DESIGN AND CONSTRUCTION OF AN FM TRANSMITTER

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Program of this kind carried out and a project written on it, is not always easy except with the help of some concerned individuals who feel your success in this life is also a thing of concern to them. So to this category of people I say thank you all for your highly rewarding efforts.

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Also not to be left out are my friends and well wishers, thank you all and may God bless you.

DEDICATION

This project is dedicated to almighty God for sparing me the time and strength to carry out this program successfully.

CERTIFICATION

ıis is to certify that this project titled **DESIGN AND CONSTRUCTION OF A MINI REQUENCY MODULATION TRANSMITTER**, was carried out by **OBEKPA INALEGWU** ıder the supervision of **Mr. EMMANUEL ERONU** and submitted to the department of Electrical ıd Computer Engineering, Federal University Of Technology Minna in partial fulfillment of the equirement for the award of a Bachelors of Engineering (B.ENG.) Degree in Electrical and Computer Engineering.

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ABSTRACT

Due to man's curiosity for fast information dissemination, science and technology has made it so fast that information can be transmitted and received within seconds by electronic means. Information can be transmitted from one point to another through frequency modulation technique. Transmission of information through this means is so common, that it is found in almost every corner of our planet.

Frequency modulation, is a modulation technique generated by varying the frequency of a carrier which is between a frequency range of 88MHZ – 108MHZ, with an audio frequency range of 20HZ – 20KHZ which is then transmitted in electromagnetic waves for reception and processing into its original audio form at different locations.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 INTRODUCTION

The most significant aspect of science cod technology is communication. This area of science and technology is also the fastest growing field in terms of its vast applications. There are many other forms of electronic communication' some of which are, transmission of video, sound, and text all in electronic form from one point to another.

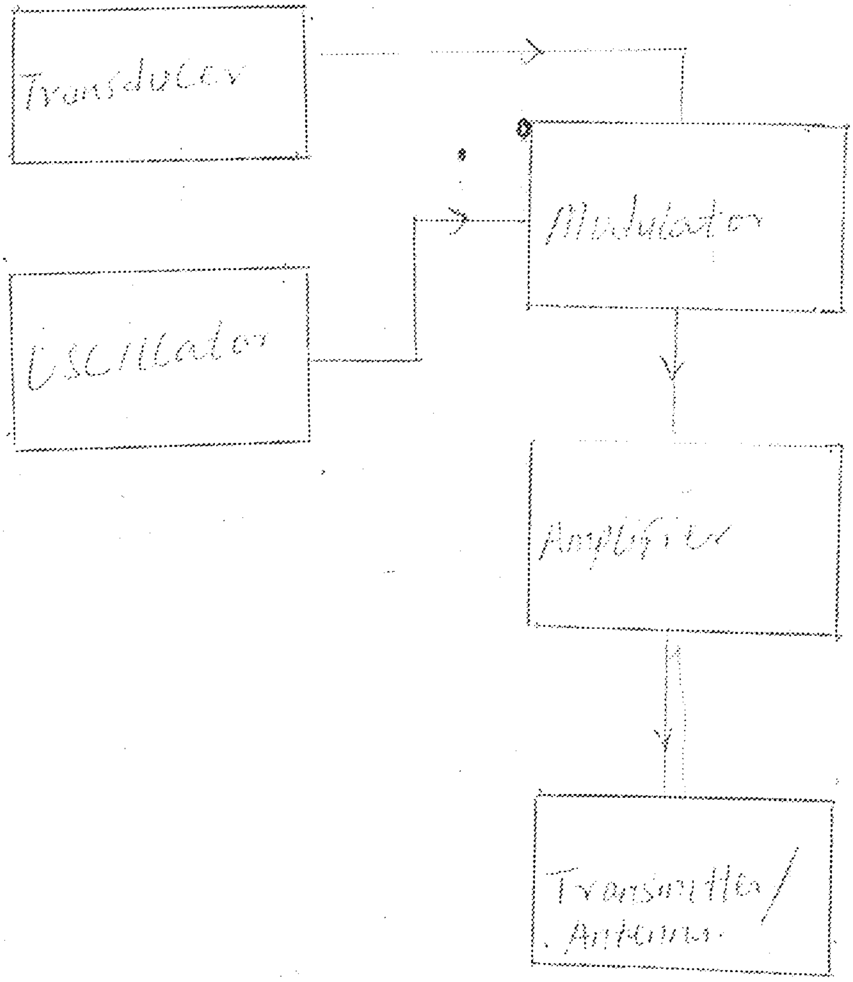
Wireless broadcasting of information, forms a major aspect of communication, which is used in the transfer of information from one point to several areas for public use. There are many modes of wireless broadcasting, namely, Amplitude modulation, Frequency modulation and Phase modulation just to name a few. Among these modes of broadcasting, frequency modulation is the most preferred system due to its advantages over the others, some of which are high signal to noise ratio and wider bandwidth which is responsible for its stereo quality. Its also has its shortcomings, mainly shorter area of broadcasting due to its line of sight characteristics.

