DESIGN AND CONSTRUCTION OF OPERATIONAL AMPLIFIER FM TRANSMITTER

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2001/12030EE

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ELECTRICAL COMPUTER ENGINEERING DEPARTMENT

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Dedication

To the God of all ages from whose fountain of infinite wisdom I draw inspiration and gain insight into all which I ought to know. To my parents Mr. and Mrs. Dare for their unfailing dedication to their responsibility of giving me good Education.

It also goes to all who have at one time or the other contributed to my success.

Declaration

I, Michael Tunde Dare, declare that this work was done by me and has never been 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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Acknowledgement

I humbly use this medium to acknowledge God's ever increasing faithfulness upon my life and his help through the years. Also I want to appreciate all lecturers of the Federal University of Technology Minna, especially my supervisor Engr. Caroline for her unclenching support and guidance.

Also I use this page to recognize the effort of staffs of NTA Domsat, Abuja to making this project a reality.

ABSTRACT

The project is based on the design and construction of an Operational Amplifier FM transmitter, It is designed to operate between 76MHz and 108MHz,the device incorporates just one Audio input channel which can be increased and it operates with Audio sources only such as CD player, headphones, e.t.c. which can be modified as desired in later designs.

This project could be employed in transmitting audio signals within a community, organization, a house and the likes. It will also remove the load of wires required to link the source and destination of an information such as between a control room and studio of a TV broadcast station without encroaching on the frequency of other broadcast stations since the radius of transmission is not large.

After proper testing, the project was found to have worked according to the specifications and calculations in this report. The use of IC's has made the reduction of size and weight possible.

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CHAPTER 1

INTRODUCTION

We usually think of a transmitter as being a 'black box'. However, that is the form a transmitter takes for our use on the amateur band. Many electrical circuits are transmitters, even though transmitting may not be their primary function. Anything that emits electromagnetic energy at any frequency is a transmitter, from radio at the low-frequency end of the spectrum, to gamma rays at the high-frequency end. Electromagnetic fields are combinations of both electrical and magnetic field, and are produced whenever an electromagnetic wave is transmitted.

The basic electrical resonant circuit is the combination of an inductor (coil) and a capacitor called a tuned circuit. A pulse of energy applied to this tuned circuit will make it ring (oscillate) at its resonant frequency. The energy in the circuit transfers between the inductor and the capacitor every cycle of the oscillation and the frequency of the resonance depends on the values of L and C. To keep the circuit oscillating, rather than having it die away, we must supply the circuit with just enough energy to replace the energy lost both by radiation and by losses in the circuit itself. Because of this, a transistor working with the tuned circuit exists to provide this extra energy.

As it stands, of course, even with its transistor, our oscillator will not radiate very far. Connecting an aerial to it gives a very low-power CW (continuous wave) transmitter. Adding a couple more transistors form a radio-frequency (RF) amplifier and this is the basis of a simple low-power transmitter. A transmitter (sometimes abbreviated XMTR) can therefore be defined as an electronic device which with the aid of an antenna propagates an electromagnetic signal such as radio, television, or other telecommunications.

A transmitter usually has a power supply, an oscillator, a modulator, and amplifiers for audio frequency (AF) and radio frequency (RF). The modulator is the device which piggybacks (or modulates) the signal information onto the carrier frequency, which is then broadcast. Sometimes a device (for example, a cell phone) contains both a transmitter and a radio receiver, with the combined unit referred to as a transceiver. More generally and in communications and information processing, a "transmitter" is any object (source) which sends information to an observer (receiver). When used in this more general sense, vocal cords may also be considered an example of a "transmitter".

Given the above introduction, an FM transmitter can therefore be described as a portable device that plugs into the headphone jack or proprietary output port of a portable audio or video device, such as an iPod (or other types of MP3 players), CD players, and satellite radio systems. The sound is then broadcast through the transmitter, and plays through an FM frequency. Can be typically used with portable audio devices such as MP3 or CD players, but are also used to broadcast other outputs (such as that from a computer sound card) throughout a home or other building.

The FM-transmitter plugs into the audio output of audio devices and converts the audio output into an FM radio signal, which can then be picked up by appliances such as car or portable radios. Most devices typically have a short range of about 30 feet with any average radio up to about 75 feet with a very good radio and can broadcast on any FM frequency from 76.0 MHz to108.0.MHz

1.1.0 OBJECTIVE

Purposes for this FM transmitter include playing music from a device through a car stereo, or any radio without an audio input jack.

1.2.0 PROJECT LAYOUT

This project report is arranged in five chapters. Chapter 1 introduces the work, tells about the objective, methodology and constrains to achieving desired performance while Chapter 2 dwells on the literature review, theoretical background, and difficulties that limit performance. Steps taken in designing and construction were well enumerated in Chapter 3 while Chapter 4 was dedicated to discussion of result and tests carried out on the work. Chapter 5 contains the summary of the work

CHAPTER 2

LITERATURE REVIEW AND THEORITICAL BACKGROUND

2.1.0 HISTORICAL BACKGROUND

The early history of radio is the history of technology that produced instruments that use radio waves. Later in the timeline of radio, the history is dominated by programming and contents, which is closer to general history. Various scientists proposed that electricity and magnetism, while both capable of causing attraction and repulsion of objects, were linked.

In 1802 Gian Domenico Romagnosi suggested the relationship between electric current and magnetism, but his reports went unnoticed. In 1820 Hans Christian Ørsted performed a widely known experiment on man-made electric current and magnetism. He demonstrated that a wire carrying a current could deflect a magnetized compass needle. Ørsted's experiments discovered the relationship between electricity and magnetism in a very simple experiment. Ørsted's work influenced André-Marie Ampère to produce a theory of electromagnetism

In 1933, FM radio was patented by inventor Edwin H. Armstrong. FM uses frequency modulation of the radio wave to minimize static and interference from electrical equipment and the atmosphere, in the audio program. In 1937, W1XOJ, the first experimental FM radio station, was granted a construction permit by the FCC. After World War II, the FM radio broadcast was introduced in Germany. In 1948, a new wavelength plan was set up for Europe at a meeting in Copenhagen. Because of the recent war, Germany (which did not exist as a state and so was not invited) was only given a small number of medium-wave frequencies, which are not very good for broadcasting. For this reason Germany began broadcasting on UKW ("Ultrakurzwelle", i.e. ultra short wave, nowadays called VHF) which was not covered by the Copenhagen plan. After some amplitude modulation experience with VHF, it was realized that FM radio was a much better alternative for VHF radio than AM. Because of this history FM Radio is still referred to as "UKW Radio" in Germany. Other European nations followed a bit later, when the superior sound quality of FM and the ability to run many more local stations because of the more limited range of VHF broadcasts were realized. Despite having been developed in the 1940s, FM broadcasting took a long time to be adopted by the majority of radio listeners.

