DESIGN AND CONSTRUCTION

OF 6 – WATT FM

TRANSMITTER WITH AFC

INCORPORATED

WRITTEN BY

SADIQ BALA ABUBAKAR

(95/4456)

A PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENT FOR THE AWARD OF A BACHELOR OF

ENGINEERING (B.ENG) DEGREE

TO

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SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY

MINNA, NIGER - STATE

DECEBER, 2000

CERTIFICATION

This is to certify that I **Sadiq Bala Abubakar[95/4456]** had successfully completed the project work of designing and constructing of a 6 – watt FM transmitter with Automatic Frequency Control (AFC) incorporated in partial fulfillment of the requirement for the award of Bachelor of Engineering Degree in the Department of Electrical and Computer Engineering, Federal University of Technology, Minna, Niger – State, Nigeria.

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SUPERVISOR'S NAME/ SIGNATURE **DATE.**

-- 16/1/04

HEAD OF DEPT'S NAME/ SIGNATURE **DATE.**

-- 17/1/04

EXTERNAL EXAMINER'S **NAME/SIGNATURE** **DATE.**

DECLARATION

I hereby declare that this thesis is my own personal work and that it has never been presented anywhere for the award of a Certificate of any kind.

All the Information gotten from published and unpublished work of others have been acknowledged .

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STUDENT'S NAME	**SIGNATURE**	**DATE.**

DEDICATION

This project work is specially dedicated to My beloved and caring Father Late **Liman Abubakar Sadiq**. May his gentle soul rest in perfect peace "Amin Summa Amin".

ACKNOWLEDGEMENT

I am very grateful to God [the Beneficent the Merciful] who gave me the wisdom as well as the opportunity that led to the success of this project, for without his hand in my life I wouldn't have accomplished my goal.

My acknowledgement goes to my able Supervisor Mr. Usman Abraham U. who worked tirelessly to see to the success of this project despite his tight schedules. It is obvious that without his constructive criticism and advice here and there, this project wouldn't have become a reality. Special thanks goes to all my lecturers ,for this project is no doubt the product of the knowledge they impart on me in one way or the other; especially My Head of Department (HOD) Engr. (Dr.) Y. A. Adediran.

My appreciation goes to my Beloved and Caring Mother Mrs. Rakiya Abubakar Sadiq for her financial, moral and physical support. And also to my Brothers and Sisters for the love, care and support they rendered in one way or the other to enhance my success in life generally.

Finally , my appreciation is also extended to my project Colleagues Alonge Olabisi and Oladeji F. Oladoye and to all my Class Members for the countless advice they rendered.

ABSTRACT.

This project report is concern with the design and construction of an FM radio transmitter, that is capable of transmitting signal up to a distance of 300 meters.

The project is realised using integrated circuit [IC] at different stages of the transmitter such as the power supply unit, Voltage amplification stage, filtering stage e.t.c for reduction in size [compactness] and yet better results at the outputs of the respective stages and consequently at the final stage of the transmitter. Also Signal stability is achieved through the used of an external compensating capacitor.

It comprises of four chapters. Chapter One , contains the Introduction, in which many important terms were defined, different kinds of signal that can be transmitted were also discussed. The types of transmitter available were as well stated. Then followed by the method adopted in the design, and lastly the review of relevant literatures.

Chapter Two ,deals with the design and calculation of the value of the components used for the construction work. Chapter Three on the other hand, contains all the details, of how the construction work was carried out, the difficulties encountered, and how such difficulties were later tackled.

The last Chapter , comprises of t! ·nclusion, recommendation as well as the References.

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CHAPTER ONE

1.1 INTRODUCTION

GENERAL INTRODUCTION

Communication between one person and another , one device to another device or between one point to another involve the sending and receiving of information to be exchanged between the two [i.e between any of the respective pair mentioned]. Since this project is solely concerned with the sending of information [i.e transmitting] , therefor, it will be very important to start the introduction by defining the word "Communication".

Communication simply means the process of exchanging or conveying meaningful information or message from one point (the source) to another point (the dest[illegible]tion) usually at some distance apart, through a common sys[illegible]f symbol. The information can be more or less mean[illegible]l symbols.

The integration of the devices used [illegible] transmitting and receiving such information or message, as well as the devices linking them [i.e. source and destination] form a system called " communication system". Communication System can therefore be define literally, as the process of encapsulated particles of meaning that are transmitted between individual organisms by means of special sending and receiving devices.

The information or signal to be transmitted can be in form of Analogue or Digital. The Analogue Signal is a physical quantity that changes with time usually in smooth and continuous fashion examples of this type of signal are angular position of an Aircraft, Gyro, Acoustic Sound Pressure e.t.c.

The Analogue Communication System should deliver a waveform with a degree of fidelity, due to the fact that, the signal is in a time – varying waveform.

On the other hand, Digital Communication involves the use of an ordered sequence of symbols selected from finite set of discrete elements .Examples of Digital Signals are: Keys you press on the Keyboard of a Computer System, Printed Letter on Paper e.t.c.

These Signals (in form of Symbols) are delivered with a great degree of accuracy in a given time (using digital) , due to the fact that the information resides in a discrete symbols.

Communication can only be achieved if there is transmission of the message signal at the transmitting end [by the transmitter] , as well as the ption of the signal transmitted at the receiving end (by the receiver). However, as said earlier this project shall focus more on the transmitter.

There are basically two different kinds of transmitter, based on the type of modulation technique adopted. We have the Amplitude Modulation (AM) transmitters, which are used for broadcasting purposes at medium frequency ranging from 3 – 30MHz frequency Band.

The second one is the Angle Modulation which is of two types, namely: Frequency – Modulation ( ) and Phase modulation (ϕM). The Angle modulation r ires a greater bandwidth of about 30 – 300MHz Fr ncy Band. In which that of FM, falls between the range of 88 – 108 MHz , thus, providing better reception of signal used for Public Broadcasting than that of AM.

The advantages of FM over AM is that, the amplitude variations introduced over a transmission channel due to additive disturbances or fading can, to a large extent be eliminated at the receiver when FM is used.

Secondly, the FM transmitter can always operate at Peak Power, because of the fact that the Modulated Signal has a constant Peak Amplitude.

Another advantage of FM is that it provid ter discrimination against noise and interference M, though this is achieved at the expense of increase t ission bandwidth

1.2 AIM AND OBJECTIVES

This project is to embarked upon with the sole aim of designing and constructing of a 6 – watt frequency modulation (FM) transmitter with the automatic frequency control (AFC) incorporated; and with the objective that, it can transmit message with some degree of fidelity along side improved Quality.

Radio transmitter and receiver as well as many other devices are used in a communication system ,but the most essential part of this communication (Radio Communication) is the transmitter.

The transmitter serves the function of delivering enough Radiation Frequency (RF) power, for radiation by the transmitting antenna. This process includes modulating a high frequency carrier with the message signal for ease of radiation and also for other purposes like:

(i) Channel Assignment (i.e transmitting at unique frequency band to avoid mix – up with other signals]

(ii) Multiplexing (i.e. transmitting several messages through a channel) e.t.c.

Therefore the design and construction of FM transmitter with those qualities that enable a transmitter to carry out such functions mention above , are the aims and objectives of this project work.

1.3 METHODOLOGY

Another way of catergorising transmitter, is based on the power output of the Oscillator. Hence we have two types of transmitter which are the High level transmitter and the low level transmitter.

The one adopted as far as this project is concerned is the high level transmitter. The main difference between the two is that , in the Low level transmitter the out put of the oscillator is characterised by a small power of the modul[illegible] ignal [RF signal] , that the signal can not cover a very lon[illegible] stance, thus needs a booster. The booster here is the Rf amplifier, that up – grade the power high enough for transmission by the antenna.

Conversely, the high level transmitter, does not require boosting of the power before the antenna can transmit the signal.The block diagram of a high level transmitter [as used in this project work is as shown below in figure 1.1].

