receiver should be viewed as a signal chain. If the receiver is dead the problem is to find the broken link in the chain. Signal injection should begin at the output (speaker) end of the chain. However, a receiver involves gain at different frequencies [4]. In this project, when troubleshooting the stated points above should be borne in mind.

CHAPTER FIVE

CONCLUSION

The project is the documentary presentation of the construction of a two – way transceiver intended for use by operational police officer in combating crime. Initial set back was quickly overcome and eventually the aim and objective of the project was realized. Walkie –Talkie was successfully miniaturized and attaching the device with a head phone/microphone make the use of this device superior to walkie-talkie in police operations due to confidentiality of communication.

Moreover, the transceiver was able to transmit audio message to a distance of fifteen meters apart. Environment and weather condition played a large role in quality of the received signal.

The major problem encountered while carrying out this project was un-availability of necessary components, thus, the design has to be modified several times to incorporate available components.

5.1 Recommendation

Project topics should be given out as early as in three hundred level to enable students conclude design on time and source for components that will satisfy their particular design. This will go a long way in making students realize their original aim of performing a particular project. The department should provide a high frequency oscilloscope and frequency meters. The available ones could not measure beyond 20 MHz of frequency. It therefore poses a serious problem for students carrying out project involving very high frequency.

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