The first FM broadcasting stations were in the United States, but initially they were primarily used to broadcast classical music to an up market listenership in urban areas and for educational programming. By the late 1960s FM had been adopted by fans of "alternative rock" music, but it wasn't until 1978 (the first year that listenership to FM stations exceeded that of AM stations) that FM became mainstream. During the 1980s and 1990s, Top 40 music stations and later even country music stations largely abandoned AM for FM. Today AM is mainly the preserve of talk radio, religious programming, ethnic (minority language) broadcasting and some types of minority interest music. Ironically, this shift has transformed AM into the "alternative band" that FM once was.[1]

In the United Kingdom, the BBC began FM broadcasting in 1955, with three national networks carrying the Light Programme, Third Programme and Home Service (renamed Radio 2, Radio 3 and Radio 4 respectively in 1967). These three networks used the sub-band 88.0 - 94.6 MHz. The sub-band 94.6 to 97.6 MHz was later used for BBC and local commercial services. Only when commercial broadcasting was introduced to the UK in 1973 did the use of FM pick up in Britain. With the gradual clearance of other users (notably Public Services such as police, fire and ambulance) and the extension of the FM band to 108.0 MHz between 1980 and 1995, FM expanded rapidly throughout the British Isles and effectively took over from LW and MW as the delivery platform of choice for fixed and portable domestic and vehicle-based receivers.

The BBC (British Broadcasting service) initiated broadcasting in Nigeria on December 19, 1932 with the introduction of Radio Distribution service through the post and telegraphs department in some part of the country including Enugu. It was however legally adopted in 1933 by the then Colonial Government. It relayed the overseas service of the British Broadcasting Corporation through wired system with loudspeakers at the listening end. The service was called Radio Diffusion System, RDS.

From the RDS emerged the Nigeria Broadcasting Service, NBS in April 1950. Prior to the NBS, the Colonial Government had commissioned the Nigeria Broadcasting Survey undertaken by Messrs Byron and Turner which recommended the establishment of stations in Lagos, Kaduna, Enugu, Ibadan and Kano. Mr. T.W. Chalmers, a Briton and Controller of the BBC Light Entertainment Programme was the fist Director-General of the NBS.[2]

2.2.0 LITERATURE REVIEW

While Edwin Armstrong was working in the basement lab of Columbia's Philosophy Hall, he created frequency modulation radio (FM, patented in 1933 as US patent 1941066 with the title of "Radio signalling system"). Rather than varying the amplitude of a radio wave to create sound, Armstrong's method varied the frequency of the wave instead. FM radio receivers proved to generate a much clearer sound, free of static, than the AM radio dominant at the time. In 1922, John Renshaw Carson (AT&T), who was the inventor of single side band (SSB), published a paper in the Proceedings of the Institute of Radio Engineers (IRE) that FM did not appear to offer any particular advantage [3].

Armstrong managed to demonstrate the advantages of FM radio despite Carson's negative review of FM's promise. Armstrong published a classic paper on FM in the Proceedings of the IRE in 1936 [4], which was re-printed in the August 1984 issue of Proceedings of the IEEE. However, Armstrong's invention, and his genius, were ultimately proven in the marketplace by today's broad acceptance of the FM band.

In the year 2000, Oladeji F.O (95/4578 EE) who graduated from Electrical and computer Engineering Department, Federal University of Technology Minna, designed and constructed a 6-Watts FM Transmitter with automatic frequency control. This he was able to achieve using transistor BC 109 for pre-amplification, JRC 4558 op amp for voltage amplification and C824 for oscillationos. Most of the components used where only those that were readily available at the time and this did affected the result of the work, and though this problem still exists, effort was made to get very close substitute thereby achieving a highly reliable result.

2.3.0 THEORETICAL BACKGROUND

The function of a transmitter is to amplify an RF carrier modulated with the desired signal, adding a minimum of distortion to the encoded information.

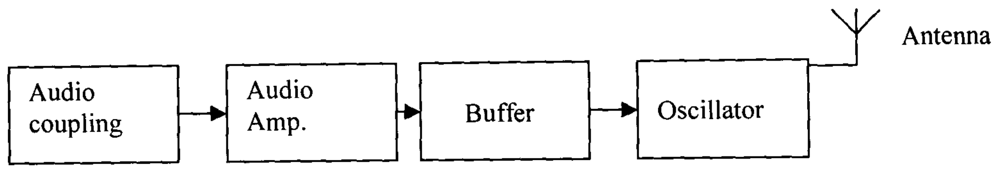

Fig. 2.1 Block Diagram of the FM transmitter

A typical block diagram is shown above in figure 2.1. Frequency of modulation, modulation method, and other details of the actual application dictate most of the architecture decisions, though some generalisations are possible.

