DESIGN AND CONSTRUCTION OF LONG RANGE FM TRANSMITTER

By

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

DECEMBER, 2009

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A FINAL YEAR PROJECT REPORT SUBMITTED TO THE DEPARMENT OF ELECTRICAL AND COMPUTER ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,IN PARTIAL FULFILMENT OF THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING.

DECEMBER, 2009.

DEDICATION

I dedicated this project work to the Almghty Allah the Lord of Universe and my parents; Mallam Adamu Liman and Mallama Aisha Adamu who have seen to the fulfillment of my dream in life.

ACKNOWLEDGEMENT

I am first of all grateful to Almighty Allah (S.W.A), the creator of universe, for sparing my life up to this moment and for his grace, inspiration, wisdom and understanding given to me to complete this program successfully.

My profound gratitude first goes to my parents: Mallam Adamu Liman and Mallam Aisha Adamu for the parental role they played from the beginning of my life to date. May Allah provides their needs for them and grant them with paradise. My next gratitude goes to the H.O.D Electrical and computer Eng. Dept. ENGR. DR.A.Y Adediran and my project supervisor, Mallam Bala Salihu, and Mrs Asindi, for their guidance, advice, encouragement and absolute support throughout the project work.

This project work has been supported by many people whose their advice and encouragement were critical throughout the whole process such of those people are my uncles: Mallam Yunusa liman, Alhaji Yunus Idris Ndako, Adamu Idris and Haruna Idris. My brothers and sisters; Salihu Adamu, Abdullahi Adamu, Aishat Adamu, Fatima Adamu, Ajiya Kasimu and all the entire family. I am indebted to all of them for their moral and financial support towards the success of this program.

I also want to note the valuable contribution of my friends; Abdullahi Adamu, Mohammed Kitabu who's their prayers went along way to the completion of this project work.

Finally, I offer my deepest appreciation to the effort of my course mate Ahmad Ibrahim who endured all the long weekends and late nights I devoted to compile this project work to worked hand in hand with me. May God bless you all.

DECLARATION

I, Zakari Adamu, declare that this work was done by me and has never be presented else where for the award of a degree. I also hereby relinquish the copyright to the federal university of Technology, Minna.

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(May 6, 2010)	03/03/10
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ABSTRACT

This project is the design and construction of long range FM transmitter. This project was actualized to know the relationship of carrier frequency, modulation frequency to efficiency and bandwidth. To compare FM systems to AM systems. The project is design to cover a range 1-2km distance from the transmitter. Also the project is divided into five units namely; audio unit, oscillating/modulating unit, radio frequency (RF) driver/Amplifier unit, RF Amplifier unit and transmitting unit. These units work together to achieve the expected result.

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CHAPTER ONE

INTRODUCTION

1.1 GENERAL INTRODUCTION TO COMMUNICATION SYSTEM

One of the most significant areas of science and technology is communication. Transmission of information is an indispensable process in the field of electronics and electrical communication both in intercommunication and telecommunication. Communication is therefore said to be the transfer of information from one point to the other usually through a medium. There are various forms of communication, some of which are transmitted in the form of video, audio or text. Wireless transmission or broadcasting of information forms the major unit of communication. Information cannot be broadcasted directly as human voice has a frequency range of transmission and if everyone's voice is to be transmitted at the same time and at the same frequency, interference would occur rendering the communication ineffective. To avoid this, it is advisable to modulate all information to be transmitted.

The term modulation is defined as the process by which the parameters (e.g amplitude, frequency or phase) of high frequency signal (known as the carrier asignal) is modified in accordance with the instantaneous value of message signal (modulation signal)[1].This implies that the transmission is done at high frequency but modified to carry low frequency information .Once the information reaches the receiver ,the desired signal is processed to suit the output transducer by a process called demodulation (opposite of modulation). Thus, the only effective means of information transmission is through modulation. Modulation is therefore important in communication for the following reasons:

1 for efficient signal transmission

2 to overcome hardware limitation

3 for reduction of noise and interference in communication channel

4 for frequency assignment

5 for multiplexing

6 for easy radiation and to use reasonable antenna length [2]

The block diagram of simple communication system is shown in fig 1.1

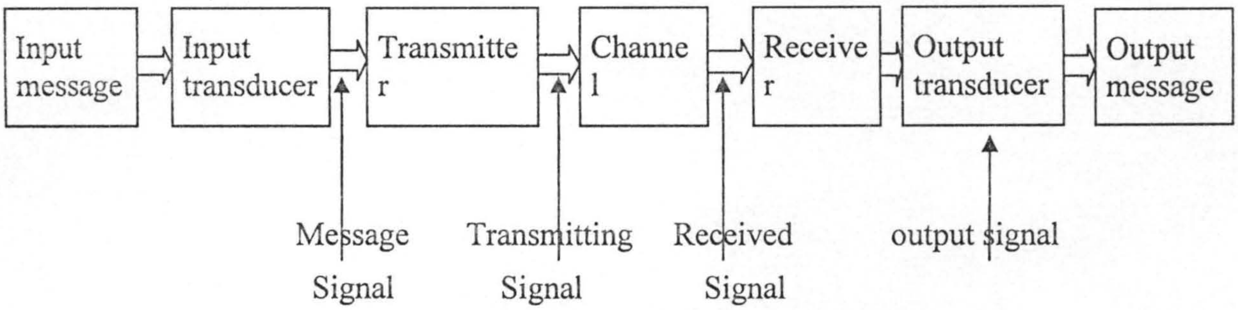


fig 1.1 Basic block diagram of communication system (1)

From fig. 1.1,

a The input transducer converts the input message which may be analogue or digital from its original form into electrical signal

b The transmitter is the modulating stage. The carrier wave is modulated by the message signal producing the modulated signal which is amplified before transmission.

c The channel is the medium through which signal get to the receiver. It may be pair of wires, a coaxial cable, a radio wave or a laser beam.

d The receiver takes up the transmitted signal, re-amplifies and feed into the demodulator where the information is extracted from the carrier.

e The output transducer is a device that converts the electrical output signal of the receiver into the form desired by the user, for example a loudspeaker converts electrical signal to sound wave for the user to hear [1].

Mathematically, a high frequency carrier is represented in the form of a sine wave as:

$$V_c(t)=V_c \cos(\omega_c + \Phi) \quad \text{.........(1)}$$

Where V_c = amplitude of the carrier frequency

$\omega_c = 2\pi f_c$ = angular frequency of the carrier and

Φ = initial phase angle of the carrier

The phase angle and the angular frequency can be viewed in accordance with the low frequency information signal to produce the modulated signal. If the amplitude term is varied, we have AMPLITUDE MODULATION (AM), if the frequency term is varied; we have FREQUENCY MODULATION (FM) and of course, PHASE MODULATION (PM) if the phase angle is varied.

For the sake of this project, frequency modulation is the most preferred due to its advantages over the others, some of which are high signal to noise ratio and wider band which is responsible for its stereo quality.

The modulation process is one in which the frequency of operation of the oscillator is controlled by the signal modulating it [3]

1.3 AIMS AND OBJECTIVES

This project explains how a more efficient mode of broadcasting or information dissimilation mechanism (FM broadcasting) can be designed. Other aims and objectives of this project includes:

i. To know the relationship between carrier frequency, modulation frequency and modulation index to efficiency and bandwidth.

ii. To compare frequency modulation (FM) systems to amplitude modulation (AM) systems with regard to efficiency, bandwidth and noise.

iii. To ensure the development of the project construction skills and ability for creating new ideas.

iv. To help student engineer's perfect basic trouble-shooting skills.

v. To transmit the signal at different frequencies.