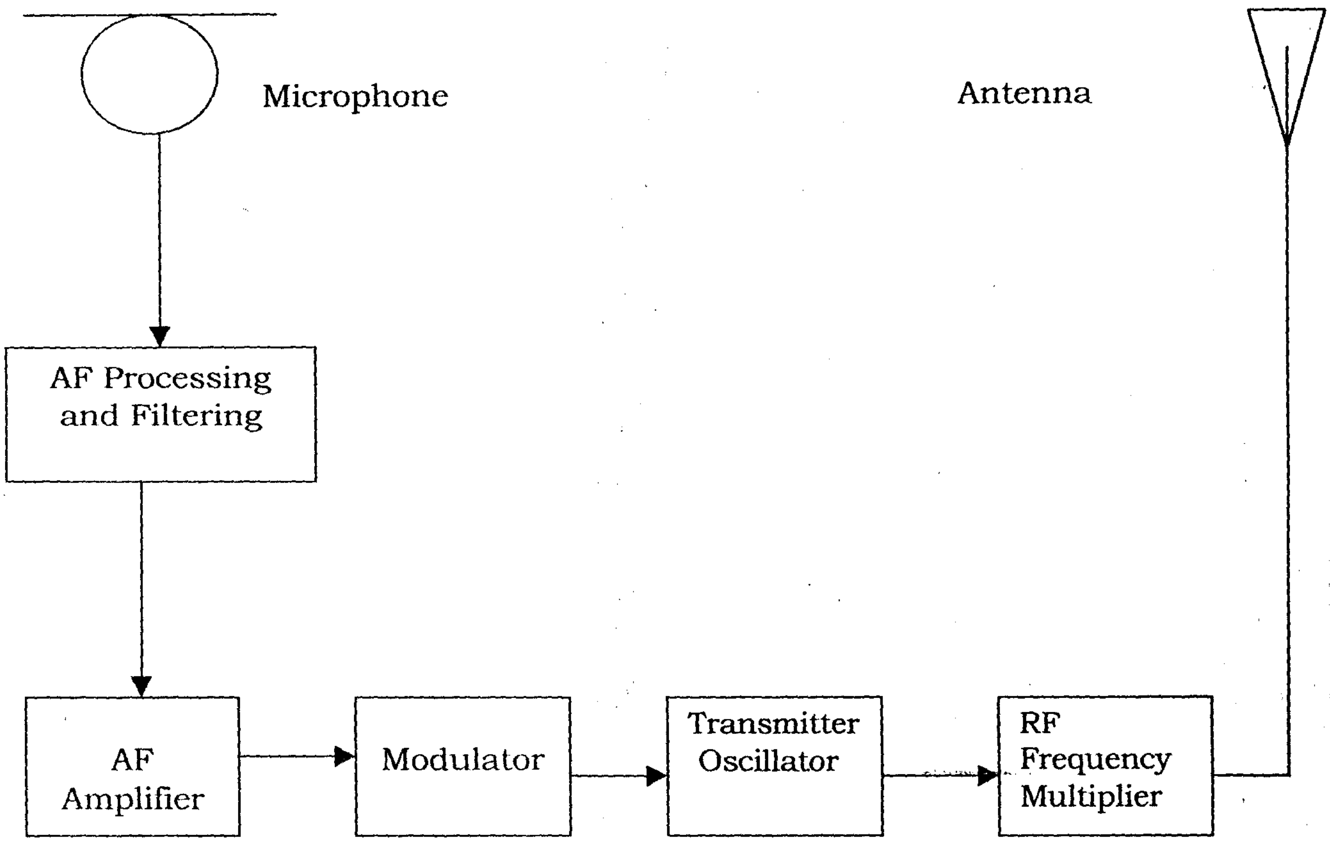

FIGURE 1.1 BLOCK DIAGRAM OF A HIGH LEVEL TRANSMITTER.

The human vocal mechanism produces speech by creating fluctuation in acoustic pressure. The Microphone senses the variation of this acoustic pressure (variation in air pressure) and then converts this variation to an electric signal usually in form of electric voltage or current of the same amplitude and frequency. Then the signal will move to the audio frequency processing and filtering unit for further signal filtration.

Filtering involve changing the relative amplitude of the frequency components in a signal or eliminating some frequency components entirely. In high – fidelity audio system, filter is included in the pre – amplifier to compensate for the frequency – response.

Then , the processed and filtered signal is sent to the audio frequency amplifier unit, where the signal is amplified. This involves increasing the relative strength of the high frequency component of the audio signal after which it is fed into the modulator.

The modulation unit, where modulation takes place consist of a Varactor modulator (which enhance Variable junction capacitance). The Varactor modulator is a diode designed to enhance variable junction capacitance which is a characteristic of all reverse – biased diode. The signal is used to vary the varactor diode which causes the diode junction capacitance to vary in steps with the audio signal.

In a nut shell modulation or frequency modulator (to be specific) can simply be defined as the process of modulation in which the instantaneous frequency of the carrier signal is varied in accordance with the instantaneous value of the message (or modulating) signal.

From the modulator the signal goes to the oscillator where the oscillator frequency is being varied as required. And lastly the frequency multiplier keeps the oscillator stage operating at a low frequency since at high frequencies, oscillator frequency stability becomes difficult to maintain.

The output signal of the oscillator is then launched into the air by the transmitting antenna.

1.4 LITERATURE REVIEW.

1.4.1 DEVELOPMENTAL STAGES IN THE INVENTION OF RADIO TRANSMITTER.

The invention of radio transmitter was carried out alongside the receiver . Therefore is it very difficult to talk about the invention of transmitter as a separate topic.

The first transmission was made by the German Physicist called Heinrich Hertz in 1887; though another man called James Clerk Maxwell in 1864 formulated before him, the electromagnetic theory of light . It is from his prediction of the existence of radio wave that Hertz established the existence of such wave as well as transmitter signal using electromagnetic wave; but only through a short distance of few fact. And the "message" transmitted was simply a transfer of energy which appeared as a spark in a gap on a loop of wire.

Later, an Italian Physicist Guglielmo Marconi (at the age of 20) on the 12th of December 1901 was able to receive a radio signal at signal Hall in Newfoundland, the radio signal had originated in Cornwall(UK), England, some one thousand seven hundred (1700) miles away. A number of people such as the English Physicist Sir Oliver Lodge and A.S. Popov, whom the

Russians call the inventor of radio, were studying the new "Hertzian waves".

The first, main use of radio waves was for communication over water, where the well – established telegraph and telephone could not reach.

The first broadcasts of speech by radio were made in Germany and US in 1906, but no one seems to have place great importance on these experiments. It was not until the Triode Vacuum tube was introdu d by US inventor L'ee De Forest that speech and music could be transmitted easily. The triode can be used either to transmit, receive or amplify signals, and it made possible much greater power. The first scheduled broadcasting station began in 1921. Since then, tremendous broadening of scope of communications which led to the invension of Digital modulating techniques that was first employed for Micro – wave radio transmission in France in the 1930s. Then after a long pause , digital radio (i.e digital communication by radio) experienced a renaissance in the early 1970s to this moment.

1.4.2 REVIEW OF SOME RECENT WORKS DONE ON TRANSMITTERS

Before this project work, many students from different institution of learning as well as private lividuals have made tremendous effort in designing and cons ing FM transmitter.

In most cases the limitation encountered, is that stabilising the centre frequency , which is done by the Automatic Frequency Control Network [AFC network]. It is very difficult to construct an efficient AFC network because of the fact that the components needed for that, are not readily available. And are very costly also , if found.

Another limitation, is that of the power of the transmitter. For the fact that ,the higher the power of a transmitter, the higher the distance that transmitter can transmit its output signal; most of the transmitters can only send signal only to a short distance.

However, in this project Automatic Frequency Control is achieved locally by incorporating a diode and a capacitor is some passion in the modulator / oscillator circuit as can be seen in the circuit diagram. Also, the transmitter was designed to have a power of about 6 watt thus, can transmit signal to a considerable distance.

1.4.3 PRINCIPLES INVOLVED IN RADIO COMMUNICATION

Radio is the name given to the system of transmission and reception of information by the propagation of electromagnetic radiation as a radio wave through space. It is the most significant contemporary technique for the transmission of information over distance.

The message signal is propagated by an electromagnetic wave (generated by the Oscillator). This carrier wave is modulated by changing one of its parameter (e.g frequency, amplitude, phase e.t.c.) in accordance with the message signal (modulating signal).

Each transmission is provided with a "signature tone " called carrier frequency , also each transmitter has its own "signature tone " so that any transmission can be selected. Then the signal is , in some way, superimposed on this carrier wave before transmission. The resulting signal is fed into the antenna which launches it into the air.

The receiver is "tuned into" this carrier frequency and, with suitable electronic circuitry , Segregates the carrier wave from the signal (demodulation) , after receiving it through the receiving antenna.

1.4 HISTORY OF RADIOTELEPHONE.

As the name implies , Radiotelephone is a device that operates on radio transmission [by the transmitter] and reception using radio techniques to carry signal from one point to another. Radiotelephone like many technological development were perfected during wartime for military applications.

During World War II , the ability to communicate with Aircraft, Ships and Vehicles was essential. Often the distance between radio stations were short and therefore did not require the high – power transmitter used in broadcasting.

Low – powered but Very High Frequency (VHF) radiotelephone system were therefore developed , which operate over some tens of miles rather than hundreds of miles for which high power transmitters were used.

After World War II, In 1947 the British Post Office Licensed the very first commercial radio telephone system. Radiotelephones are now used extensively by transport companies delivery services , Doctors e.t.c.

With the development of transistors and subsequently the transistor radio, cheap and compact radio telephone become commercially viable. In US a "Citizen Band " was allocated in the medium Wave AM Waveband. While in Britain the VHF/FM [Very High Frequency /FM] waveband has been adopted for "Citizen Band" transmission.

1.4.5 SATELLITE COMMUNICATION.

A Man called Arthur C. Clerk in 1945, proposed an idea of using an earth – orbiting Satellite as a relay point for communication between places on the earth surface. Later another Satellite Sputnik 1 was launched by the Soviet Union in 1957. The Sputnik 1 was able to transmit telemetry signal for 21 days. Shortly, another satellite explorer 1 was launched by the US in the year 1958, which was able to transmit telemetry signal for a period of about 5 months.

Much later on the 10th of July 1962, the Telstar I form Cape Canavaral was launched. This satellite was built by the Bell Telephone Laboratories which had acquired considerable knowledge from work by John R. Pierce. The Telstar 1 satellite was capable of relay TV programs across the Atlantic, this is achieved by using the master receivers and large antenna.

In the month of July 1964 , a Multinational Organisation in the INTELSAL was formed to design, develop, construct and maintain the operation of space segment of a global commercial communication satellite system..

In 1965 another satellite , The Early Bird (INTELSAT I) , a geostationary communication satellite , was launched . In a period of seven years four generation satellites [INSTELSSAT I – IV] were launched and placed in commercial operations.

CHAPTER TWO

SYSTEM DESIGN AND CALCULATIONS.