The wireless broadcast type designed in this project is a frequency modulation (FM) transmitter. Frequency modulation is a system of broadcasting in which the amplitude of a carrier is kept constant, while its frequency and rate of change are varied by the modulating signal. The first practical FM transmitter was put forward in 1936 as an alternative to AM in an effort to make radio transmission more resistant to noise.

A standard FM system is made up of five main sections namely, The audio pre-amplification unit, oscillatory unit, modulation unit, amplification unit and the transmitting unit. The audio pre amplification unit, transduces voice or sound into electrical pulses with the aid of a microphone. The modulating unit receives audio signals from the transducer, processes it then uses it to modulate the carrier frequency at the oscillatory unit. The modulating signal will cause the carrier to deviate from its resting frequency by a certain amount . The maximum deviation specified by the Federal Communication Commission (FCC) is 75KHz. This amount of deviation ensures that the modulated signal is not transmitted with distortions. The modulated signal is then fed into a class C amplifier, which amplifies the radio frequency for high transmitting power. The last section which is the transmission unit, consist of an antenna, which converts the modulated signal into electromagnetic waves for wireless transmission for public use.

The block diagram of an FM system is shown on the next page.

fig 1.0



FM SYSTEM BLOCK DIAGRAM

1.2 LITERATURE REVIEW

Electronic broadcasting requires a very accurate design to achieve a desired noise free transmission, since the aim of transmission is to transfer information from one place to another without error or interference.

Frequency modulation additionally has the advantage, over both AM and PM, of providing greater protection from noise for the lowest modulating frequencies. The resulting noise signal distribution is here seen as triangle, whereas it is rectangular in both AM and PM. A consequence of this is that FM is used for analog transmission, whereas PM is not. Because FM broadcasting is a latecomer compared with AM broadcasting, the system design has benefited from the experience gained with AM. Two of the notable benefits are the provision of guard bands between adjacent transmissions and the use of pre-emphasis and de-emphasis. With emphasis, the highest modulating frequencies are artificially boosted before transmission and correspondingly attenuated after reception, to reduce the effect of noise

Wideband FM is for broadcast transmissions, with or without stereo multiplex, and for the sound accompanying TV transmissions. Narrowband FM is used for communications, in competition with single sideband (SSB), having its main applications in various forms of mobile communications, generally at frequencies above 30MHz. Two basic methods of generating FM are in general use. The reactance modulator is a direct method of generating FM, in which the tank circuit reactance, and the frequency of an oscillator, is varied electronically by the modulating signal. To ensure adequate frequency stability, the output frequency is then compared with that of a crystal oscillator and corrected automatically as required. The alternative means of generating FM, the Armstrong system, is one in which PM is initially generated, but the modulating frequencies are correctly bass-boosted. FM results in the output. Because only small frequency deviations are possible in the basic Armstrong system, extensive frequency multiplication and mixing are used to increase deviation to the wanted value. The power and auxiliary stages of FM transmitters, except that FM has an advantage here since it is a constant amplitude modulation system, all the power amplifiers can be operated in a class C, i.e., very efficiently.