1.4 SCOPE AND LIMITATION

The scope of this project includes the design and construction of long range FM transmitter .This is therefore limited to the design and construction of long range FM transmitter to cover only to a distance of 1- 2 Km. This technology has application in television, radio stations, intercom, public address system and security system.

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORY OF RADIO BROADCASTING

Electronics broadcasting requires a very sensitive and accurate design to achieve desired noise free transmission and reception with little or no error or interference. This account for the reason why radio has no specific inventor but a series of attempts by several people.

During the 1960s, Scottish physicist, Jams Clerk Maxwell predicated the existed of radio waves, and in 1886, German Physicist, Henrich Rudolph Hertz demonstrated that rapid variation of electric current could be projected into space in form of radio waves similar to those of light and heat[4].

Gugliemo Marconi, an Intalian inventor, proved the feasibility of radio signal in Italy in 1895. By 1899, he flashed the first wireless signal across the channel, and two years letter he received the letter 'S' telegraphed from English to new form land. This was the first successful radiotelegraph message in 1902.

Radiotelegraphy is the sending of radio waves by the same dot-dash message used by telegraph. Transmitters at that time were called spark-gap machines. It was developed mainly for ship-to-store communication. This is a way of communicating between two points. However, it was not public radio broadcasting as we know it today [4].

By 1899, commercial communication between England and France was established. In 1901, a simple message was sent across the atlantics. This success was attributed in the development of a receiver and an oscillator, which was then connected to antenna to transmit the radio wave over a good distance.

Overseas, radio service developed slowly, because the initial radio telegraph transmitter discharge electricity within the circuit and because the electrodes was unstable causing interference. The Alexanderson high frequency alternator and the De frost tube resolved many of these early technical problems.

Lee De Frost invented space telegraphy, the triode amplifier and the audio. In the early 1900's the requirement for further development of radio was an efficient and delicate detector of electromagnetic radiation; De Frost provided that detector. It made possible to amplify the radio frequency signal picks up by the antenna before amplification to the detector. Thus, much weaker signal could be utilized than had previously been possible. De Frost was also the person who first used the word "Radio." The result of Lee De Frost's work was the invention of amplitude modulation or AM radio that allowed for a multitude of radio stations. The earlier quark-transmitter did not allow for this [5].

Reginald Fessenden in 1906 designed a system that transmits both speech and music over a hundred miles of Massachusetts coast. The creation of vacuum tube by J.A Fleming (1906), and the triode by Lee De frost (1913) made possible the development of power transmitters with improved frequency stability. E. Howard Armstrong using the diode and the triode, invented the regenerative circuit (1912), the super heterodyne (1918) and the super regenerated circuit(1920) for high frequency generation. This led to the first significant demonstration of speech transmission by J.R. Carson in (1915). The first transmitter to broadcast speech and music was letter developed by

American Marconi Company in 1916. In 1925, E.H Armstrong's worked on the corrective of static in radio, resulted in the achievement of FM that year. Edwin Howard Armstrong invented frequency modulated radio in 1933, while in 1943, the Supreme Court overturned Marconi's patent in favour of Tesla Nikola. Radio technology has grown significantly since its early development. In 1974, Bell Lad Scientist invented the transistor which made possible the invention of the multiplex transmission by Armstrong in 1953[6].

By the late 1940's, the low frequency (LF) and medium frequency (MF) broadcast bands were heavily used, and as a result many services were limited by the night time co-channel interference. It was therefore necessary to bring a higher frequency band into use so that further transmission could be accommodated. The very high frequency (VHF) band II (approximately 88-108MHz) using FM was allocated to radio broadcasting, and then besides providing additional channels, had a number of advantages over the LF and MF broadcast bands. Because of higher frequency band, much wider channels are available and this enable FM to be used so that programs of high quality, including stereophony (stereo) can be transmitted [7].

2.2 OVERVIEW OF FM TRANSMITTER

The main function of a transmitter in radio communication and broadcasting is to deliver enough radio frequency (RF) power for radiation by the transmitting antenna. The amplitude modulation techniques are employed in low frequency (LF), medium frequency (MF), and high frequency (HF) broadcasting with transmitter output power ranging from a few Watts to a few megawatt. According to the international agreement, the occupied frequency bands ranges are 150KHz–285KHz for LF, 525KHz – 1605KHz for MF(MW), and 3.95MHz –26.1MHz for HF (SW) [1].

Frequency modulation (FM), which is use for sound broadcasting occupies 88MHz–108MHz bands (band 11). The FM transmitter power hardly exceeds 25KW since it is meant for local services [3]. However, FM transmitter is considered in this project work due to the following advantages over other transmitters:

i. The signal to noise ratio is high

ii. Large bandwidth, and

iii. Transmitted power is almost constant

The general view of FM transmitter can be given in form of a block diagram with each block performing the actions that are required of it. The block diagram is shown in fig.1.2

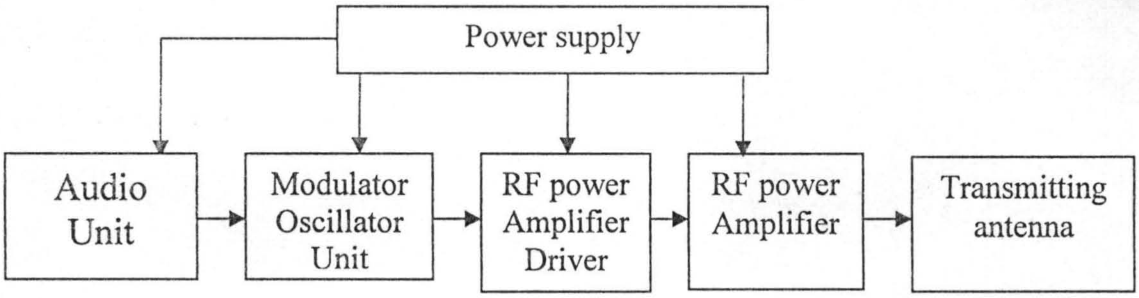


Fig. 1.2 Block diagram of the FM Transmitter

2.3 THEORETICAL BACKGROUND

There are different ways to indicate where to find different station on a radio dial for example; we could say that a station is operating on 9600kHz, 9.68MHz or on 31 meters; And all three ways would be correct. Radio waves are transmitted as a series of circles, one after the other.

The term "wavelength" is left over from the early days of radio. Back then, frequencies were measured in term of the distances between the peaks of two consecutive cycles of radio wave instead of the number of circles per second. The relationship between a radio signal's frequency and its wave length is as follows;

$$\lambda = v/f \ldots\ldots\ldots\ldots 2.1$$

Where λ =wavelength (m)

V =velocity =3 x10^8

F =frequency (Hz)

Using a frequency range of interest for FM (88 -108MHz) in this formula yield wave length of 3.4 and 2.77 meters respectively. As the formula indicate, the wavelength of radio signal decreases as the frequency increases. This is important because the length of various types of antenna must often be a fraction (usually one quarter or one half) of the wavelength of the signal to be transmitted or received. This means that most antennas designed for frequencies near 4000kHz will be physically much larger than antennas designed for frequencies near 30MHz. The following is table of some common radio and shortwave broadcasting found on frequencies between 3KHz to 300GHz.