In this project, the design is carried out in sequential stages as shown in Fig.2.1 where each block represent a stage.

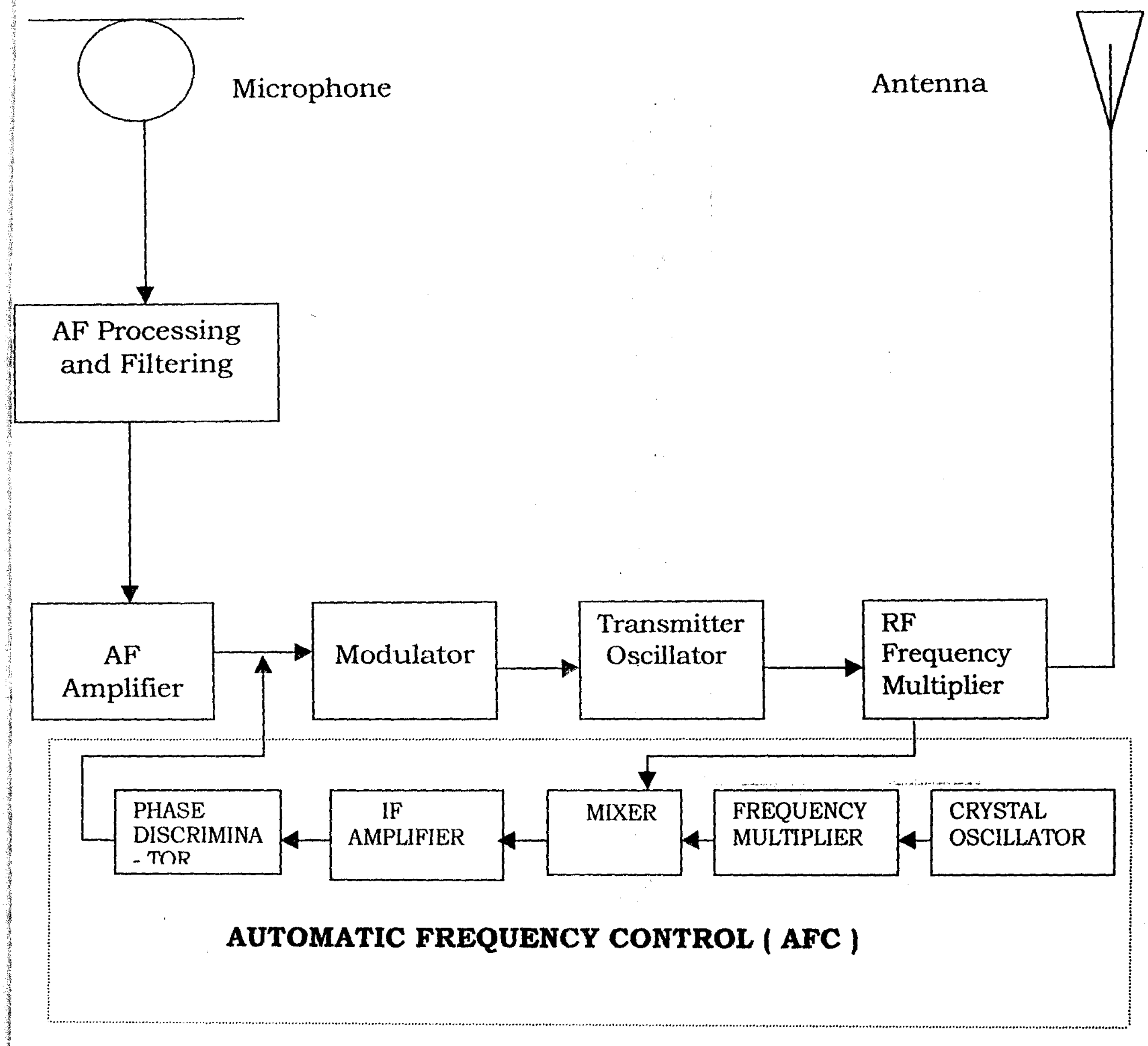

FIG.2.1 GENERAL BLOCK DIAGRAM OF AN FM TRANSMITTER

However , the Automatic Frequency segment is not designed in stages as in figure 2.1. Rather, it is incorporated in the circuit network in order to make the design less bulky.

The AFC consist of a phase discriminator, mixer, crystal oscillator, IF amplifier as well as frequency multiplier. A certain multiplier is being fed to the mixer, and also, receives signal from the crystal oscillator, which is amplified, or multiplied rather, by the frequency multiplier. The two, are then mixed, and the resulting signal which is normally of low frequency of about $^{1}/_{12}{}^{th}$ of the primary oscillator frequency is been amplified [by the IF amplifier] and then fed into the phase discriminator; whose output is connected to the modulator, to correct automatically any shift in the average frequency of the primary oscillator.

At high frequency shift of the primary oscillator there will be a higher frequency that would be fed to the mixer and consequently a higher frequency will be fed to the discriminator; since the output of the crystal oscillator is approximately constant. This will be made to provide a positive dc voltage as long as a higher frequency is fed into it. The discriminator is tuned to the required frequency difference [i.e $^{1}/_{12}$ of the primary oscillator frequency] , which is between the two oscillators. Therefore , it implies that a higher Input frequency results in a positive dc voltage which when fed in series with the reactance of the varactor modulator, increase its transconductance. The output capacitance of the modulator is thus increased, and hence the oscillator centre frequency will be low.

On the other hand, at a low frequency shift of the oscillator , there will be a negative voltage, hence the frequency of the oscillator increases with respect to the differences [produced by the mixer].

2.1 POWER SUPPLY UNIT DESIGN.

The designed circuit is to be powered by a 12volts dc supply. Therefore the power supply unit consist of a centre - tapped transformer, rectifying diodes, smoothing circuit as well as regulators as shown in fig. 2.2

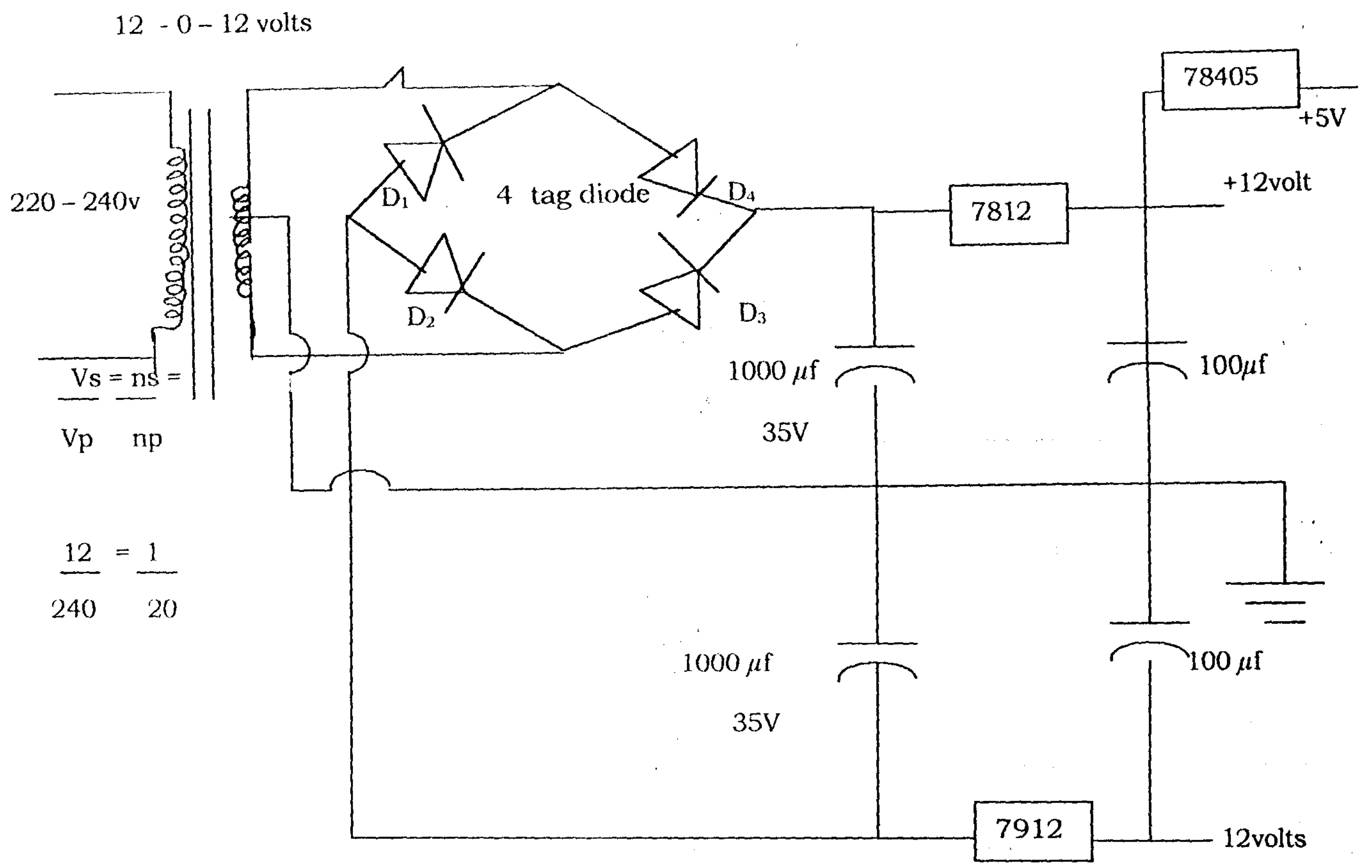

FIG 2.2 CIRCUIT ARRANGEMENT OF THE POWER SUPPLY UNIT.