2.3.1 AUDIO COUPLING STAGE

The circuit is fairly conventional, with a couple of small refinements. It all begins with an impedance divider. A voltage divider is usually thought of as two resistors, but for electronics signals at a given frequency, capacitors, inductors, or any combined impedance can be used. The divider was made in this way with a resistor and capacitor:

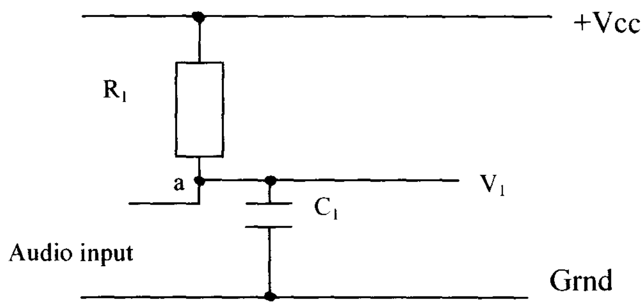

Fig. 2.2 Impedance divider

The resistor's impedance is simply its resistance: $Z_R = R$

The capacitor's impedance is a large resistance at low frequencies and a low resistance at high frequencies. The exact formula is:

$$Zc = \frac{1}{SC}$$

where C is the capacitance of the capacitor, and S is the frequency function.[5]

2.3.2 AUDIO AMPLIFICATION STAGE

The function of a preamp is to amplify a low level signal (possibly at high impedance) to line-level. A list of common sources would include a, microphone, CD player or other transducer. The op-amp gain calculated at DC does not apply at higher frequencies. To a first approximation, the gain of a typical op-amp is inversely proportional to frequency. This means that an op-amp is characterized by its gain-bandwidth product. This low-pass characteristic is introduced deliberately, because it tends to stabilize the circuit by introducing a dominant pole this is known as frequency compensation. Typical low cost, general purpose op-amps exhibit a gain bandwidth product of a few megahertz. Specialty and high speed op-amps can achieve gain bandwidth products of hundreds of megahertz.

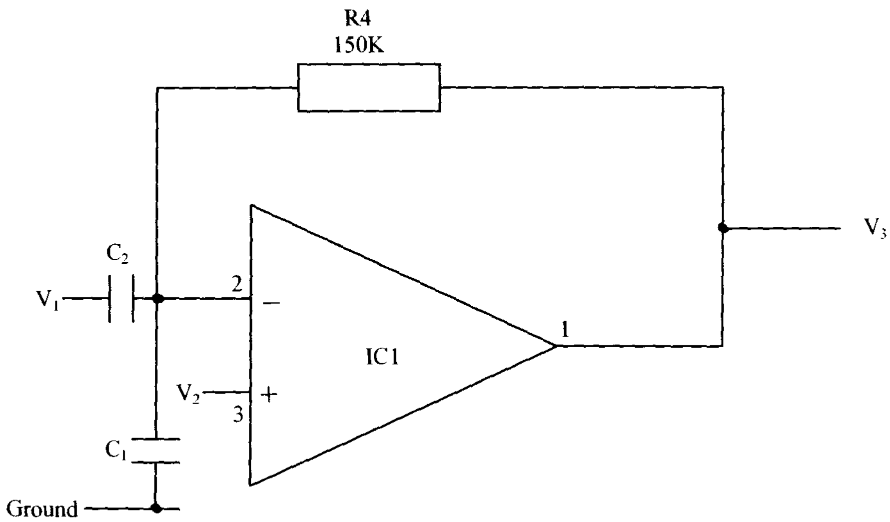

Fig 2.3 AF Amp stage of the transmitter

2.3.3 LM358P PIN ASSIGNMENT (DUAL IN-LINE PACKAGE)

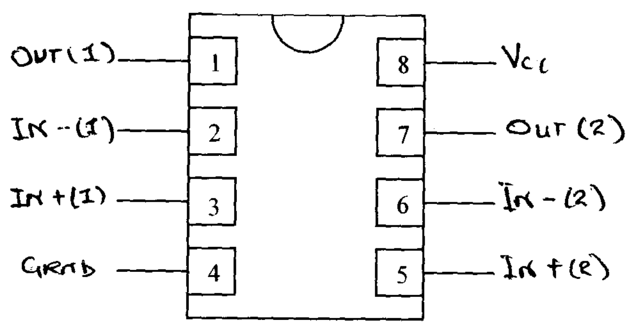

Fig 2.4 LM358p Pin Assignment

The amplifier's differential inputs consist of an inverting input and a non-inverting input and ideally the op-amp amplifies only the difference in voltage between the two. This is called the "differential input voltage AC behavior.

2.3.4 THE BUFFER STAGE

A buffer amplifier (sometimes simply called a buffer) is one that provides electrical impedance transformation from one circuit to another. Typically a buffer amplifier is used to transfer a voltage from a first circuit, having a high output impedance level, to a second circuit with a low input impedance level. The interposed buffer amplifier prevents the second circuit from loading the first circuit unacceptably and interfering with its desired operation. If the voltage is transferred unchanged (the voltage gain is 1), the amplifier is a unity gain buffer; also known as a voltage follower. A unity gain buffer amplifier may be constructed very simply as shown in the diagram below by connecting the output of an operational amplifier to its inverting input (negative feedback), and connecting a signal source to the non-inverting input. For this circuit, V_{out} is simply equal to V_{in}.

Other unity gain buffer amplifiers include the bipolar junction transistor in common-collector configuration (called an emitter follower because the emitter voltage follows the base voltage).All such amplifiers actually have a gain of slightly less than unity, but the difference is usually small and unimportant.

2.3.5 THE OSCILLATOR STAGE (colpitts)

A Colpitts oscillator is the electrical dual of a Hartley oscillator. In the Colpitts circuit, two capacitors and one inductor determine the frequency of oscillation. The Hartley circuit uses two inductors (or a tapped single inductor) and one capacitor.[6]

The ideal frequency of oscillation is given by this equation:

$$f_o = \frac{1}{2\pi\sqrt{L\left(\frac{C1+C2}{C1C2}\right)}}$$

where the series combination of C1 and C2 creates the effective capacitance of the LC tank.