1.3 AIMS AND OBJECTIVES

Signal broadcast provides a means whereby different people at different locations can receive information at the same time. This system requires the need for a reliable and efficient system of broadcasting. Out of these modes of analog broadcasting, FM broadcasting provides the highest level of signal to noise ratio, hence very resistant to noise. This project explains how this high efficient mode of broadcasting is designed.

4 PROJECT OUTLINE

There are four chapters in all, each chapter containing important sections concerning the project.

Chapter 1 is a general introduction and contains background information necessary for a proper understanding of the project.

Chapter 2 has the design and analysis of each stage making up the project.

Chapter 3 is an explanation of how the project was constructed and tested and the result of testing are given.

Chapter 4 gives the conclusions and recommendations for use and further improvement.

References and Appendices are given thereafter.

CHAPTER TWO

2.1 INTRODUCTION

In frequency modulation, the shift in the carrier is proportional to the amplitude voltage. The shift in the carrier frequency from its resting point compared to the amplitude of the modulating voltage is called the deviation ratio (a deviation ratio of five is the maximum allowed in commercially broadcast FM). The rate at which the carrier shift from its resting point to a non resting point is determined by the frequency of the modulating signal. If the modulating signal (AF) is 15KHz at a certain amplitude and the carrier shift (because of the modulating voltage) is 75KHz the transmitter will produce eight significant sidebands. This is known as the maximum deviation ratio.

$$\text{Deviation ratio} = \frac{F\,dev(max)}{F\,af(max)}$$

If the frequency deviation of the carrier is known and the frequency of the modulating voltage (AF) is known, we now establish the modulating index (MI).

$$MI = \frac{Fdev}{Faf}$$

Both these terms are important because of the bandwidth limitations placed on wideband FM transmitting stations by the regulating agencies through-out the world.

2.2 TRANSDUCER

Transducers are generally used to convert physical quantities into electrical signals. The one used in this system, converts sound into electrical pulses, by changing movement caused by air pressure into electrical pulses. This process is achieved with the use of a carbon microphone, which changes movement caused by air pressure from a sound source into electrical pulses.

A single 4 kilohms MC480 carbon microphone is used to achieve this purpose. There are different types of microphones, but for simplicity and convenience a small carbon microphone is used. The signal input to the microphone is made small in order not to overdrive the microphone circuit, which could results to positive feedback of the microphone. A loud humming sound could be heard due to this effect at the receiving end.

The circuit of fig 2.0 on the next page explains this action.

R1, biases the carbon microphone to produce the required current needed for its operation.

$$\text{Input current, Iin} = \frac{Vs}{Rin} = \frac{9}{24k} = 0.0034mA$$

Capacitor C1 allows only alternating signals to pass while blocking dc signals from upsetting the next bias stage. The 50uF capacitor used, works by providing a high reactance for direct current, while providing a low reactance for signal current.

2.3 MODULATION UNIT

This is the unit where the audio signal is combined with a carrier frequency to produce the frequency modulation. At this stage, the audio signal is used to vary or shift the frequency of a carrier. The frequency of the carrier is determined by the values of the capacitance and the inductance.

An oscillator circuit is used to achieve this purpose. The carrier frequency for this design is meant to be 95.0MHz. The values of the capacitance and inductance used to produce a 95.0MHz,is carefully calculated to achieve a 95.0Mhz carrier frequency. This unit consist of the modulating circuit and the carrier circuit, which work together to generate the required modulated signal for transmission. The circuit diagrams on the next page illustrate this process.