As it can be seen above, full wav ification is adopted, which is connected to the secondary terminal of the transformer.

The 240 volts (240v) mains which is an AC signal is rectified to DC signal [by the 4 – tag diode] . Then two smoothing capacitors of 1000μf 35v each, were connected across the positive and terminals as well as the earth terminal as seen in the diagram above. Then follow by a negative and positive 12volt regulators. Another two capacitors of 100μf each follow, which are used for further smoothening . Lastly a 5 volt regulator [voltage regulator] was connected to power the light emitting diode [LED] which serves as an indicator that shows the supply of power to the circuit.

2.2 **MICROPHONE**

Microphone is a transducer that senses variation in acoustic pressure [of sound] which are then converted to an electrical signal [in the form of voltage or current variation] in accordance with the amplitude and frequency of the sound.

Microphone can be of different kinds based on the application it is meant for. Microphones are rated based on their frequency response, sensitivity, impedance e. t. c .

The one used in this project is the carbon type and is as shown in fig.2.3 .

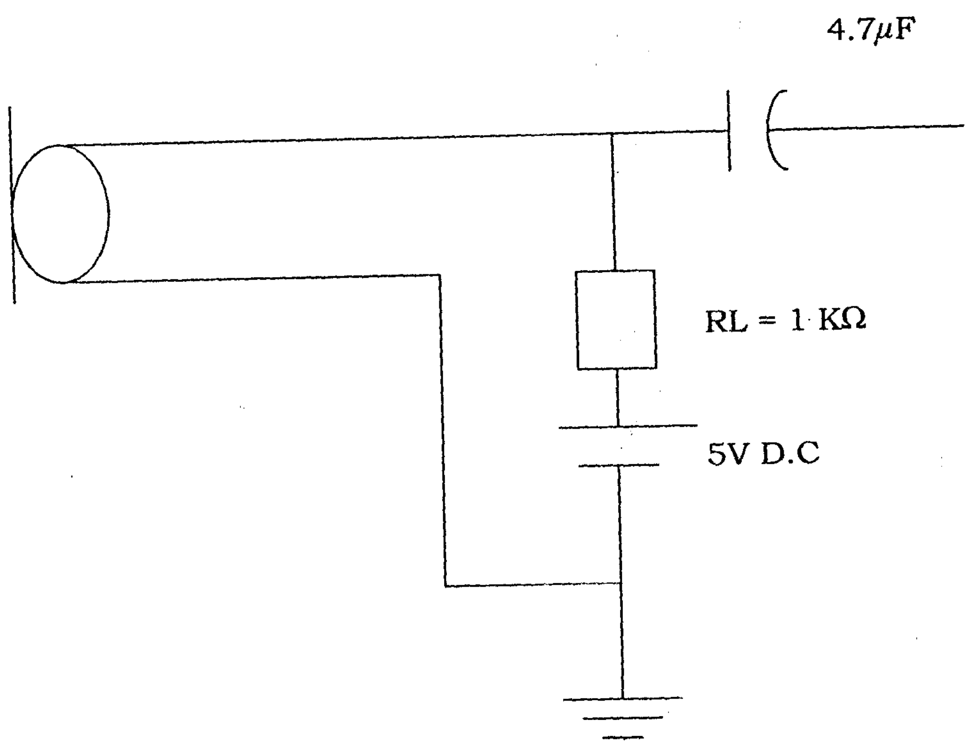

FIG. 2.3 CARBON MICROPHONE CIRCUIT DIAGRAM.

2.3 PRE – AMPLIFICATION STAGE.

The signal coming from the output of the microphone is being amplified at the pre – amplification stage, to a certain level . The amplification is linear in order to prevent distortion in the message signal.. Therefore, to achieve this a class A transistor was chosen because of its linear characteristic

The design of the Pre – amplification Stage is as shown in Fig. 2.4.

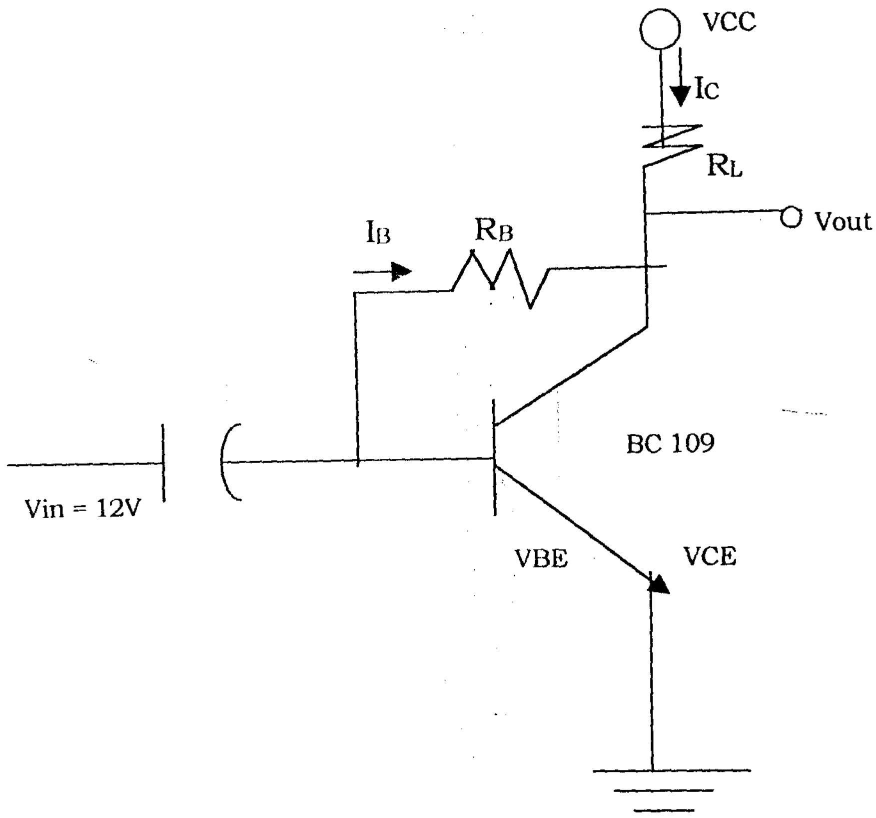

FIG 2.4 PRE – AMPLIFICATION CIRCUIT DIAGRAM

From the above diagram

Using KVL

$VCC = I_C R_L + VCE$

$VCE = I_B R_B + VBE$

But for class A transistor,

$VCE = ½ VCC$

⟹ $VCE = ½ X 12$ [since VCC = 12v]

Setting RL = 6KΩ

$I_C = (V_{CC} - V_{CE}) / R_L$

$= (12 - 6) / 6 \times 10^3$

$= 0.001$

$= 1 \times 10^{-3}$

$\therefore$ $I_C = 1mA$.

From the manufacturer's data book the gain of BC109 is 300

$h_{fe} = 300$

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

$I_B = I_C / h_{fe}$

$$I_B = \frac{1 \times 10^{-3}}{300}$$

$I_B = 3.33\mu A$

From $V_{CE} = I_B R_B + V_{BE}$

But for Silicon transistor , $V_{BE} = 0.7V$

$$R_B = \frac{V_{CE} - V_{BE}}{I_B}$$

$$= \frac{6 - 0.7}{3.33 \times 10^{-6}}$$

$R_B = 1.56m\Omega$

$V_{out} = V_o$

$V_o = V_{cc} - I_c R_c$

$= 12 - 1 \times 10^{-3} \times 6 \times 10^{3}$

$= 12 - 6$

$V_o = 6V$

2.4 VOLTAGE AMPLIFICATION STAGE.

The voltage amplification stage is employed to boost the weak output signal from the pre – amplifier to a higher level for the modulation by the modulator.

To achieve this objective an IC [JRC 4558] is used.