Table 2.1 Radio Frequency Spectrum [4]

FREQUENCIES	DESTINATION	ABBREVIATION	WAVELENGHT
3-30KHz	Very low frequency	VLF	1000000-10000m
30-300KHz	Low frequency	LF	10000-1000m
300-3000KHz	Medium frequency	MF	1000-100m
3-30MHz	High frequency	HF	100-10m
30-300MHz	Very high frequency	VHF	10-1m
300-3000MHz	Ultra high frequency	UHF	1m-10cm
3-30GHz	Super high frequency	SHF	10cm-1cm
30-300GHz	Extremely high frequency	EHF	1cm-1mm

CHAPTER THREE

DESIGN AND CONSTRUCTION

3.1 Design of Power Supply Unit

Most of the electronic devices and circuits required a dc source for their operation. The dc power supply converts the standard 230V, 50Hz ac available all wall outlets into a constant dc voltage. It is one of the most common electronic circuits that you will find. The dc voltage produced by power supply is used to power all types of electronic circuits, such as television receivers, computers and laboratory equipments [15]. A typical dc power supply consists of five stages as shown in fig. 3.1. Thus, the circuit is powered by a power supply of 9V, hence the supply must be regulated to prevent fluctuation in voltage level.

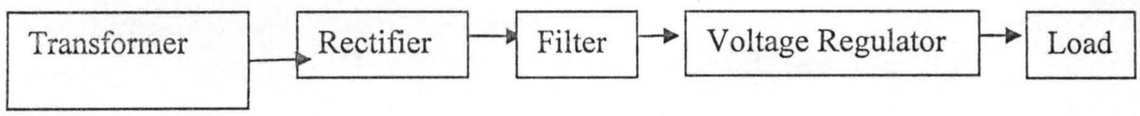


Fig. 3.1 A typical dc power supply block diagram.

These blocks can be briefly explained as follows:

1 **Transformer:** its work is either to step up or (mostly) step down the ac supply voltage to suit the requirement of the solid state electronic devices and circuits fed by the dc power supply.

2 **Rectifier:** it is a circuit which employs one or more diodes to convert ac voltage into pulsating dc voltage [14, 15,]. A rectifier can either be a half- wave rectifier or full-wave rectifier [15]. In this design a full-wave rectifier was employed.

an acceptable level. The resulting ripple voltage (dv) can be calculated by considering the waveforms given in fig. 3.3.

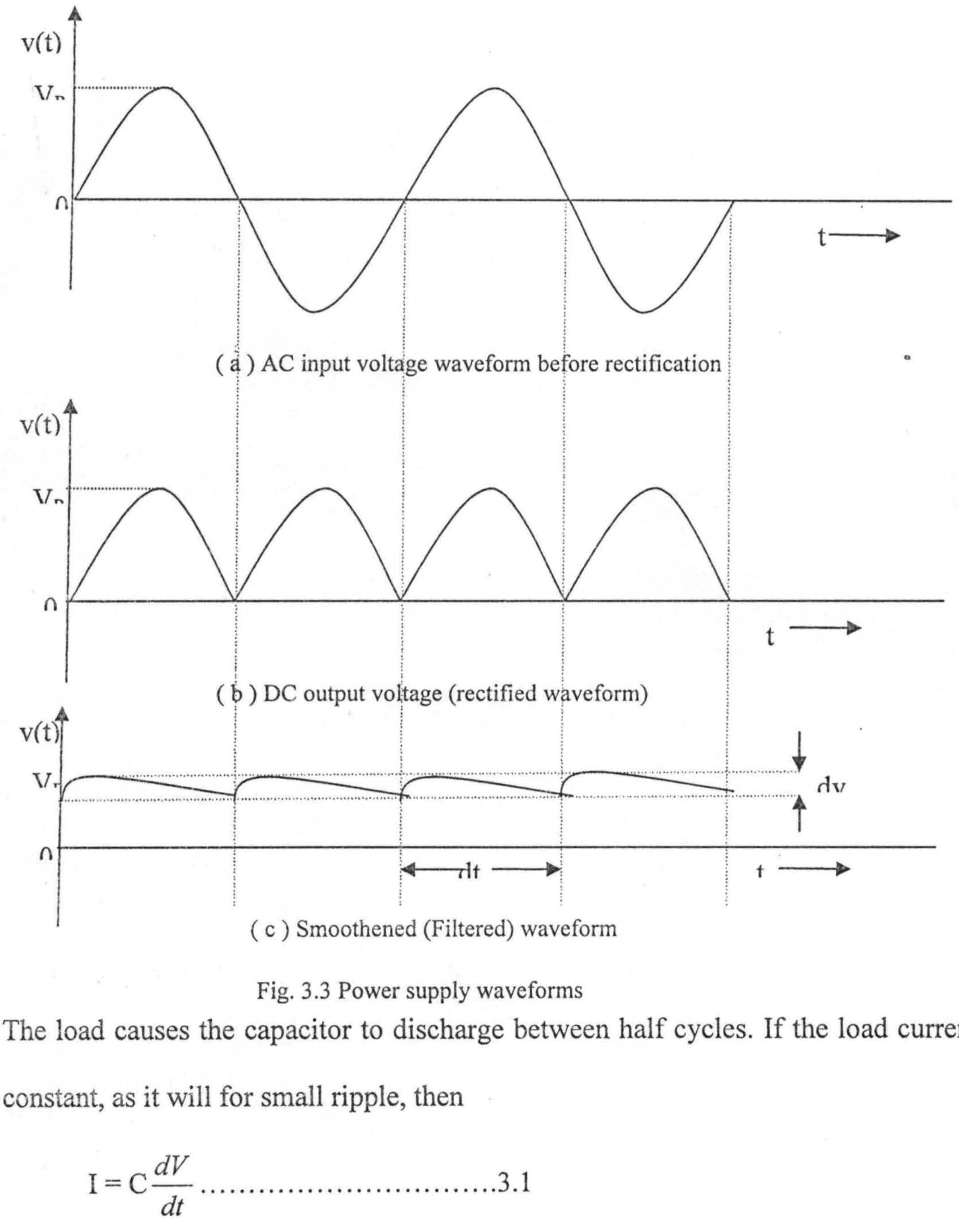


Fig. 3.3 Power supply waveforms

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

$$I = C\frac{dV}{dt} \qquad \text{...............................3.1}$$

The frequency of the full wave signal is double the input frequency. A full wave output has twice as many cycles as the sine wave input has. The full wave rectifier inverts each negative half cycle, so that we get double the number of positive half cycles. The effect is to double the frequency [17].

Therefore, the output frequency of the full wave rectifier is:

$f_{out} = 2f_{in}$ 3.2

(i.e. twice the input frequency) [12, 17]

This implies that,

$$dt = \frac{1}{2f_{in}} \quad \text{where dt is the oscillating period}$$

$$= \frac{1}{(2*50)} = 0.01s$$

This 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 main circuit is determined by the voltage regulator following the filtering capacitor..

The standard 7800 series can produce output current in excess of 1A when used with adequate heat sink. Therefore, it can supply a maximum of 1A. This current will be drawn from the supply. Thus I_{load} = 1A (maximum). The value of capacitor C can then be calculated from

$$C = \frac{Idt}{dv} \quad \text{..3.3}$$

But generally dv, which is the ripple voltage, is chosen to be 25% of V_p, where V_p is the peak voltage, V_{rms} is the root mean square voltage

Therefore, $V_p = V_{rms}\sqrt{2}$ 3.4

Where V_{rms} =12V, since the transformer of 220V/12V was used.