The audio signal from the microphone is fed into the input of the C830 transistor through resistor R1 for amplification ,which is used to modulate the carrier frequency of the oscillator. The action of the audio signal is to shift or deviate the carrier frequency of the oscillator by a certain amount determined by the amplitude of the modulator signal, i.e. the higher the amplitude of the modulator, the higher the shift or deviation of the oscillator frequency.

From the circuit of fig 2.0, R2, sets the base emitter bias. C4, is a coupling capacitor which ensures separate paths for direct current and for the generated Radio frequency signal current. R3, sets the collector emitter bias. R4, sets the emitter collector bias, while C3 is a bypass capacitor used to prevent ac signal degeneration. C5 and L1 combine to form an oscillator to provide the carrier frequency needed for modulation.

The carrier frequency is determined using

F = 1/(2# LC)

Where C = 23uF, L = 0.152mH

1/(2# 23*10 * 0.152*10) = 95.0MHz

The hfe of the transistor C830 is 100. hfe = output current / input current.

Input current = 0.34mA

Output current = 10 * 0.34 = 3.4mA

Deviation ration = fdev(max)/ faf(max). Where fdev, is the maximum deviation of the carrier frequency. Faf is the maximum modulation frequency

Fdev = 75MHz, Faf = 15KHz.

Deviation ratio = 75 / 15 = 5. This is the maximum allowed in commercially broadcast FM.

The carrier power, Pc is given as follows.

Pc = V^2 / R. Where V, is carrier voltage, R, is carrier resistance.

V = 9volt. R = 7 Pc = 9^2 / 7 = 11.6Watt.

Transistor C830 has an hfe of 100.

Hfe = output / input. Where input signal = 0.0034mA, hfe = 100.

output signal amplification = 100 * 0.0034 = 0.34mA.

Signal power = I * V. Where V = signal voltage

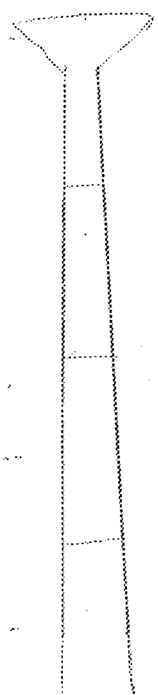
I = signal current. Signal power = 0.34 * 9 = 3.06watt.

Modulation power Mp is the summation of carrier and signal power, which is given as signal power + carrier power. Where signal power is 3.06watt.

Carrier power is 11.6watt. Modulating power Mp = 3.06 + 11.6 = 14.66watt

2.4 TRANSMISSION UNIT.

The transmission unit consist of basically an antenna Which converts the modulated signals into electromagnetic waves for wireless broadcasting. The antenna type used here is a 7ohms Yagi - Uda antenna. Six ohms is used here to establish impedance matching which is very necessary in preventing over driving the modulating system or the antenna. The transmitting range of the transmitter depends on the height of the antenna and the transmitting power of the modulated signal. Since the predicted transmitting range is about 500 meters, a convenient antenna height of 0.5 meters is used to achieve this range. The diagram on the next page shows a Yagi-Uda antenna.



Yagi-Uda antenna.

The power dissipated by this antenna is calculated using $P = I^2 * R$.

Where I is the modulating current, R is the antenna resistance. The modulating current I is found using, $I^2 = P / R$. Where P is the modulating power, R is the antenna resistance.

$I^2 = 14.6 / 6 = 2.4 = 1.5$Ampers.

Power dissipated by antenna $P = 7 * 1.5^2 = 15.75$watt.