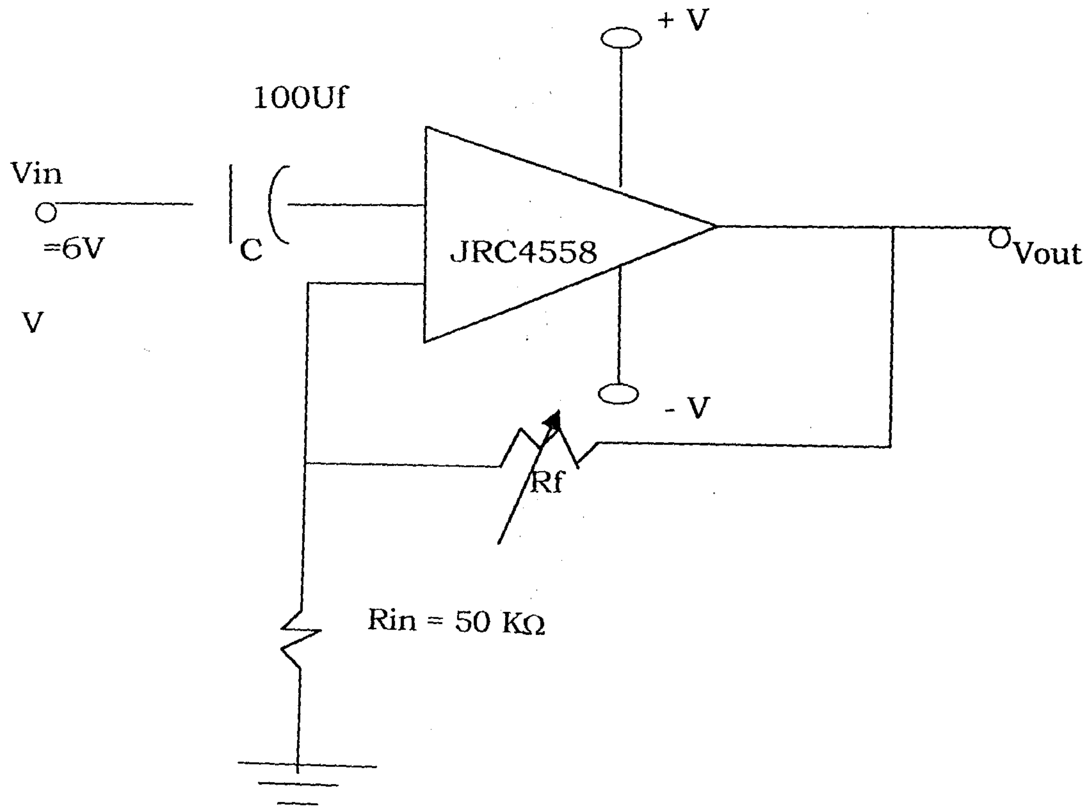

FIG. 2.5 VOLTAGE AMPLIFIER CIRCUIT

From the manufacturer's data sheet the gain of the IC [JRC 4558] is 10

$$V_o = \left(1 + \frac{Rf}{Rin}\right) Vin$$

Since the gain of the IC = 10

$$\therefore \text{ Gain } = \frac{V_o}{Vin} = 10$$

$$\Rightarrow 10 = 1 + Rf / Rin$$

Setting Rin = 50KΩ

$$Rf = Rin\,(10 - 1)$$

$$= 9\ Rin$$

$$= 9 \times 50$$

$$Rf = 450\ K\Omega$$

$$\frac{Vout}{Vin} = gain$$

$$\Rightarrow \frac{Vout}{Vin} = 10$$

But from the last stage

$$Vin = 6V$$

$$\therefore Vout = Vin \times 10$$

$$= 6 \times 10$$

$$Vout = 60V$$

The internal circuit diagram of JCR 4558 is as shown in Fig. 2.6 it consist of a pair of 741 Op- amps on a monolithic clip with closely matched characteristics and tracking which produces an excellent channel separation.

It is most suitable if the gain and phase matching are needed. It is used in potentiometric amplifiers and differential amplifiers.

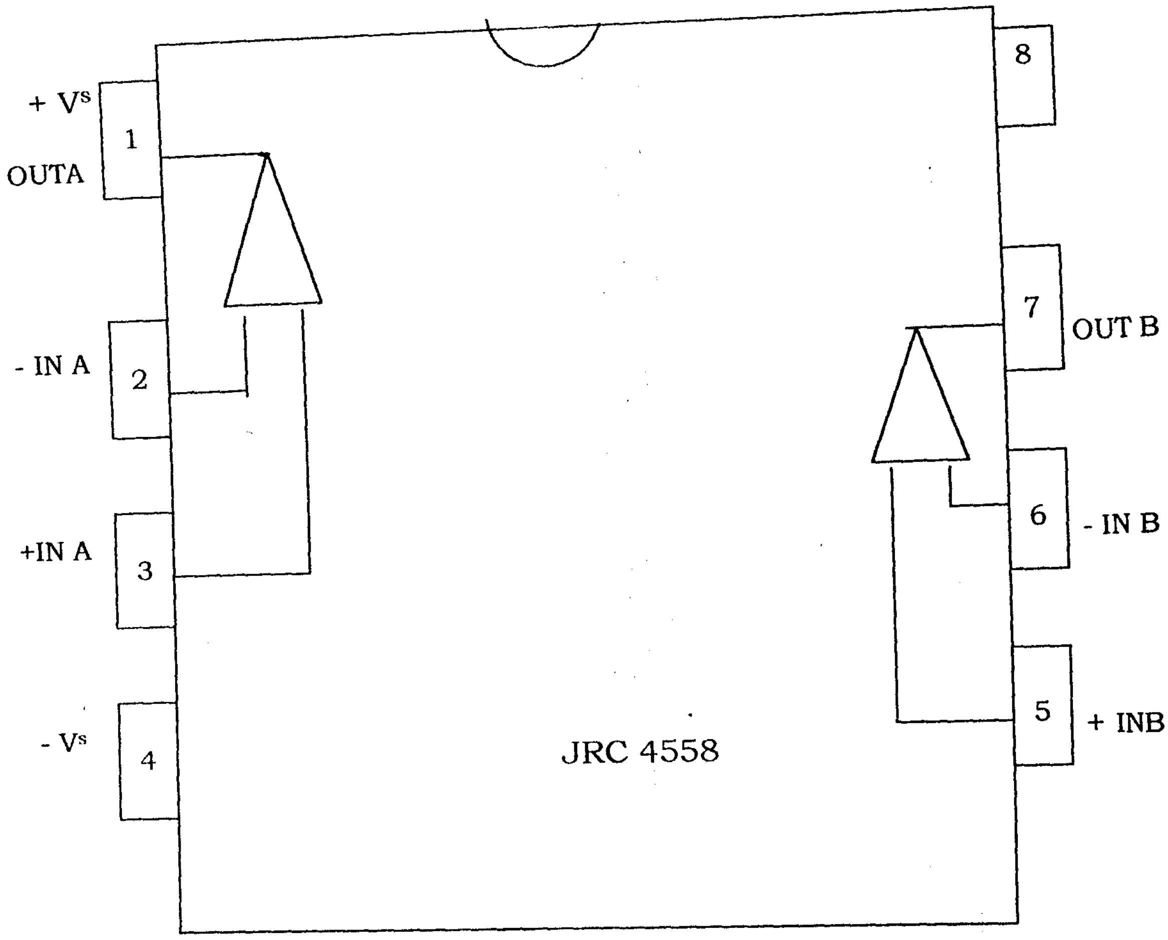

FIG 2.6 INTERNAL CIRCUIT OF JRC 4558 IC.

2.5 FILTERING STAGE.

Filter simply means changing the relative amplitude of the frequency components in a signal; or eliminating some of the frequency components entirely. For linear time – invariant system, the spectrum of the output is that of the input multiplied by the frequency response of the system.

Therefore , filtering can be conveniently accomplished through the use of such systems with an appropriately choosen frequency response.

Filter can be classified into ;

(1) Active filter

(2) Passive filter.

ACTIVE FILTER.

This consist of a solid – state device surrounded by a network of resistors and capacitors.

PASSIVE FILTER

On the other hand passive filter consist of only a network of resistors, capacitors and inductors.

In this project , the active filter is used so as to allow signal [current at voice frequencies]that ranges between 300Hz to 3.4 KHz to pass.

2.5.1 **DESIGN OF A LOW PASS FILTER**

The steps adopted in designing of a low pass filter are as follows:

1. Obtain data for low pass filters normalised for Wc =1

rad/sec. Using Butter worth table.

2. Based on the condition in one above , it is easier to obtain a normalised active filter circuit first as follows

(i) Choose a capacitor with a value say C = 1F

(ii) Choose other capacitors of value that are lower or higher multiple of 1F

(iii) Note that the capacitance value of the capacitors in (ii) above must be selected in such a way that calculations under the radical of G_2 gives a positive number.

2. Calculate conductance G_1, G_2 and G_3 using the formulae below.

$$b_0 = G_2 G_3 / C_1$$

$$b_1 = G_1 + G_2 + G_3$$

$$K = R_2 / R_1 = G_1 / G_2$$

3. Then carry out the denormalization process as follows

(i) Denormalization is carried out by dividing the capacitor – normalized values by impedance scaling factor (ISF) and by multiplying resistor normalised values by (ISF).

(ii) Demormalized value [practical value] of the capacitor C_p is given as

$$C_p = \frac{C_n}{U\,(ISF)} \quad \text{where} \quad U = \frac{W_c}{W_n}$$

C_p = Practical Capacitor Value

C_n = Noramlised Capacitor Value

U = Frequency Normalising Factor

ISF = Impedance Scaling Factor

W_c = $2\Pi f_c$, the desire cut off frequency expressed in radian / second.

W_n = $2\Pi f_n$, the normalised cut off frequency expressed as 1 radian / second.

(iii) Demormalised Resistor Value [Practical Value]

$R_p = R_p\,(ISF)$

R_p = Practical Resistor Value

R_n = Normalised Resistor Value

ISF = Impedance Scaling Factors.

5. If the denormalised resistance and capacitance obtained are not suitable, multiply the resistor values and divide capacitor values by common factor.