$\Rightarrow V_p = 12*\sqrt{2} = 16.97V$

2 **Filter:** the function of filter of this circuit element is to remove the fluctuations or pulsations (called ripples) present in the output voltage supplied by the rectifier . This is done by connecting a capacitor filter to the rectifier.

3 **Voltage Regulator:** its main function is to keep the terminal voltage of the dc supply constant even when the ac input line voltage to the transformer, or the load varies [15, 17].

4 **Load:** the load block is usually a circuit for which the power supply is producing the dc voltage and load current [15].

Therefore, the complete circuit diagram of the power supply is as shown below.

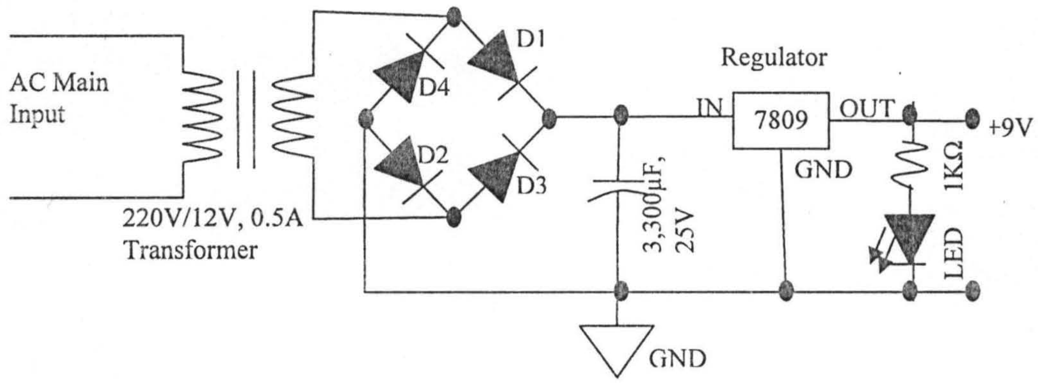


Fig. 3.2 Circuit Diagram of Power Supply Unit

The main voltage of 220V is stepped down by a 220V/12V, 0.5A transformer. It is then rectified by full wave bridge diode rectifier. The waveform at this stage has no negative component, but a lot of ripples. Smoothing capacitors are needed to reduce the ripple to

For bridge rectifier $V_{P(out)} = V_{P(in)} - 1.4V$, since 0.7V dropped across a diode whenever it conducts. And it is only two diodes that will conduct at a time [17].

Therefore, $V_{P(out)} = 12 * \sqrt{2} - 1.4 = 15.57V$

$$\Rightarrow \text{dv} = (\frac{25}{100}) * 15.57 = 3.89V$$

$$\text{Therefore, } C = \frac{(1 * 0.01)}{3.89} = 2.569 * 10^{-3}F$$

$$= 2{,}569\mu F$$

So, the commercial value of 3,300μF, 25V was used in order to reduce the ripple to the nearest minimum. Then, the expected ripple voltage using this value of capacitor is

$$\text{dv} = \frac{(1 * 0.01)}{3{,}300\mu} = 3.03mV$$

This means that the output waveform goes from a peak value of 15.57V to (15.57-$3.03*10^{-6}$) =15.57V. It may be noted that the input voltage to the IC regulator must be at least 2V above the output voltage. This is required in order to maintain regulation .

Therefore, the peak value of 15.57V to 15.57V is acceptable since the output voltage is 9V. The ripple is neglected by the 7809 to a negligible value.

The average voltage going to 7809 is calculated by

$$V_P - 0.5\text{dv} = 15.57 - (0.5 * 3.03 * 10^{-6}) = 15.57V.$$

The output from the 7809 is 9V, at maximum current output of 1A. The output remains constant in spite of input voltage variation.

For power indication, a light emitting diode (LED1) is connected from the positive supply line immediately after regulator to ground through a resistor. The resistor value is determined by the current carrying capacity of the diode. A typical red LED will drop 1.7V cathode to anode when forward biased (positive anode-to-cathode voltage) and will Illuminate with 10 to 20mA flowing through it. Since the red LED is used as an indicator, then the required limiting resistor R can be calculated as:

$V_{cc} = V_d + I_dR$..3.5

Where V_{cc} and V_d are supply voltage and voltage drops across diode respectively

$= 1.7 + 10mA * R$

Therefore, $R = \frac{9-1.7}{15*10^{-3}A} = 730\Omega$

The commercial value of 1kΩ was used in the design.

The diode and resistor served as a path to ground 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.

3.2 AUDIO UNIT

This unit consists of transducer {microphone}, coupling capacitor current limiting resistor and audio input signal eg sound. The transducer is generally used to convert physical quantities into electrical signals in the form of voltages or current signals. In this project a condense microphone is as a transducer because of its high degree of sensitivity. The circuit diagram of this unit is shown in fig 3.3

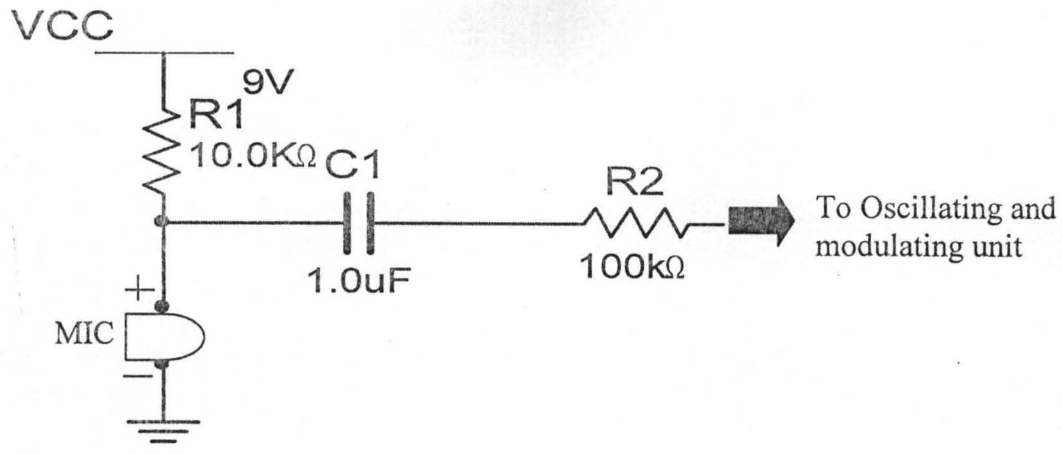


Fig 3.3 Circuit diagram audio unit

From the fig 3.3, the value of R_2=10k can be calculated using ohm's law Therefore,

$V_{mic} = R_{mic} * I_{mic}$

Where V_{mic} is the voltage drop across microphone

R_{mic} is the internal resistance of microphone =50Ω

I_{mic} is the current that flows through microphone =1mA

=► V_{mic}=50*1mA

=50mV

$V_{cc} = I_{mic} R_2 + V_{mic}$.......................................3.6

$$R_2 = \frac{Vcc - Vmic}{\operatorname{Im}ic} = \frac{9 - 0.05}{1 * 10^{-3}}$$

= 8.95kΩ

Therefore, the commercial value of R_2 =10kΩ was used in the design.

The output of audio unit is coupled to the oscillating/modulating unit through capacitorC_3 and 100kΩ resistor.