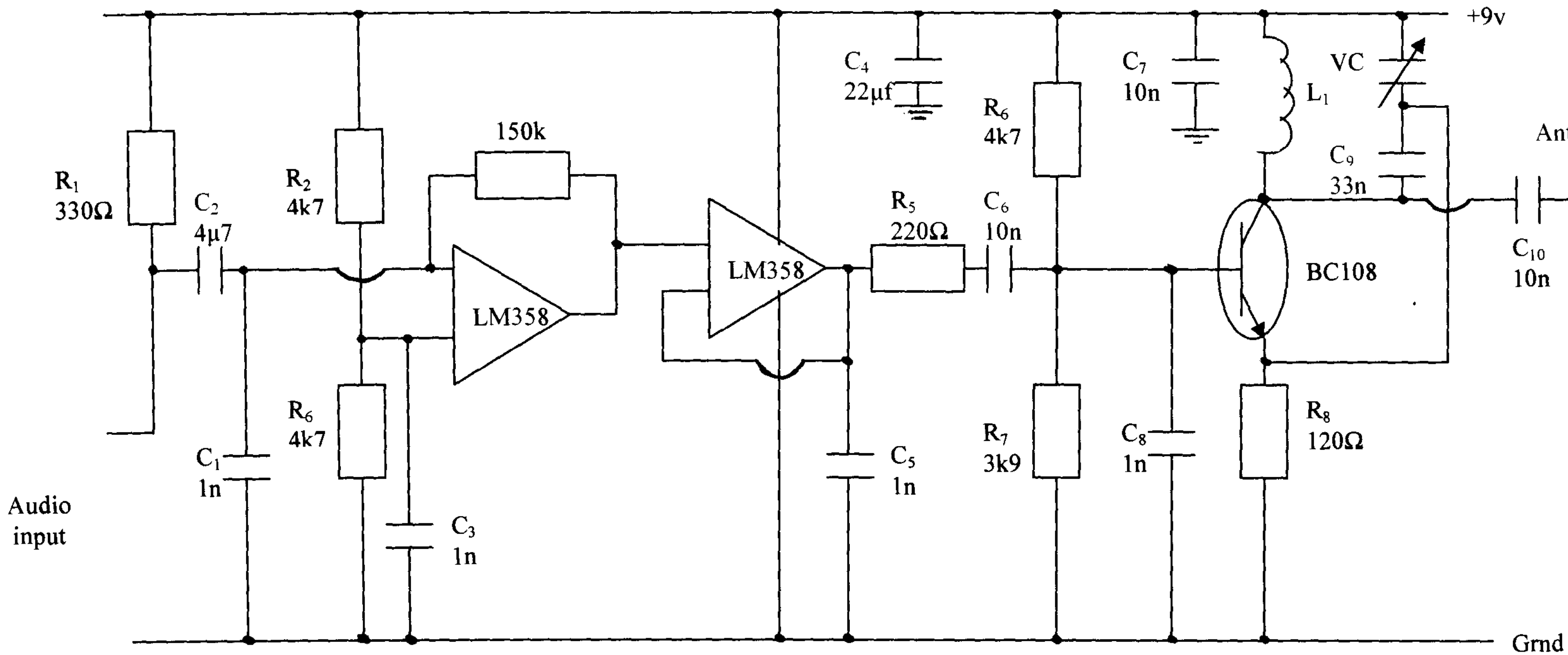

Fig.6.0 The Complete Circuit Diagram

CHAPTER 3

DESIGN AND IMPLEMENTATION

3.1.0 AUDIO COUPLING STAGE

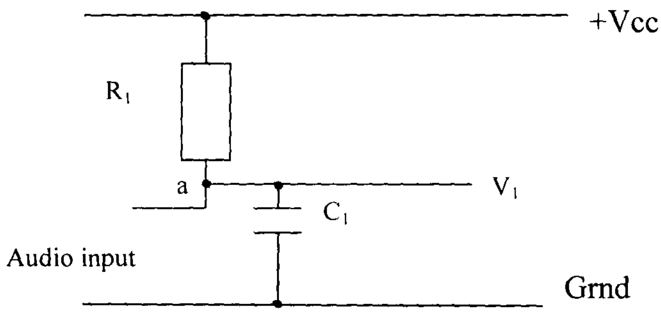

Fig. 3.1 Impedance divider

This divider will then have the voltage ratio:

at node "a"

$$\frac{Vcc - V_1}{R1} - \frac{V_1}{X_{C1}} = 0$$

$$\frac{Vcc}{R_1} = V_1\left[\frac{1}{R_1} + \frac{1}{X_{C1}}\right]$$

$$\frac{Vcc}{R_1} = V_1\left(\frac{X_{C1} + R_1}{R_1 X_{C1}}\right)$$

$$V_1 = \frac{Vcc X_{C1}}{X_{C1} + R_1} \cdots\cdots\cdots\cdots (1)$$

$$\frac{V_1}{Vcc} = \frac{X_{C1}}{X_{C1} + R_1}$$

But V_1 *is required to be* 65% *of* V_{cc}

so, from equation (1)

$$\frac{X_{C1}}{X_{C1} + R_1} = 0.65$$

$$X_{C1} = 0.65(X_{C1} + R_1)$$
$$X_{C1} = 0.65\,X_{C1} + 0.65R_1$$
$$X_{C1}(1 - 0.65) = 0.65R_1$$

$$R_1 = X_{C1}\left(\frac{0.35}{0.65}\right)$$

therefor $R_1 = 0.54X_{C1} \cdots\cdots\cdots\cdots (2)$

but $X_{C1} = \dfrac{1}{2\pi f C_1}$

if C_1 *is fixed at* $1n$
and $f = 265KHz$

then $X_{C1} = \dfrac{1}{2\pi \times 265 \times 10^{3} \times 1 \times 10^{-9}}$

taking $\pi = \dfrac{22}{7}$

$X_{C1} = 600.58\Omega \quad \cdots\cdots\cdots (3)$

$substituting\ \ for\ \ X_{C_1}\ \ in\ \ equation\ (2)\ \ gives$

$R_1 = 0.54 \times 600.58$

$R_1 = 324.43\Omega$

$but\ \ the\ \ next\ \ highest\ \ fixed\ \ value\ \ of\ \ resistor\ \ is\ \ 330\Omega$

$therefor\ \ 330\Omega\ \ was\ \ selected\ \ as\ \ R_1$

$so, \quad R_1 = 330\Omega$

The ratio then depends on frequency, in this case decreasing as frequency increases with V_1 feeding the inverting terminal of the AF op amp as shown in the circuit diagram.

Also,Considering figure 3.2, which is the network supplying the non-inverting terminal of the AF amp.