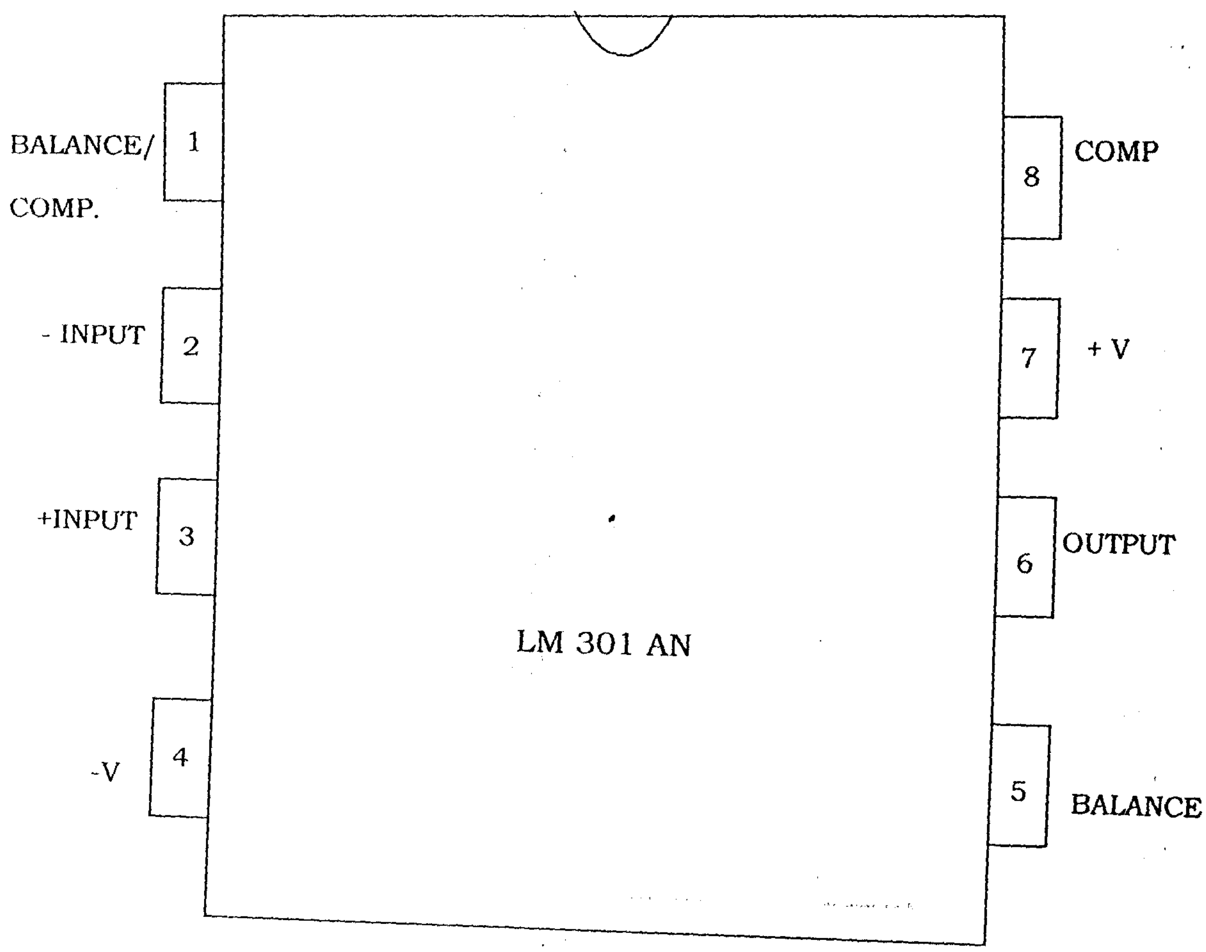

FIG. 2.7 PIN ARRANGEMENT OF LM 301 AN IC.

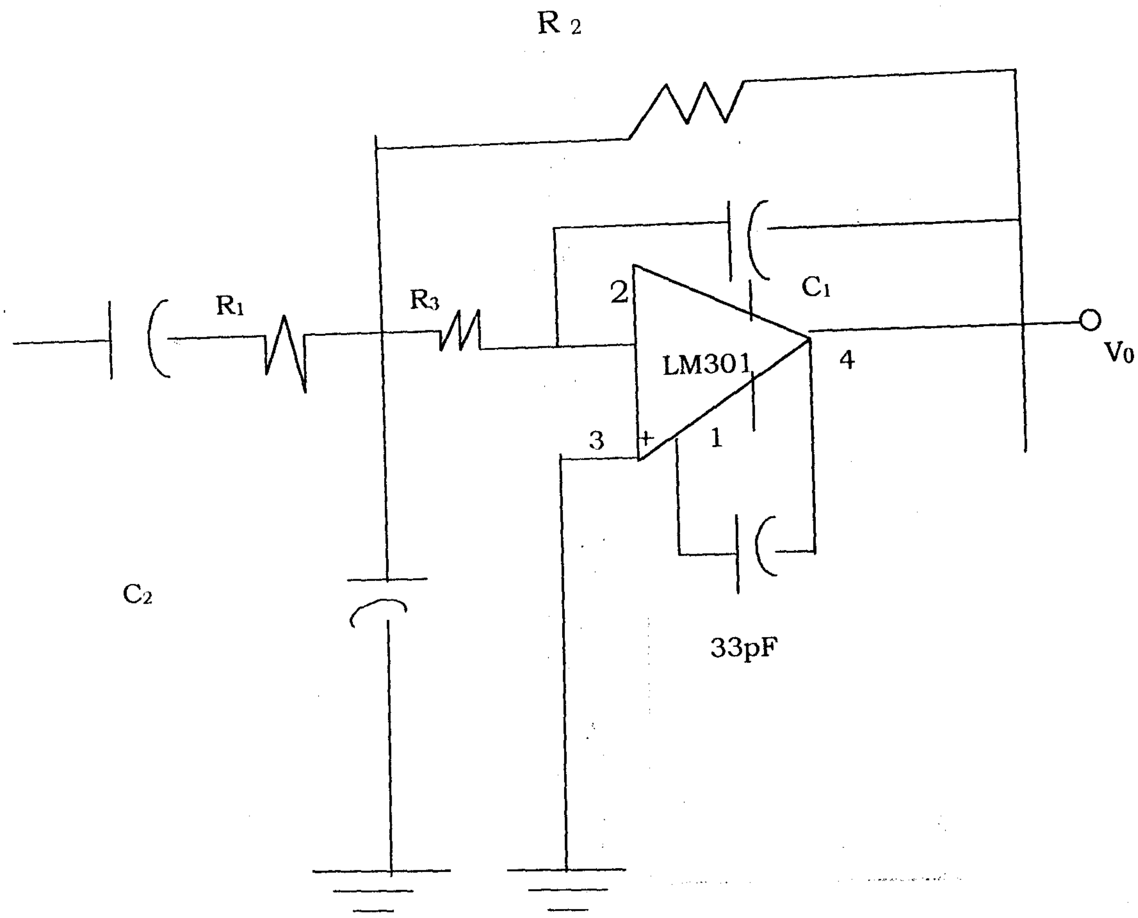

FIG. 2.8 LOW PASS FILTER CIRCUIT DIAGRAM.

To find the low pass filter normalised value for

W_c = 1 $^{rad}/_{sec}$ using Butter worth table

Selecting C_2 = IF

From the table

b_0 = 1

b_1 = 1.41421

K = 10

F_c = 3.4 KHZ [Maximum Voice Signal]

Selecting a lesser multiple of C_2

$\Rightarrow \quad C_3 = 0.001 = 1$ mf

Then , from $b_0 = {G1\ G3} / {C1}$

$$\Rightarrow \quad G_3 = \frac{b_0 C_1}{G_0} \quad \text{----------- (a)}$$

$$b_1 = G_1 + G_2 + G_3 \quad \text{-------- (b)}$$

$$K = {R2} / {R1} = {G1} / {G2} \Rightarrow G_1 = KG_2 \text{ ----- (c)}$$

Putting (a) and (c) in (b)

$$\therefore\ b_1 = K G_2 + G_2 + b_0\ {C1} / {G2}$$

$$\Rightarrow b_1 G_2 = K G^2{}_2 + G^2{}_2 + b_0\ C_1$$

$$\therefore\ G^2{}_2\ (K+ 1) - b_1 G_2 + b_0\ C_1 = 0$$

$$\Rightarrow G_2 = \frac{b_1 \pm \sqrt{b^2{}_1 - 4 (K + 1) b_0\ C_1}}{2 (K + 1)}$$

$$= \left(1.41421 + \sqrt{1.9559899} \right) / 22$$

$$= 2.81277 / 22 = 0.1279$$

$\therefore$ $G_2 = 0.1279$ mho

But $G_3 = C_1 b_0 / G_2$

$$= \frac{(1 \times 10^{-3})(1)}{0.1279}$$

$G_3 = 0.0078$

Also

$G_1 = K\,G_2$

$= 10 \times 0.1279$

$G_1 = 1.279$

Hence $G_1 = 1.279$

$G_2 = 0.1279$

$G_3 = 0.0078$

To find the practical value

Scaling factor I S F $= F_c / 2\Pi$

Where $F_c = 3.4 \times 10^{3}$

$\Rightarrow \quad R_1 = \frac{1}{G1} \times ISF$

$= \frac{1}{1.279} \times 3.4 \times 10^{3} / 2\Pi$

$\therefore \quad R_1 = 42.309 \times 10 \longrightarrow$ Common Factor.