3.3 OSCILLATING/MODULATING UNIT

This unit plays the most important role in this design. It consists of tank circuit, modulator, vericap diode (varactor diode) and variable resistor. The circuit diagram of this unit is depicted in fig 3.4.

This project is design in such away that the fundamental frequency can be varied, which is accomplished by the use of vericap diode and variable resistor. The circuit diagram of this unit is depicted in fig 3.4

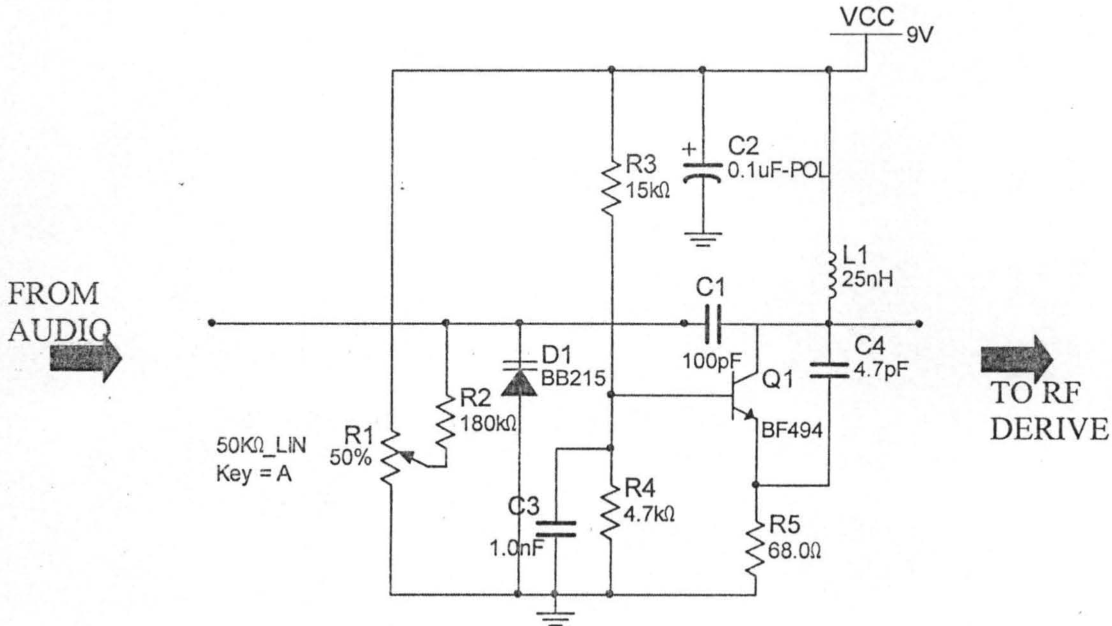


Fig 3.4 Circuit diagram of Oscillating/ Modulating Unit

3.3.1 Design of Tank Circuit

An inductor (L) is used in conjunction with capacitor (C) to provides frequency selection in communication systems. The tank circuit allows the narrow band of frequencies to be selected while the other frequencies are rejected. The frequency selectivity is base on the fact that the reactance of both inductor and capacitor depends on the frequency and the interaction of these two components when connected either in series or in parallel [13].

From fig 3.4, L_1 and C_6 are used to generate fundamental (carrier) frequency of the transmitter at F=100MHz.

The parameters F, L_1 and C are related by the formula:

$$F = \frac{1}{2\pi\sqrt{LC}} \quad \text{..3.7}$$

Where, F is the fundamental (carrier) frequency of the transmitter

L is the inductance of inductor

C is the capacitance of capacitor

From equation 3.7, taking L_1= 25nF

F = 100MHz

$$C = \frac{1}{4\pi^2 f^2 L}$$

$$= \frac{1}{4\pi^2 * 100 * 10^6 * 25 * 10^{-9}}$$

$$C = 101\text{pF}$$

Therefore, the commercial value of C=100pF was used in design.

From fig 3.4, it is noted that at a constant value of L, the fundamental frequency is inversely proportional to the value of capacitance. Therefore, by making L to be constant, the transmitting frequency can be varied by varying the value of C.

3.3.2 Vericap Diode (Varactor Diode

Varactor diode is a semiconductor, voltage dependent variable capacitor in which the change of capacitance with applied reverse voltage is enhanced as far as possible by the diode's physical construction. Even so, both the overall capacitance and the amount change are very small, though they are sufficient to enable the vericap diode to be used in tuning circuits. The capacitance of vericap diode is inversely proportional to V_R^n

Where n varies from 1/3 to1/2, and V_R is the reverse applied voltage.

Typical vericap diode has a capacitance swing from 6pF 20pF for applied voltage of 2v to 20v. Since the junction capacitance of a varactor diode is in the pF range, it is suitable for use in high frequency circuits. Its main applications are as follows:

1. Automatic frequency control device.
2. Parametric amplifier.
3. Adjustable band pass filter.
4. FM modulator.

The variation in reverse voltage across varactor is achieved using a variable resistor. The variable resistors or potentiometers are used as volume control in radios and television set. The rotation of the spindle change the resistance and voltage.. In this design, the variation in capacitance of vericap diode is enhanced through variable resistor which is connected in such that as the of variable resistor is changing, the voltage across the vericap diode also changes thereby changing its capacitance value. Both variable resistor and varicap are connected as shown in fig 3.4 so that the capacitance value of varactor will be added to C_6. Therefore, any changing in the capacitance value of vericap will change the fundamental (carrier) frequency of transmission. The value of variable resistor 50kΩ was choosing to suit the design.

3.3.3 Modulator

The modulator is a circuit arrangement used to combined an audio frequency signal with radio frequency RF carrier wave. The process is called the modulation.

The modulation process is shown in fig 3.5

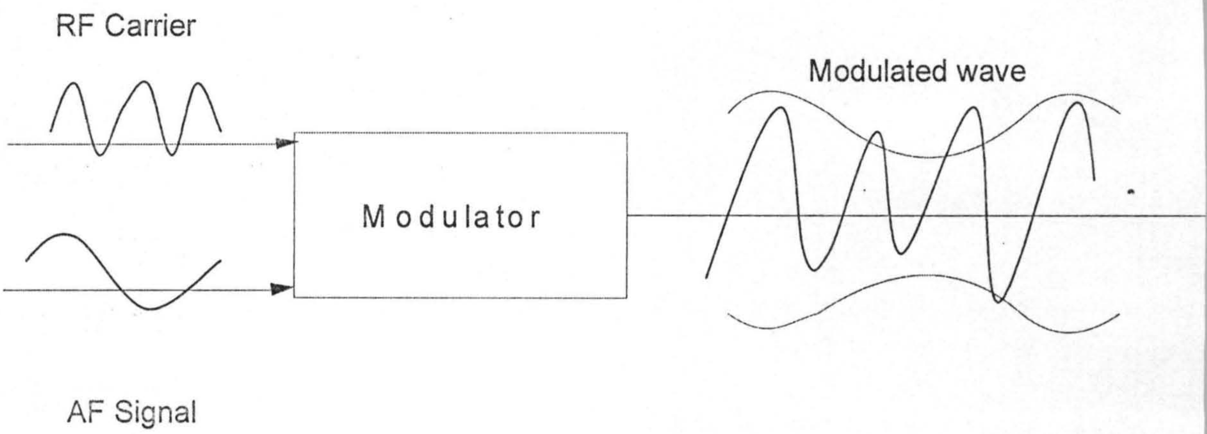


Fig 3.5 modulation process

The modulation is achieved by the use of BF494 transistor. It is a NPN transistor configured in common emitter mode.