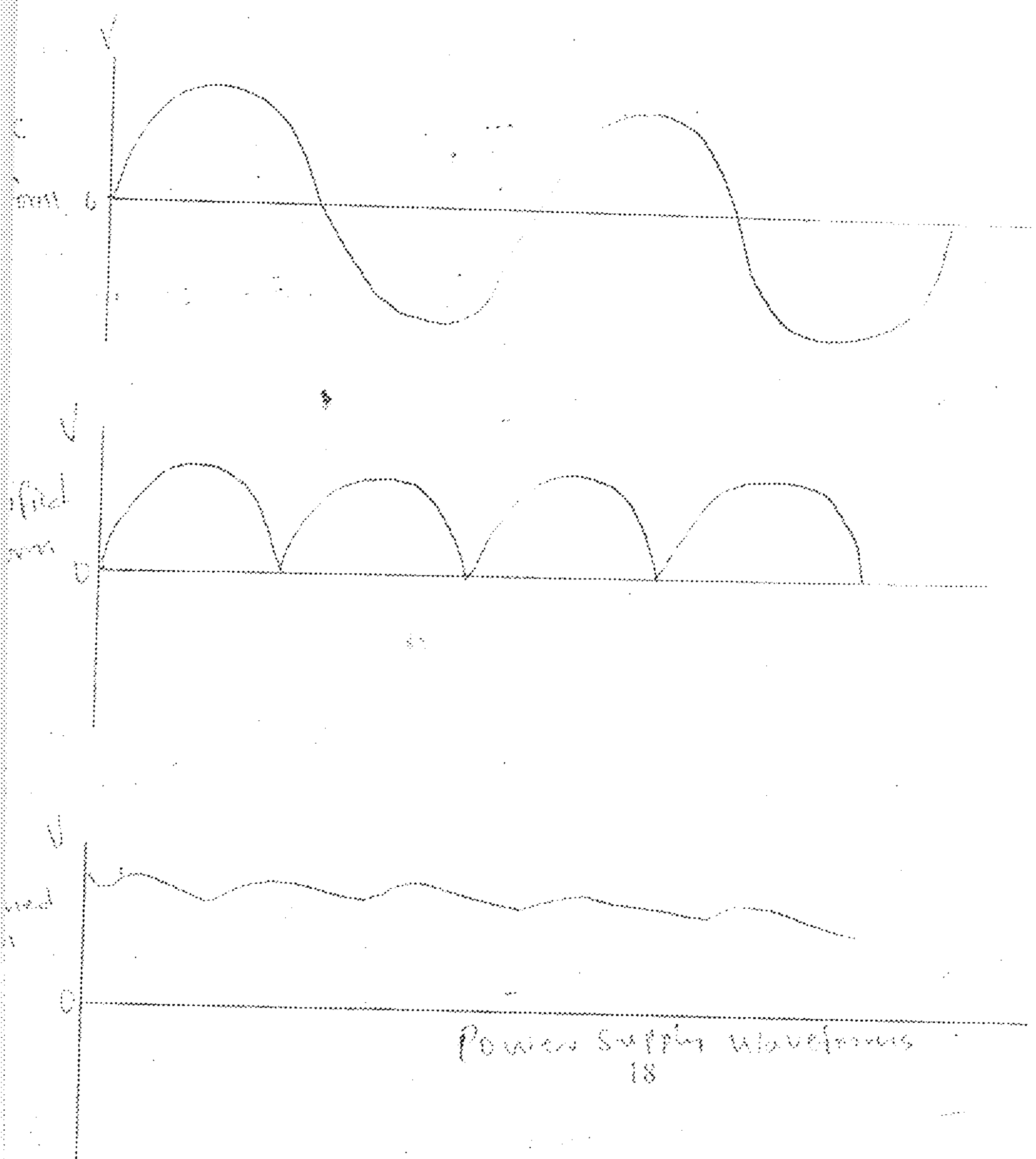
Since the antenna power consumption is 15.75watt and that of the modulating power output is 14.66, the difference shows an ideal level of impedance matching which is necessary for the systems normal operation.

2.5 THE POWER SUPPLY

The TTl ICs used run on a power supply of +-5%. Thus the supply must be regulated to prevent any fluctuations in voltage level. Its design is given overleaf.