$= 423\Omega$

$$R_2 = \frac{1}{G_2} \times ISF$$

$$= \frac{1}{0.1279} \times {}^{170}/_{11}$$

$$= 423.086$$

$$\Rightarrow R_2 = 4230.86$$

$$= 4230.86$$

$$R_2 = 4.231K\Omega$$

Also,

$$R_3 = \frac{R_3}{G_3} \times ISF$$

$$= \frac{1}{0.0078} \times {}^{170}/_{11}$$

$$= 6921.012$$

$$\Rightarrow R_3 = 6921.012 \times 10$$

$$= 69210.12$$

$$R_3 = 6.921K\Omega$$

To find the capacitance of the capacitors

Frequency normalised factor " U " is given as

$$U = \frac{W_c}{W_n} = 2\Pi F_c / 2\Pi F_n$$

$$\Rightarrow \quad U = \frac{2\Pi \times 3.4 \times 10^3}{1}$$

$$= 6.8\Pi \times 10^3$$

$$= 21.36283 \times 10^3$$

Using the formula

$$C_P = C_n / (U \times ISF)$$

For $C_n = C_2 = 1F$ (as selected earlier on)

$$C_P = \frac{1}{(21.36283 \times 10^3) \times {}^{170}/_{\Pi}}$$

$$= 865.05 \times 10^{-9}$$

$$\Rightarrow \quad C_P = C_1 = \frac{865.05}{10}$$

$$C_1 = 86.5\ pF$$

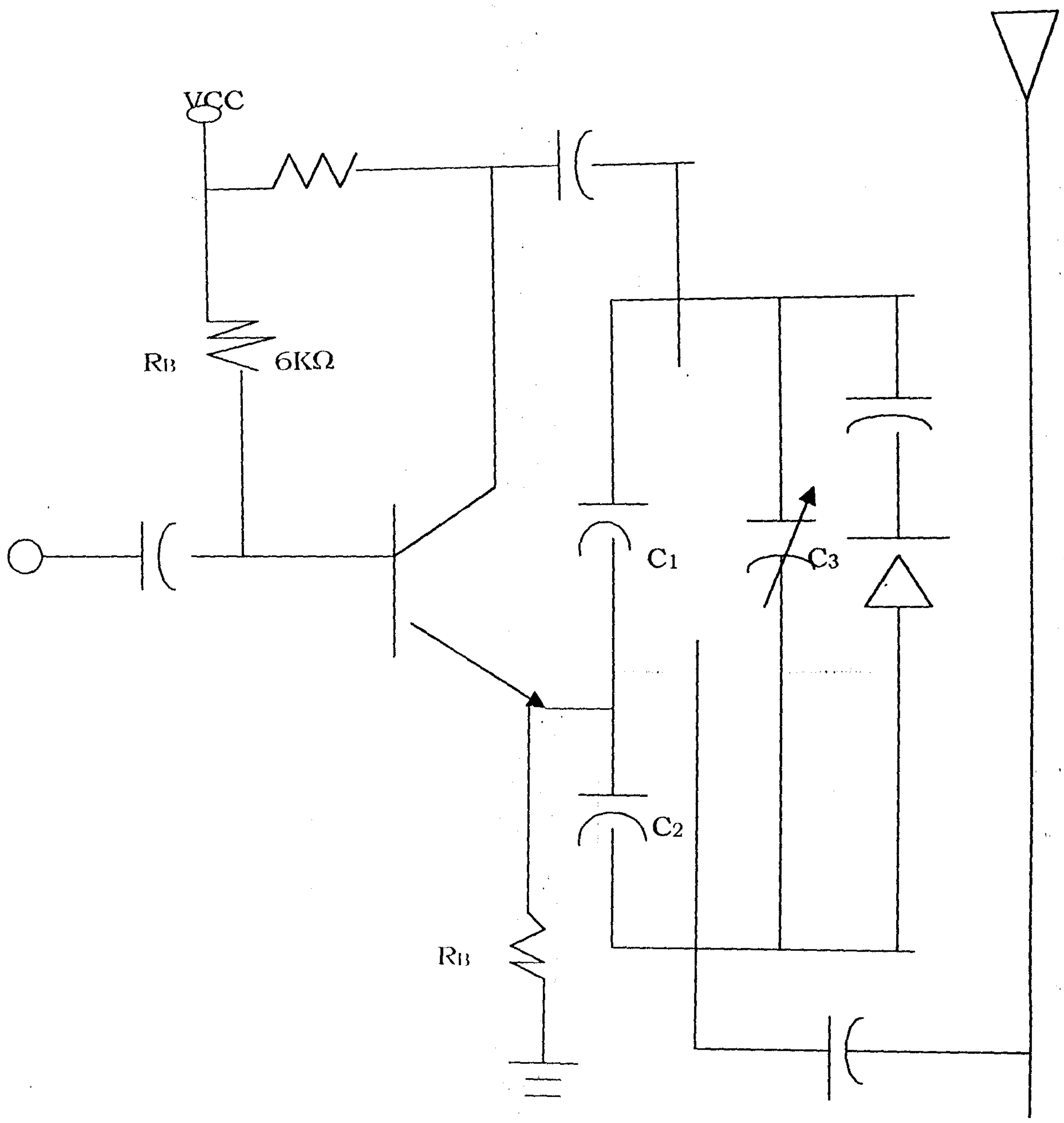

FIG. 2.9 MODULATOR / OSCILLATOR CIRCUIT DIAGRAM.

To calculate the total capacitance of the colpitts oscillator

Let the maximum variable capacitor of the oscillator tank

be

107. 07643 pF which is C_3

$\Rightarrow$ $C_3 = 107.07643PF$ which is C_3

$C_2 = 5PF$

$C_1 = 68PF$

$C_t = (C_1 \times C_2) / (C_1 x C_2) + C_3$

$=(68 X 10^{-12} X 5 X 10^{-12})/(68 X 10^{-12} + 5 X 10^{-12}) + 107.0764PF$

$= 4.6575 X 10^{-12} + 107.07643 X 10^{-12}$

$C_t = 111.73393PF \Rightarrow C_t = 112PF.$

To calculate the values of inductor used:

$F = 1 / 2\Pi \sqrt{LC}$

$= 1 / (2 X 3.142 \sqrt{LC}$

$\Rightarrow \sqrt{L} = 1 / 2 X 3.142 X 108 X 10^6 \sqrt{111.73393 X 10^{-12}}$

$L = 1.393951 X 10^{-4}$

$L = 1.18065 X 10^{-2} H$

$L = 11.8065 mH$

At resonance the dynamic Resistance of the Oscillator can be calculated as follow:

$Q = 2\Pi F_o L / r^s$

But $Q = 1 X 10^6$ and $F_o = 108 X$ 6

$\Rightarrow 1 X 10^6 = (2 X 3.142 X 108 X 10^6 .01180657) / r^s$

$\therefore r^s$ = 8011788.475/ 1 X 10^6

$\Rightarrow r^s$ = 801175. But the preferred r^s = 10.735 Ω

To calculate R_B which is given by

R_B = [(VCC – VBE) $2\beta R_c$] / VCC

But R_c = r^s

= [(12 – 0.7) 2 X 300 X 8.01175] / 12

= (11.3 X 2 X 300 X 8.01175] / 12

= 54319 .665/ 12

= 4526. 63875

= 4.527 KΩ

R_B = 5 KΩ

To calculate I_C which is given by

I_C = VCC/2 r^s

= 12/ 21 . 470398

= 0.7489

I_C = 0.75 A

∴ Power of the transmitter is P_T is given by

P_T = $I_C^2\ r^2$

= $(0.75)^2$ X 10.735

= 0.5625 X 10. 70

= 6.0187

$P_T \quad = \quad 6$ Watt

2.7 ANTENNA.

The Antenna (transmitting Antenna) is usually located at the output of the transmitter. It radiates radio frequency in the form of electromagnetic wave or signal into the space for the receiving antenna to capture.

All transmitting antennas, except few , function with standing waves of voltage and current along the element .Voltage is fed to the antenna, and this produces current flow along the metal to the open end.

The related magnetic field collapses back into the antenna and makes the voltage maximum at the ends.

Antenna can either be a resonant or non – resonant type. Regardless of the type of antenna, there should be impedance matching between the antenna and the transmission line.

2.8 DESIGN OF ANTENNA.

The length of the antenna used can be calculated if the transmission frequency known . This is done as follows:

$$\lambda = V/F$$

For this project $L \leq \lambda$ is used which is for frequencies between 10KHz - 1GHz

$\therefore \lambda \leq {}^{V}/_{F}$

Where V = Velocity of light in free space = Velocity of sound in free space

$= 3 \times 10^{8}\ {}^{m}/_{s}$

F = Frequency of signal radiation.

λ = Wavelength of the signal

$$\therefore \lambda = \frac{3 \times 10^{8}}{100 \times 10^{6}} = 3m$$

for better efficiency, there is need for the length of the antenna to approach ¼ of the wave length of the working frequency.

$$\therefore \text{Length " L "} = \frac{\lambda}{4} = \frac{3}{4} = 0.75m$$

$\Rightarrow L = 75cm$

This means that the operating frequency , the antenna to be used will be of length 75cm.

of the different stages (refer to section 3.1 for more detail) were then carried out, to confirmed that, they (all the stages) carried out their desired functions.

The main construction work was then carried out on the Vero board. This is done by transferring all the components to the Vero board by soldering them, using soldering iron and lead so that they are firmly fixed in position.

Finally the "casing" was constructed in a rectangular shape so as to conveniently accommodate the transmitter; as shown in fig. 3.1 .