From the datasheet of BF494, the following parameters were provided.

I_c=20mA

V_{BE}=0.7

P=300mW

From fig 3.4, R_5 and R_6 are provide voltage divider and their values are 15kΩ and 4.7kΩ respectively. The base voltage is set at 2v by V_{cc}, R_5 and R_6.

Therefore,

$$V_B = \frac{R_6}{R_5 + R_6} * Vcc \quad \ldots\ldots 3.8$$

$$= \frac{4.7k}{4.7k + 15k} * 9$$

$$= 2.1V$$

Also, the value of R_E can be calculated from

$$V_B = V_{BE} + I_E R_E \quad \ldots\ldots 3.9$$

Where $I_E = I_C$ and $R_E = R_7$

$$\Longrightarrow R_7 = \frac{V_B - V_{BE}}{Ic}$$

$$= \frac{2.1 - 0.7}{20 * 10^{-3}}$$

$$R_7 = 70\Omega$$

Therefore, the commercial value of $R_7 = 68\Omega$ was used in the design.

Note: C_4 is used to filter the upper harmonic of the oscillator which may cause noise along the power line.

C_2 is a bye pass capacitor which allows ac signals to pass and block dc signals.

C_5 is feed back capacitor which makes transistor to oscillator.

3.4 RADIO FREQUENCY (RF) DERIVER/AMPLIFIER UNIT

The transistor 2N3866 is used as RF deriver/amplifier. The output from Q_1 (BF494) is coupled to the base of RF deriver through a coupling inductor by mutual induction. The 2N3866 transistor helps to boost the oscillator signal power four to five times. Thus, 200–250mW of power is generated at the collector of RF deriver/amplifier. The fig 3.6 shows a circuit diagram of RF deriver/amplifier

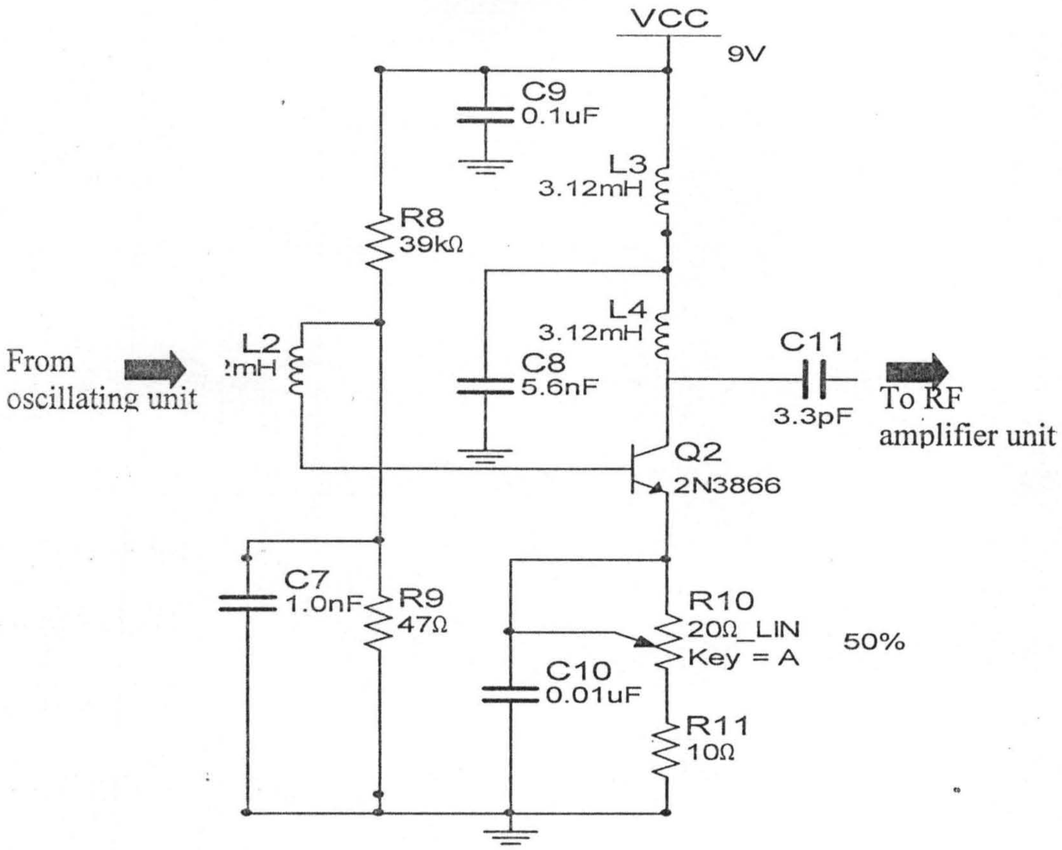


Fig 3.6 Circuit diagram RF Deriver/Amplifier Unit

3.4.1 Calculation of the Values of L_2, L_3 and L_3.

The values of inductors can be calculated using the formula:

$$L = \frac{nr}{25.4 * 90 * d} \quad \ldots\ldots 3.10$$

Where n =number of turns

r =radius of the former

d =diameter of the coil.

Taking n=7, r=2mm and d=0.56mm for both L_3 and L_4 for easy of analysis.

$$\Rightarrow L_3 = L_4 = \frac{nr}{25.4 * 90 * d}$$

$$=\frac{7*2*10^{-3}}{25.4*90*0.56*10^{-3}}$$

$=10.94mH$

Thus, the reactance inductors can be calculated using the formula

$X_L = \omega L = 2\pi FL$

Also $X_{L3}=X_{L4}= 2\pi*50*10.94*10^{-3}$

$=3.436\Omega$

Since L_3 and L_4 are connected in series their equivalent is

$X_{L3}+X_{L4}=3.436+3.436$

$=6.872\Omega$

The value of L_2 can also be calculated using the same formula

$$L_2=\frac{nr}{25.4*90*d}$$

Taking n=2,r= 4mm and d=0.56mm

$$L_2=\frac{2*4*10^{-3}}{25.4*90*0.56*10^{-3}}$$

$=6.249mH$

Thus, the reactance is calculated as:

$X_{L2}=\omega L_2= 2\pi FL_2$

$=2\pi*50*6.249*10^{-3}$

$=2\Omega$

3.4.2 Calculation of Transistor Biasing Parameters

From the data sheet of 2N3866 transistor,

$I_c=200mA$

V_{CE}=2.5V

P =250W

β=200

From fig 3.6

$V_{cc}=V_{CE}+I_C R_E+I_C R_C$................................3.11

Where $R_C = X_{L3} + X_{L4} = 6.872\Omega$

$I_C = I_E$

=> $R_E=(V_{CC}-V_{CE}-I_C R_C)/I_C$

=(9-2.5-0.2*6.872)/0.2

=25.628Ω (maximum)

But $R_E=R_{10}+VR_2$

From fig 3.6 R_E is made variable from 10Ω to 22Ω. Therefore, the commercial value of 10Ω resistor and 22Ω variable resistor were used in the design. The 22Ω variable resistor was used to control the output power of the transistor.

=> R_{10}=10Ω

VR_2=22Ω.

R_8 and R_9 provide voltage divider and their values were chosen to be 470Ω and 39kΩ respectively.