Taking the nodal analysis at node "b"

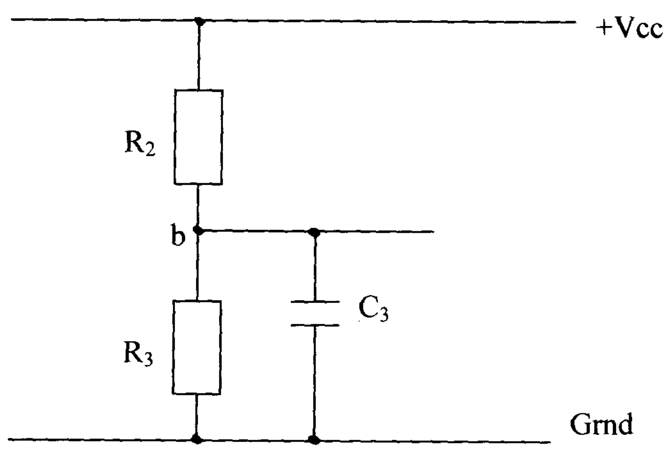

Fig 3.2 voltage divider

$$\frac{Vcc - V_2}{R_2} - \frac{V_2}{R_3} - V_2(SC_2) = 0$$

$$\frac{Vcc}{R_2} = V_2\left(\left(\frac{1}{R_2}\right) + \left(\frac{1}{R_3}\right) + SC_2\right)$$

$$\frac{Vcc}{R_2} = V_2\left(\frac{R_3 + R_2 + SC_2R_2R_3}{R_2R_3}\right)$$

$$V_2 = \frac{VccR_3}{R_3 + R_2 + SC_2R_2R_3}$$

$$V_2 = Vcc\left(\frac{R_3}{R_2 + R_3 + SC_2R_2R_3}\right)$$

But

$R_3 = R_2 = R$

$therefor:$

$$V_2 = Vcc\left(\frac{R}{2R + SC_2R^2}\right)$$

$$V_2 = Vcc\left(\frac{1}{2 + SC_2R}\right)$$

$with\ a\ zero\ frequency\ \sup ply\ at\ this\ ter\min al:$

$$V_2 = Vcc\left(\frac{1}{2}\right)$$

3.2.0 AUDIO AMPLIFICATION STAGE

The diagrame in Fig.3.3 shows the AF amplification stage of this particular work:

The reactance value of C_2 is required to be atleast 1/5 of Z_{in}.

Where Z_{in} is the input impedance of IC1 (LM358)

And the resistance of the leg 2 of the IC is Z_2=0.6Ω

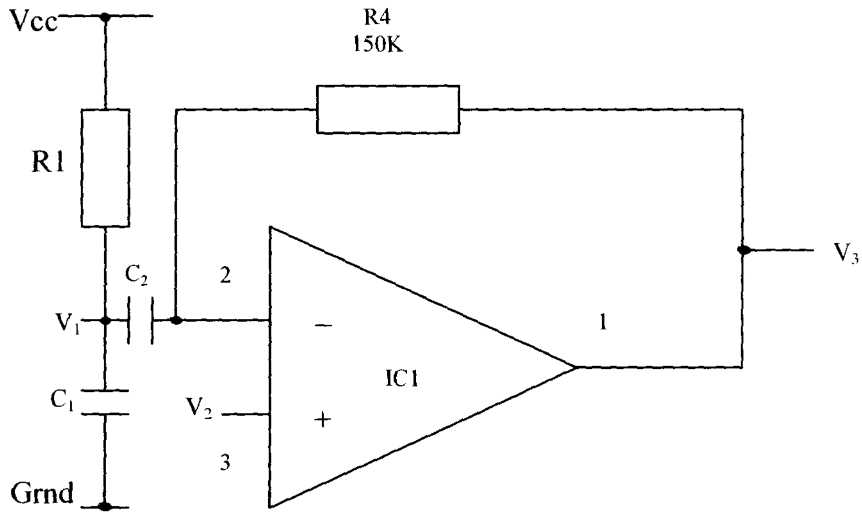

Fig 3.3 AF Amp stage of the transmitter

But R_1 and C_1 are in parallel

Therefor; $R_1//X_{C1} = Z_r =$

$Z_b = 0.6\Omega$

$Z_r = R_1 // X_{C1}$

$$Z_r = \frac{R_1 . X_{C1}}{R_1 + X_{C1}}$$

$But\ R_1 = 330\Omega,\ and\ X_{C1} = 600\Omega$

so

$$Z_r = \frac{330 \times 600}{330 + 600} = 213\Omega$$

But

$$Z_{in} = \frac{Z_2 . Z_r}{Z_2 + Z_r} = \frac{0.6 \times 213}{0.6 + 213}$$

$$Z_{in} = 0.6\Omega$$

But the reactance of C_2 is required to be atleast 1/5 of Z_{in}

$$therefor\quad X_{C2} = \frac{Z_{in}}{5} = \frac{0.6}{5} = 0.12\Omega$$

but

$$X_{C2} = \frac{1}{2\pi f C_2}$$

$$C_2 = \frac{1}{2\pi f X_{C2}} = \frac{1}{2\pi \times 265 \times 10^3 \times 0.12}$$

$$C_2 = 5\mu f$$

But the next lowest available rating is $4.7\mu f$

$$\therefore C_2 = 4.7\mu f$$

Fig. 3.3 can be represented as shown in Fig 3.4

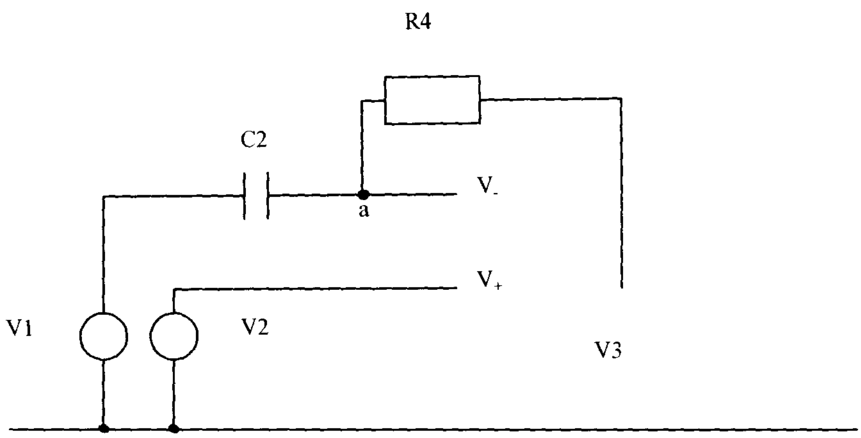

Fig 3.4 Representation of the LM358 Op Amp

taking nodal analysis at node "a"