The mains voltage of 220V is stepped down by a 220V/9V, 1.2A transformer. It is then rectified by a full wave bridge rectifier.

The wave form of this stage has no negative component, but a lot of ripple. Smoothing capacitors are needed to reduce the ripple to an acceptable level. The resulting ripple voltage can be calculated by considering the wave given below.



Power Supply Waveforms

The load causes the capacitor to discharge between half cycles. If the load current stays constant, as it will for small ripple, then from

I = C V / dt

^t can be approximated by ^t = 1/2f = 1 / (2 * 50) =0.001s.

which is on the safe side, as the capacitor begins charging up in less than half a cycle. The maximum current that can be drawn by the circuit is determined by the voltage regulator following the filtering capacitors, the 7805. it can supply a maximum of 1A if it is heat sunk properly. This current will be drawn from the supply. Thus I load = 1A. taking the value of C to be 3000uF,

^V = (1 * 0.01) / (3 * 10^-6) = 3.3V

this means that the wave goes from a peak value of 2 * 15 = 21.21V to 21.21 – 3.3 = 17.91V. this is acceptable since the input to the 7805 requires that the voltage level does not fall below 2V above its output, ie, below 7V. the ripple is further neglected by the 7805 to a negligible value. The average dc voltage going to the 7805 is calculated by Vp – 0.5Vpp = 21.21 – 0.5 * 3.3 = 19.56V.

The output from the 7805 is at a maximum current output of 1A. A heat sink is necessary and is screwed on to its back. The output remains constant in spite of input voltage variations. To trap power supply spikes, a 0.1uF capacitor is connected across the output.

For power indication, a diode is connected from the positive supply line immediately after the capacitor to ground through a resistor. The resistor value is determined by the current carrying capacitor of the diode. Thus, a resistor of 2.2km produces a current of 19.56 / 2.2 = 8.89mA which fully lights up the diode. The diode and resistance also serves as a path to ground through which the smoothing capacitor can discharge after the supply has been turned off. This prevents high voltages that might damage other parts of the circuit from remaining in the system.

CHAPTER THREE

CONSTRUCTION, TESTING AND RESULT

From the design, it could be noted that not all values from calculations that are ndard values. Due to this fact, the nearest values are used for the construction of the cuit. The complete frequency modulation transmitter circuit design, consists of five main ages. The pre-amplifier stage, the modulation stage, the oscillation stage, the class C nplifier stage and the transmission stage. These stages perform their various functions to chieve the desired goal of this project.

.2 CONSTRUCTION

The design was carried out in stages, one unit after the other using a bread board or testing board. The first stage which is the pre-amplification stage, consists of a carbon microphone for transducing voice or sound into electrical signals. Capacitors were also used to filter and block any dc signals at the output of this stage from upsetting the next bias. At this stag, resistors were also used to establish the required bias voltage and current levels for the other components in action.

The second stage which is the modulation unit, consists of a transistor, capacitors, resistors and an inductor. The transistor here, amplifies the audio signals to an ideal level for modulation. The capacitors block all dc component from affecting the ac signals. The inductor establishes the bias for the collector and prevents the ac signals from driving into the power supply. The resistors establish bias at various terminals for the transistor operation. The third stage which is the oscillation stage, consists of an inductor, capacitors, resistors and a transistor

The capacitor and inductor combine in parallel form to produce an oscillator which produces the carrier frequency to be modulated.

The transistor amplifies the carrier frequency and also acts as a feedback for the oscillator in order to stabilize the frequency of oscillation. The resistors here, also establish the required bias for the transistor terminals.

The fourth stage which is the amplifying stage, consists of a class C amplifier, resistors and capacitors. The class C amplifier which is ideal for RF amplification is used to amplify the RF signals to an ideal level for broadcasting. The resistors here also establish the necessary bias for the terminals of the class C transistors. The capacitor also filters the signal output and blocks all the dc component of the signal from affecting the next bias.