The potential at the coupling inductor L_2 to the base of Q_2 is set by V_{CC}, R_8 and R_9 .T

$$= \frac{470}{470+39k} * 9$$

=107.17mV

But $I_B=I_C/\beta$

=0.2/200

=1mA

Also voltage drop across $L_2 = V_{L2} = I_B X_{l2} = 1*10^{-3}*2 = 2Mv$

Then the base voltage $V_B = V_{LB} - V_L$

$$=107.17-2=105.17mV$$

C_7 and C_8 are by-pass capacitors that block ac signal and allows dc signals to pass. The values of C_7 and C_8 were chosen to be 1nF and 0.01μF respectively. C_9 provides ground for both L_3 and L_4 .C_{10} is used to filter the upper harmonic of the oscillator which may cause noise along the power line. Its value was chosen to be 0.1μF .L_4 is a radio frequency choke (RFC) which provides dc load for the collector and also keeps ac current out of of the dc supply V_{CC}.

3.5 RADIO FREQUENCY (RF) AMPLIFIER

This unit consists mainly of transistor (C33825). This transistor is NPN configured in common emitter mode. It helps to further amplify the output from RF deriver (2N3866) which is coupled to the base of C33825 transistor. The output of this transistor is coupled to the antenna through capacitor. The fig 3.7 shows the circuit diagram of RF amplifier

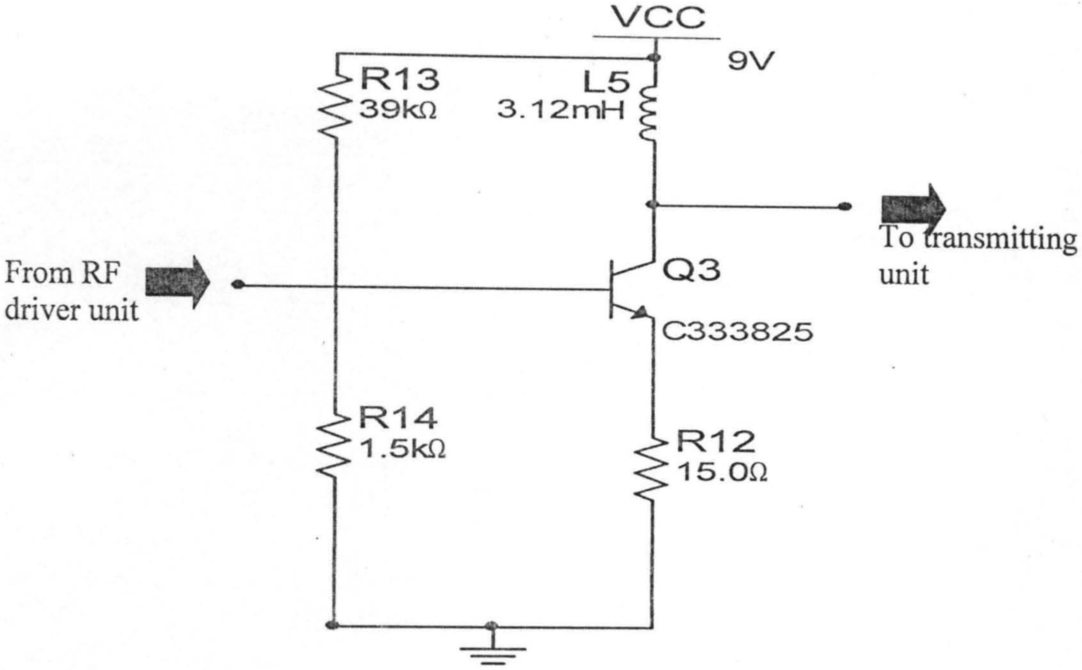


Fig 3.7 Circuit Diagram of RF Amplifier

3.5.1 Calculation of Value of L_5

From equation3.10, $L=\frac{nr}{25.4*90*d}$

Chosen n=6, r=2mm, d=0.56mm.

$$L_5=\frac{6*2*10^{-3}}{25.4*90*0.56*10^{-3}}$$

$= 9.37mH$

Thus, the reactance of L_5 can be calculated as

$X_{L5} = 2\pi FL_5 = 2\pi*50*9.37*10^{-3}$

$= 2.94\Omega$

3.5.2 Biasing of the Amplifier

From the data sheet the following parameters were obtained:

I_C (max) =200mA, P= 360mW, V_{CE} =5V and β=300.

$V_{cc} = V_{CE} + V_C + V_E$.......................................3.12

$= V_{CE} + I_C R_C + I_E R_E$

Where $R_c = X_{L5} = 2.94\Omega$

$I_E = I_C = 200mA$

From the above expression,

$$R_E = \frac{V_{CC} - V_{CE} - IcRc}{I_E}$$

$$= \frac{9 - 5 - (0.2 * 2.94)}{0.2}$$

$$= 17.O6\Omega$$

But $R_E = R_{12} = 17.06\Omega$

Therefore, the commercial value of 15Ω was used in the design.

3.6 TRANSMITTING UNIT

This unit comprises an antenna and coupling capacitor. An antenna is defined as an electrical conductor or system of conductors used either for radiating electromagnetic energy into space or collecting electromagnetic energy form space. In this design, radio frequency (RF) which is an electrical energy from the transmitter is coupled to the antenna through a coupling capacitor. This energy is converted into electromagnetic (EM) energy by an antenna and then radiated into the space with the speed of light [15]. The type of antenna used in this design is quarter wave antenna (Omni-directional antenna) with radiation pattern as shown in fig 3.8

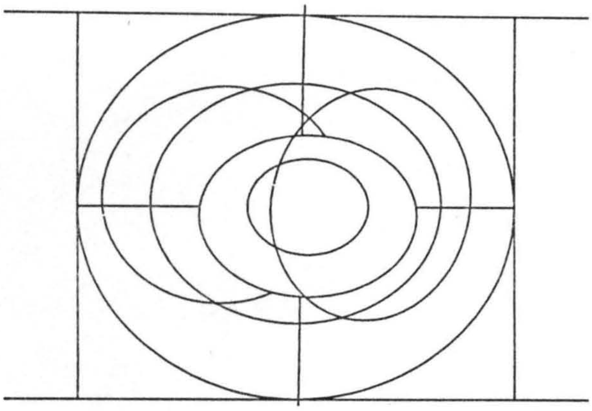


Fig. 3.8 Radiation pattern of quarter wave antenna

3.6.1 Calculation of Length of Antenna

For quarter wave antenna, the length of antenna is ¼ of the wave length. The wave length can be calculated from the expression:

$C=f\lambda$...3.13

Where C=speed of light=$3*10^8$m/s

f=carrier frequency=100MHz

λ=wave length of the signal

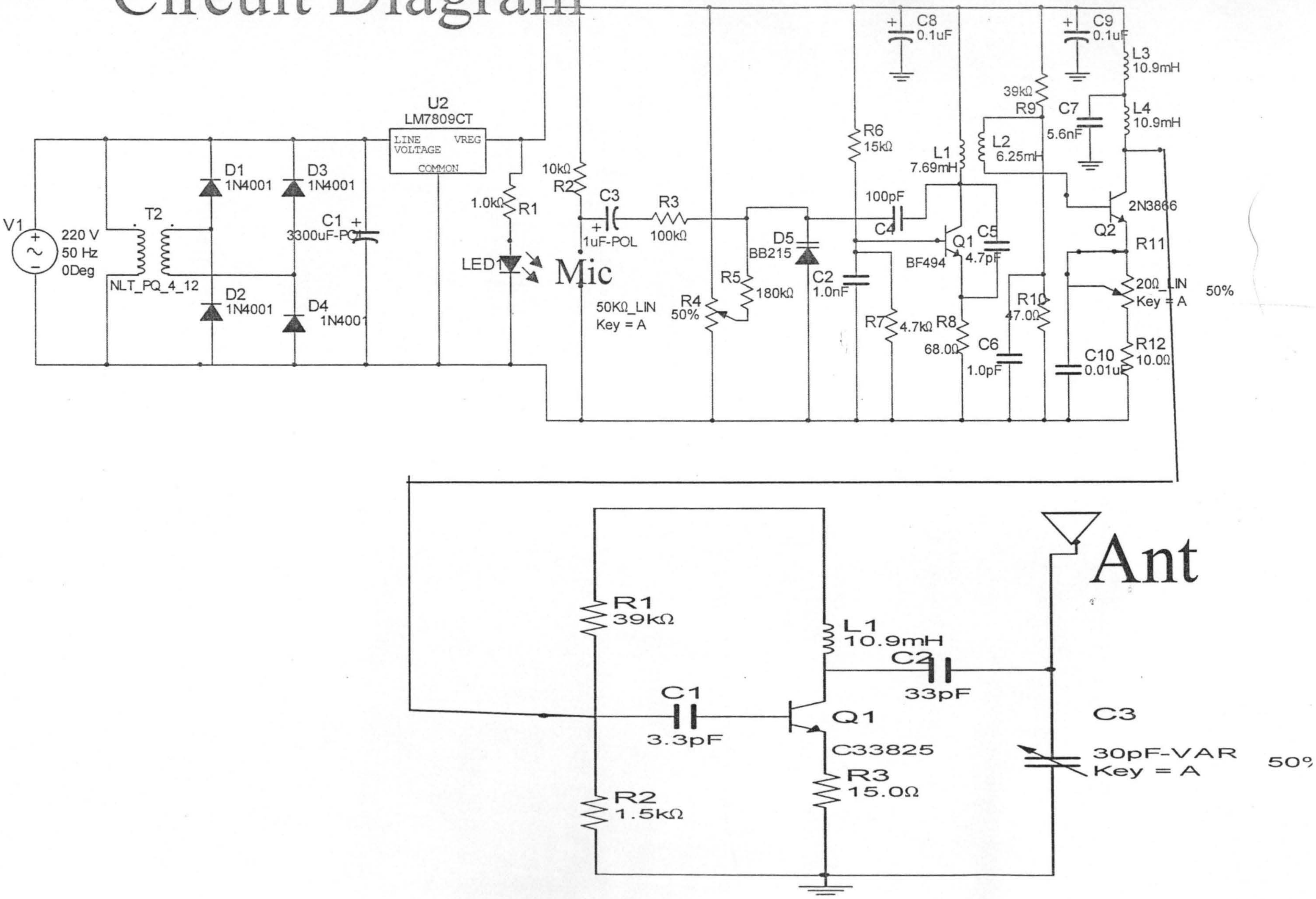
Therefore, $\lambda = \frac{c}{f}$

$\lambda=\frac{3*10^8}{100*10^6}$

=3m

Therefore, the length of antenna $L = \frac{1}{4}\lambda = \frac{1}{4}*3 = 0.75$

Circuit Diagram



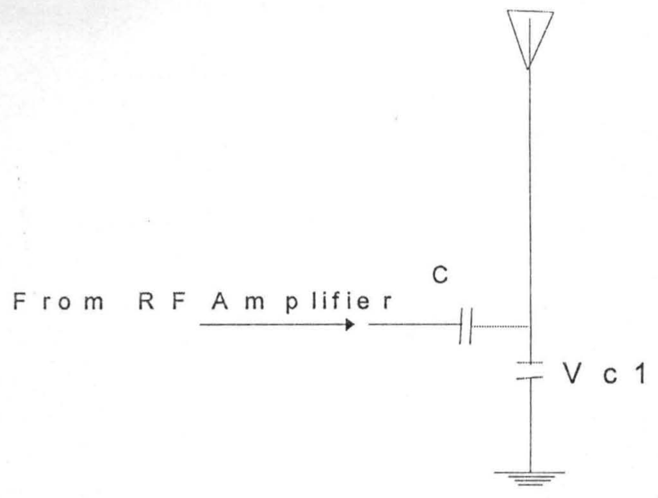


Fig 3.9 : Antenna Diagram

3.6.2 Determination of Power Radiated by the Antenna.

For an output power of 10W from the transmitter,

P=IV...3.14

$$I = \frac{P}{V} = \frac{10}{9} = 0.9A$$

This output current I is the peak current given as I_P, but the average radiated by the antenna is given by the expression:

$$P_{AV} = \frac{I_{AV} R_r}{2} \text{..3.15}$$

Where R_r is the radiation resistance of the antenna =50Ω

But $I_{AV} = I_P * 0.637$

=0.9*0.637 =0.5733V

Thus, $P_{AV} = (0.5833)^2 * 50/2$ =8W.Therefore, the power radiated by the antenna =8W.

not available in the market and hence, the closest values were used. The output wave shape expected form the oscilloscope was not possible due to the fact that the capacity of the oscilloscope in the department laboratory is limited to measure only a maximum of 20MHz frequency as against 100MHz to which the transmitter under consideration was built.

4.4 SHORTCOMING AND LIMITATION

During the course of carrying out this project, some of the problem encountered includes:

1 Strong FM signals bled over into neighboring frequencies making the frequency unusable with the transmitter.

2 Unavailability of some of the components in the market. Eg RF component

3 The means of controlling the volume of the transmitter which forced the sound to transmit out harshly and causes radio interference.

4 The cost of realizing this project is high, subsequently, the time as labor demands of this project is enormous.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

For the transmitter to be able to deliver the maximum power output at any time, it is necessary to align all the RF stages to ensure better energy transfer between them. This was achieved by perfect impedance matching.

In FM signals, the efficiency and bandwidth both depends on both the maximum modulating frequency and the modulation index. Compared to AM, the FM has a higher efficiency, a larger bandwidth and better immunity to noise. All these were achieved from design calculations.

In conclusion, the transmitter performance in this design led to the achievement of th expected result. Therefore, the aims/objectives in executing this project have achieved.

5.2 RECOMMENDATION

In order to achieve high power amplification for transmitter to transr distance, better and attractive design, the following features can be i

1 The size of the power transistor should be made considerably l

2 Transformer coupling should be used for impedance matc

3 the base of the transistor should be made thicker to ha

4 Frequency measuring instrument should be used t

APPENDIX

MANUAL OPERATION

The transmitter has been designed to operate between 88MHz – 108MHz.The transmitter is energized by an ac source or dc source (12v).

The operations can be done as follows:

1 Press the power button to the ON position.

2 Check the power indicator to ensure there is power in the circuit.

3 Connect the audio input cord to the circuit.

4 Adjust the potentiometer for clearer reception by the receiver

TROUBLESHOOTINGS

The following troubleshooting tests will help to identify the major faults in the FM transmitter:

1 When the system is ON, and the light emitting diode does not glow, the power supply unit may be faulty.

2 If it is discovered that the whole system fails, check bridges across adjacent or soldering flux residues that usually cause problems.

3 When the system is ON but there is no output, the system may be put under fault investigation. Check for damaged components.

4 When humming sound is heard from the receiver unit, the system may be too close to the receiver.

5 When there is transmission signal but no sound, the audio source may be faulty.

6 When there is transmission but not clear, adjust the potentiometer.

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