$$\left(V_1 - V_-\right)SC_2 + \frac{V_3 - V_-}{R_4} = 0$$

$$V_1SC_2 + \frac{V_3}{R_4} = V_-\left(SC_2 + \left(\frac{1}{R_4}\right)\right)$$

$$\frac{V_1SC_2R_4 + V_3}{R_4} = V_-\left(\frac{SC_2R_4 + 1}{R_4}\right)$$

$$V_- = \frac{V_1SC_2R_4 + V_3}{SC_2R_4 + 1}$$

$$also \quad V_+ = V_2$$

$$and \quad V_+ + V_- = 0$$

$$\therefore \quad V_2 - \left(\frac{V_1SC_2R_4 + V_3}{SC_2R_4 + 1}\right) = 0$$

$$thus \quad V_2 - \frac{V_1 SC_2 R_4}{SC_2 R_4 + 1} = \frac{V_3}{SC_2 R_4 + 1}$$

$$V_3 = V_2 SC_2 R_4 + V_2 - V_1 SC_2 R_4$$

$$V_3 = V_2 - SC_2 R_4 (V_1 - V_2) \cdots\cdots\cdots (4)$$

$$but \ \frac{1}{SC_2} = X_{C2}$$

$$\therefore V_3 = V_2 - \frac{R_4 (V_1 - V_2)}{X_{C2}} \cdots\cdots\cdots (5)$$

small signal voltage gain for $LM358$, $G = 280V/mV$

$$G = 280K$$

$$\frac{V_3}{V_1} = \frac{V_2}{V_1} + \frac{V_2}{V_1}\left(\frac{R_4}{X_{C2}}\right) - \frac{R_4}{X_{C2}}$$

$$\frac{V_3}{V_1} = \frac{V_2}{V_1}\left(1 + \frac{R_4}{X_{C1}}\right) - \frac{R_4}{X_{C1}} \cdots\cdots\cdots\cdots (6)$$

$$\frac{V_3}{V_1} = -G = -280K$$

and

$$V_2 = \frac{1}{2} V_{cc} \quad = 0.5 \times 9 \ = 4.5V.$$

also

$$V_1 = V_{cc} \frac{X_{C1}}{X_{C1} + R_1} = 9 \times \frac{600.58}{600.58 + 330} = 5.8V$$

thus, from equation (6)

$$-280 \times 10^3 = \frac{4.5}{5.8}\left(1 + \frac{R_4}{600.58}\right) - \frac{R_4}{600.58}$$

simplifying the expression further gives;

$$R_4 = 149.9K\Omega$$

the nearest highest fixed value is $150K\Omega$

therefor $R_4 = 150K\Omega$

3.3.0 THE BUFFER STAGE

In this case: $v_3 = v_4$ ....(7)

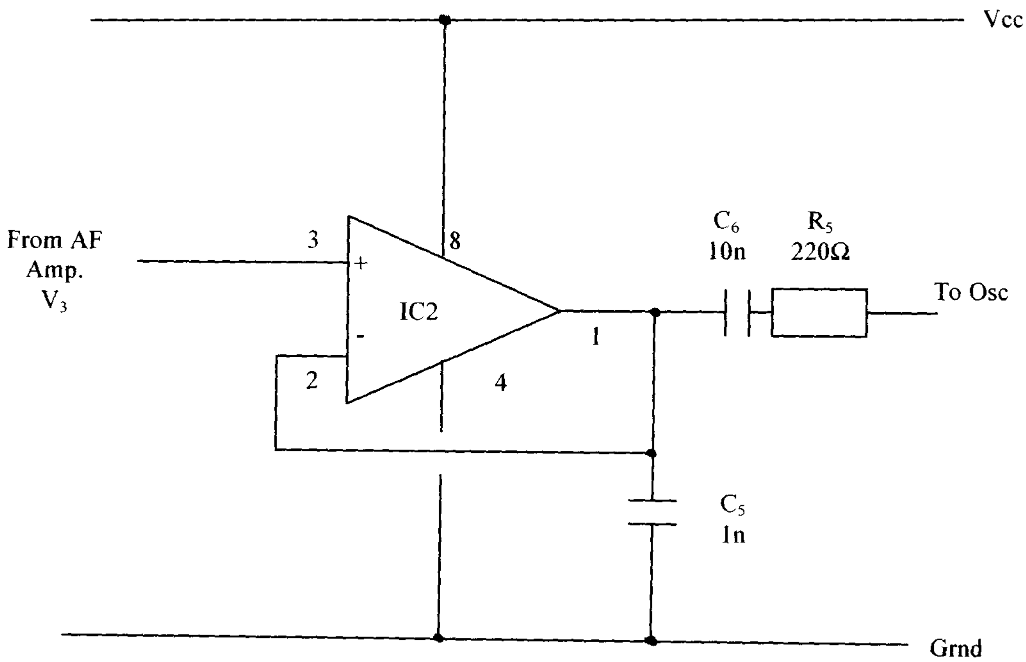

Fig 3.6 The Buffer stage

3.4.0 THE OSCILLATOR STAGE

3.4.1 Voltage Divider:

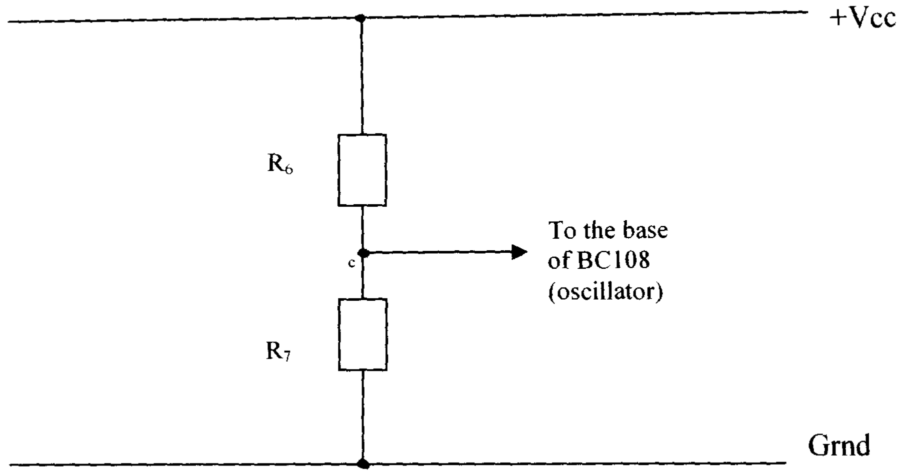

Fig 3.7 The voltage divider connection for the transistor

$$\frac{Vcc - V_5}{R_6} - \frac{V5_5}{R_7} = 0$$

$$\frac{Vcc}{R_6} = V_5\left(\left(\frac{1}{R_6}\right) + \left(\frac{1}{R_7}\right)\right)$$