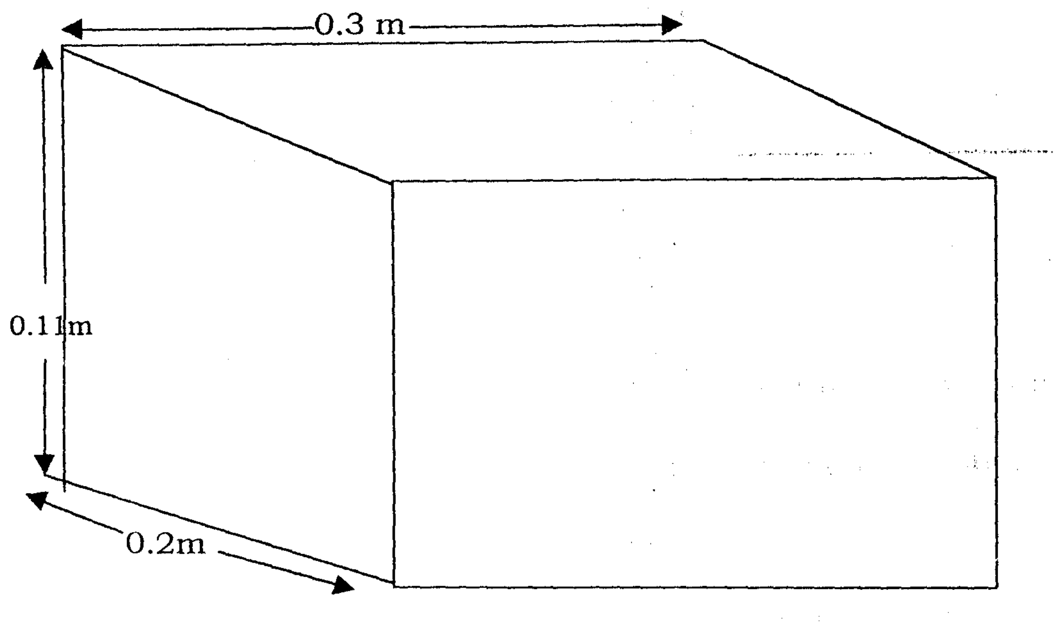

FIG.3.1 THE SCHEMATIC DIAGRAM OF THE TRANSMITTER CASING

The Casing of the transmitter is important, because it protects the user from receiving a shock when he touches the AC part of the construction e.g when the transformer is mistakenly handled. It is also necessary in order to prevent physical damage of the components and for easy relocation of the transmitter [i.e mobility of the transmitter] from one point to another, when the need arises.

Precautions taken during the course of the construction were as follows:

(i) Care was taken during the process of soldering in order to avoid short – circuit which can lead to burning of some components.

(ii) During Casing care was also taken by attaching the transmitter to the casing carefully to avoid damages.

(iii) Proper checking and analysis of the circuit were done to ensure correct connections before the circuit is powered from the source.

3.2 TESTING.

Testing is very important in what ever project work one embark upon. Because it is through this that one can know whether the aim and objective of his or her project is achieved or not . It also helpful in knowing where and how to troubleshoot, when the desire result is not obtained at a given stage of construction or after the completion of the whole construction.

After all the components were purchased , they were tested to ensure that they are in good order, before being used in the construction. As done in the process of construction, the testing is also carried out in stages. First of all, the output of the power supply unit [after construction] was tested and confirmed that the negative and positive twelve volts DC [+12V DC] , to power the transmitter is obtained. This testing was done using the Oscilloscope. Then, after the transmitter have been fully constructed the power supply unit was connected to the main circuit [i.e the transmitter circuit.]

The power supply unit was then energised by connecting the primary side of the transformer to an AC source. The output of each stage of the transmitter was then measured to ensure that the required result is gotten.

However , it was observed that the Voltage drop across the biasing resistor of the transistor [at the modulator / oscillator stage] was too high, thereby leading to a low output at the collector. But on removing the resistor and testing the output of the transistor, it was found that the required value was at the collector, but the transistor started getting hot. The power supply was quickly switched off.

Later, a resistor of lower value was used, and the transistor did not get hot any longer, when the power was switched on once again. On measuring the output of the transistor, though the exact value required was not obtained something very close was obtained.

After testing all the stages and confirmed alright. The variable capacitor at the Oscillator LC tank was tuned back and forth, as signal was sent through the microphone simultaneously; with a receiver tuned to different frequency values on the FM band, the voice signal was heard over the receiver. Then the turning [of the variable capacitor] was stopped.

With the receiver very close to the transmitter the signal heard was strong but very poor. But as the receiver was carried away from the transmitter, a clear signal was obtained.

CHAPTER FOUR

4.1 CONCLUSION

Ideally a carefully designed circuit based on accurate calculation of components values should perform its desired function when constructed. But this statement is easier said than done. Because in the course of this project work, I was made to believe that the workability of a designed circuit is not based only on the accurate circuit design but also, it depends very much on the individual characteristics of the circuit components used. For instance two resistors of the same value may have slightly different effect in a circuit. Because of the slight difference in their internal characteristics.

Therefore , a lot of creativity has to be put in , in order to take care of such limitations when trying to put any design work into a working entity.

Nevertheless , by putting this in mind, and by carefully designing of the project the stated aims and objectives of this project (in particular)have been achieved.

4.2 RECOMMENDATION.

For a project of any kind to be successfully accomplished , the material required to accomplish such project work should be made available.

Therefore, I will like to recommend at this juncture, that students should be made to have access to the relevant materials, especially textbooks, journals , data book , measuring instrument e.t. c . This can be done by equipping the library and laboratory. That, will enable the students in gathering enough information and equipment required to successfully execute their project.

Another important issue is that, the project topics should be given to students in good time so as to avoid hasty work, which will consequently lead to poor design and construction , along side poor report writing.

Lastly, the project can be improved upon in the following ways:

(i) Adopting pulse modulation system instead of the Analogue modulation system [the one used in this Project] so that transmission and processing of Discrete signals will be easier and also for the system to consume less power.

(ii) Converting the analogue signal output of the transmitter to digital , through the use of an analogue to digital (A/D) converter.

(iii) Increasing the power of the transmitter so that it can cover more distance.

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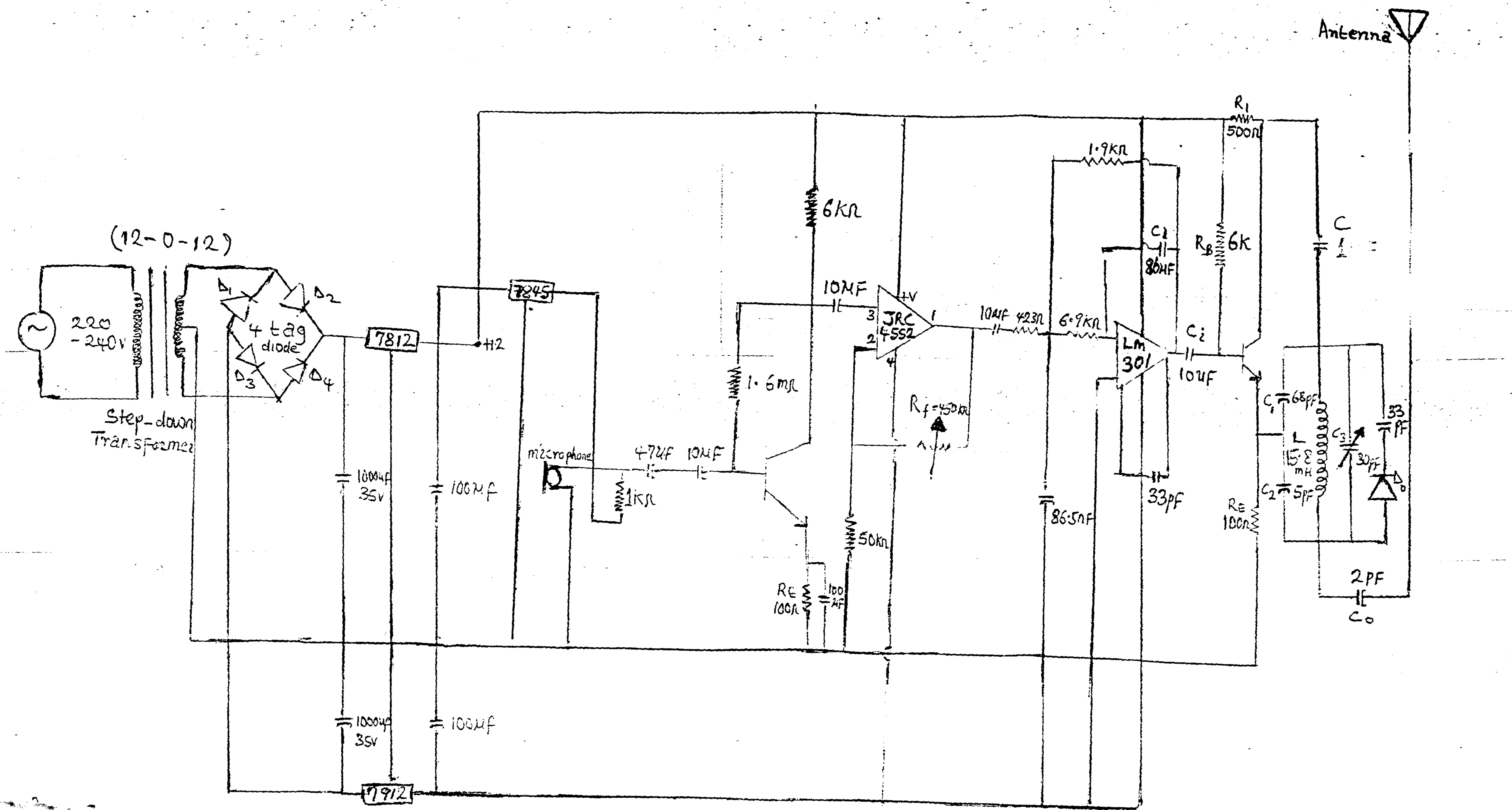

CIRCUIT DIAGRAM