The fifth stage, which is the transmitting stage, consists of mainly an antenna. The antenna type used is a Yagi-Uda antenna capable of dissipating the output RF signal of the class C amplifier.

After these stages were assembled on different breadboards and tested accordingly, they were later connected together sequentially, for final testing before assembling and soldering on a Vero board. The result of the test was satisfactorily after minor adjustment in the circuit design. The device on the breadboard was later transferred component by component for final soldering on a Vero board.

The device on the Vero board was later transferred to a housing of a well treated wooden materials having the following dimension 5cm x 6cm x 8cm.

3.3 TESTING

Microphone was considered first in the testing of this device because it is the first component in the FM system. Two important characteristics of the microphone are their impedance and pick-up pattern for this test. A 10K impedance microphone of about 2.5MV output voltage was chosen to match the input impedance of the pre-amplified circuit. Initially when the system was tested with an FM receiver, there was serious distortion in the signal output, which was due to over modulation. It was corrected by limiting the modulating signal to an ideal level. The final testing was carried out by checking the frequency range of the transmitting frequency. This was necessary due to the fact that commercial broadcasting frequency modulation channel occupies 200KHz (of which 180 KHz is used, and the remaining 20KHz guard band goes a long way towards reducing adjacent channel interference even further. This test is necessary to ensure that too much frequency range is not occupied. The use of a digital FM receiver was accurately used to carryout this procedure which achieved the desired result.

3.4 RESULT

It was noticed that as the inductor of the oscillator was varied, the carrier frequency also changed. This particular property is very useful, in the sense that the transmitting frequency can be changed in case the transmitting frequency interferes with another broadcasting station's transmitting frequency.

The transmitting range of this system occupies about 500 meter radius, which depends on antenna height and the transmitting power.

The signals generated at different stages of the FM system were studied by the use of an oscilloscope considering a microphone as source of signal. The following different shapes illustrate the performance.

3.5 TROUBLE SHOOTING CHECKS

Th following trouble checks will help to locate major faults occurring in the FM transmitter.

1. When the system is on and the light emitting diode is not glowing, the power supply unit may be faulty.
2. When the system is on but there is no output, the system may be put under fault investigation. The fault may be a disconnection of a component or its complete deterioration.
3. When a loud humming sound is heard from the receiver unit, the system may be too close to the receiver.
4. When there is transmission signal but no sound, the microphone may be faulty.

3.6 DISCUSSION OF RESULT

This project has been designed to produce a predicted transmitting range of 500 meters. Since there is no formula to estimate the maximum transmitting range, the height of the antenna and the transmitting power are used to estimate transmission range could not be achieved due to the following reasons:

- Power losses along connecting cables
- Error introduced by measuring equipment

- The non exactness of components values
- Power consumed by power components (transistors & resistors).

Since the project was designed to work within the limits of human errors, the high overall reliabilities value of 0.876 gained for a 100 hrs of operation can certify the efficiency of the system.

CHAPTER FOUR

4.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The frequency modulation transmitter designed in this project worked within the limit of human errors. It was constructed successfully not without hitches anyway. Moreover a few difficulties were encountered before the completion of the projects. First among these was finance. Although the design was done with components that are readily available, the market price was too high for the smallest component. However on the whole we have learnt a lot theoretically and practically in the process of the design.

4.2 RECOMMENDATION

An aspect of vital importance is the maintenance of the device. It is recommended here to be familiar with the precautions in case of any fault, it is advisable not to open the device if the user is a lay man. Safety remove the supply cable and bring the device to a well trained person.

The financing of the project is also a very important issue. More often students do have some bright ideas on the project but due to the cost of its implementation, it is dropped. The market price of components are too high, I therefore recommend that the department should find a way of assisting students undertaking construction projects.

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