$$\frac{Vcc}{R_6} = V_5\left(\frac{R_6 + R_7}{R_6 R_7}\right)$$

$$V_5 = Vcc\left(\frac{R_7}{R_6 + R_7}\right) \cdots\cdots\cdots\cdots (8)$$

The voltage divider is formed using external resistors R_6 and R_7. The voltage across R_7 forward biases the emitter junction. By proper selection of resistors R_6 and R_7, the operating point of the transistor can be made independent of h_{fe}.

I_e is required to be 25mA, therefor it is fixed at : I_e=25mA

And the base voltage is to be 45% of V_{cc}

$$V_e = V_{cc} - V_{be}$$
$$\therefore V_e = 0.45V_{cc} - 0.7$$

$$V_e = 4.05 - 0.7 = 3.35V$$

$$\textit{But } \mathrm{R_e} = \frac{V_e}{I_e} = \frac{3.35}{25 \times 10^{-3}} = 134\Omega$$

The next lowest value of resistor was therefor selected which is 120Ω \

$$\textit{so } \mathrm{R_e} = 120\Omega$$

$$\textit{Also} \quad I_b = \frac{I_e}{h_{fe}}$$

$$\textit{But } h_{fe} \textit{ for } BC108 = 370$$

$$\therefore I_b = \frac{25 \times 10^{-3}}{370} = 67.5\mu A$$

If the R_6 *and* R_7 *burns at atleast* 15 *times this figure*:

$$R = \frac{E}{I} = \frac{V_{cc}}{I_b}$$
$$\therefore \; R = \frac{V_{cc}}{15I_b} = \frac{9}{67.5 \times 10^{-6} \times 15} = 8889\Omega$$

But $R = R_6 + R_7$. *And the base is to be atleast* 0.45 *of* V_{cc}

therefor $R_7 = 8889 \times 0.45 = 4K\Omega$

But the next lowest value of fixed resistor is $3.9K$

$\therefore R_7 = 3.9K\Omega$

Also, $R_6 = 8889 - R_7$

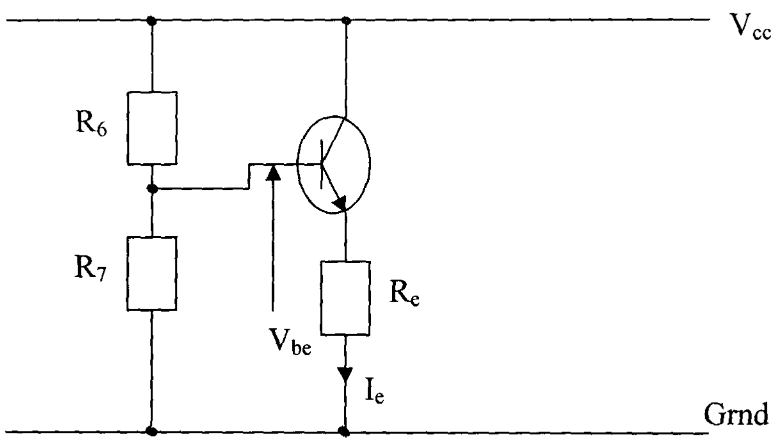

Fig. 3.8 BC 108 Biasing

$R_6 = 4889\Omega$ *so the next lowest value was selected.*

$R_6 = 4.7K\Omega$

3.4.2 Audio input to oscillator

since R_6 and R_7 are in parallel, $R_6//R_7=R_{eq}$

$$\frac{1}{R_{eq}} = \frac{1}{R_6} + \frac{1}{R_7}$$

$$R_{eq} = \frac{R_6 . R_7}{R_6 + R_7}$$

$$R_{eq} = \frac{3.9 \times 4.7 \times 10^6}{3.9 \times 10^3 + 4.7 \times 10^3}$$

$$R_{eq} = 2.13 K\Omega$$

But base impedance :

$$Z_b = R_e \times h_{fe}$$
$$= 120 \times 370 = 4.44 K\Omega$$

input impedance :

$$Z_{in} = \frac{Z_{eq} . Z_b}{Z_{eq} + Z_b}$$

$$Z_{in} = \frac{2.13 \times 4.44 \times 10^6}{2.13 \times 10^3 + 4.44 \times 10^3} = 1.4 K\Omega$$

The input at this stage need to have a reac tan *ce*, $\frac{1}{5} Z_{in.}$

$$X_{C_{in}} + R_5 = \frac{Z_{in}}{5} = \frac{1.4 \times 10^3}{5} = 0.28 K\Omega$$

$$0.28K - R_5 = \frac{1}{2 \mu f c_{in}}$$

$$\therefore C_{in} = \frac{1}{2 \mu f \left(0.28 \times 10^3 - R\right)} \qquad \textit{with } R = 220\Omega$$

$$C_{in} = 10 nf$$

3.4.3 The Tuned Circuit

If an inductor and capacitors are now added to the circuit above as shown in Fig 3.9

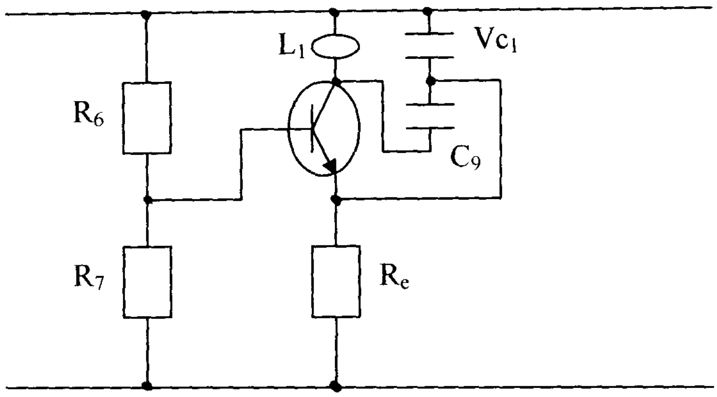

Fig. 3.9 The colpitts Oscillator

It is also required that the collector impedance be at least 1/3 of the emitter impedance.

The equivalent capacitive reactance is however required to be 50% of R_e.

Therefore, $X_{Ceq}=R_e/2 \quad =60\Omega$

Also, the reactance of inductor and capacitor are equal at resonance. so $X_L=60\Omega$

And the desired frequency is 82MHz. Basic inductive reactance formulae is:

$$X_L = 2\pi f L$$

$$\therefore L = \frac{X_L}{2\pi f}$$

$$L = \frac{60}{2\pi \times 82 \times 10^6}$$

$$L = 0.116\mu H$$

the next lowest available rating is $0.112\mu H$

therefor $L = 0.112\mu H$

Also, $X_C = X_L = 60\Omega$

And $X_C = \frac{1}{2\pi f C_{eq}}$

$$C_{eq} = \frac{1}{2\pi f X_C} = \frac{1}{2 \times \pi \times 82 \times 10^6 \times 60} = 32.3pf$$

But $C_{eq} = \frac{C_9 . V_{C1}}{C_9 + V_{C1}}$

If C_9 *is fixed at* $33pf$

$$32.3pf = \frac{33pf \times V_{C1}}{33pf + V_{C1}}$$

therefor $V_{C1} = \frac{32.3 \times 10^{-12} \times 33 \times 10^{-12}}{33 \times 10^{-12} - 32.3 \times 10^{-12}}$

$V_{C1} = 1.5nf$

3.4.4 Output Power

$I_C = I_e - I_b$

$\therefore I_C = 25mA - 67.5\mu A$

$I_C \cong 25mA$

$output\ resistance\ R_c = 120\Omega$

$and\ \ power\ P = I_c^2 R_c$

$\therefore P = \left(25 \times 10^{-3}\right)^2 \times 120$

$P = 75mW\ (output\ \ power)$

CHAPTER 4

TEST, RESULT AND DISCUSSION

4.1.0 PRELIMINARY TEST

When all the components have been fitted together, thorough check is necessary to ensure that all goes well. On this work, it began by shining a strong lamp behind the board component side and comparing the tracks with the Vero board pattern. This allows for checking solder bridges between tracks and dry joints. Being satisfied with the connections, the Antenna is then connected via a 100Ω resistor.

4.2.0 TESTS

The following tests were carried out:

(1) Fault Test: The circuit is then connected with a 9V battery in series with a 12V 3W torch lamp. The lamp glowing brightly shows that there is a fault. If there is no fault then the lamp should only glow dimly, if it glows at all. The complete transmitter should draw less than 100mA.

(2) Test for frequency of operation: With all being well, switching ON an FM radio tuned to somewhere around 82MHz and adjusting the capacitor on the board so the plates are at around maximum capacitance will make one hear the transmitter on the radio.

(3) Test with CD player: The AF IN terminal of the transmitter can now be coupled to the LINE OUT of a CD player, or even the headphone terminals of a walkman. I prefer to use a CD player since the volume control gives some control over the modulation depth. The modulation depth can be set by comparing it with other radio channels, but the transmitter is set at a little lower volume than other channels. Once the transmitter is working, the test lamp can be removed and the battery connected directly to the transmitter.

(4) Coverage test: Coverage test was also carried out on this transmitter by taking the radio receiver to some distance away from the transmitter until the transmitted signal could no longer be received. This is necessary in order to determine the distance over which the device can transmit. And it was found in this case to be about 15m.

Table 4.0 Parameters of the transmitter

parameter	Values
AF V_{RMS}	1.228V
Frequency Range	76-108MHz
Supply voltage	9V
Supply current	75mA
Output power	75mW

During the testing, it was however discovered that polarity does matter for the working of a transmitter, it was noticed that when the 9V battery was connected with the wrong polarity the transistor was heating up and the device did not work.

CHAPTER 5

CONCLUSION

This work serves to demonstrate op amp amplification and Buffering of AF. It also shows how to amplify low level signal from the 10mW level to the 75mW level and show how DC biase can be applied to make compensations for low signal level.

The sound energy that is produced from the audio source is amplified by the AF Amp. Also the carrier frequency produced by the RF Oscillator was made to vary the modulated signal. The Buffer op-amp helps to couple the amplified Audio signal to the oscillator stage without feeding the high output impedance of the previous stage to it. The oscillator output is the then fed to the antenna for radiation and it is received on a radio receiver with range 76MHz to 108MHz.

There are also different application since the unit will modulate from DC to several thousand kilohertz, the most obvious being music

5.1.0 LIMITATIONS

- The relatively low power output of FM transimitters sometimes makes it unsuitable for use in some large urban areas because of the number of other radio signals. This is compounded by the fact that strong FM signals can bleed over into neighboring frequencies making the frequencies unusable with the transmitter..[1]

5.2.0 RECOMMENDATION

1. The library of past project report should be well digitised to ensure ease of accessing past works in related fields. This will keep the students abreast of development in such areas, thereby ensuring that previouse works are built upon.
2. The department can do more in contributing to the success of student projects by liasing with companies that deal in electrical components both within and without the coutry for supply of this components , especially those that are not readily available and possibly at subsidised rates

5.3.0 BILL OF ENGINEERING MATERIALS AND COMPONENTS

Table 5.1.0 Cost of components and Accessories

Component	**Quantity**	**Cost (₦)**
Resistos	8	150
Capacitors	10	300
LM 358	2	200
BC 108	1	40
Vero Board	1	100
Battery cap	1	100
Cassing	-	800
Inductor	1	80
Antenna	1	50
TOTAL		1,820

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