DESIGN AND CONSTRUCTION OF AN FM (FREQUENCY MODULATED) TRANSMITTER

BY

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DECLARATION

I here by declare that this project is a complete original work of mine , under the supervision of Engr. M.D ABDULLAHI.

Submitted in partial fulfillment of requirement for the award of bachelor of degree (B.ENG) in electrical and computer engineering.

Students Signature

27/02/02

DATE

CERTIFICATION

This is to certify that this project work was carried out by Mr AKUBUIRO N. CHIDOZIE of the Electrical and Computer Engineering Department, Federal University of Technology, Minna.

....	....
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DR. Y. A. ADEDIRAN HEAD OF DEPARTMENT	DATE
....	....
EXTERNAL EXAMINER	DATE

DEDICATION

I dedicate this project to my Lord God Almighty who in his infinite Mercy has seen me through, from my first day on campus till date. I say may his name be glorified above all names (amen).

ACKNOWLEDGEMENT

My Immense appreciation goes to Mr and Mrs G.N .Akubuiro my parents, who through the prayers and financial commitments have bequited a resounding legacy on me. I also appreciate the whole hearted effort of my brothers and sisters.

My immense gratitude goes to Engr. M.D.Abdullahi, my project supervisor, for his assistance during the course of this project and to other staff of the Electrical and Computer Engineering Department.

I will not also forget to appreciate Engr. and Mrs. G.O. AKUBUIRO, my uncle and his wife, for their moral support and good counseling towards a well-fulfilled academic carrier. I also appreciate the financial and moral support of Mr. and Mrs. I .M. Igwe.

Lastly, my heart felt appreciation goes to all my beloved ones and well-wishers, whose names I have not mentioned, for their love, care, kindness and above all their prayers.

My prayer and wishes for you is that the Lord God Almighty will meet your numerous needs according to his glorious riches in Christ Jesus. He, also in his infinite mercy will guide your footsteps to glory. (Amen).

ABSTRACT

This is a report, which presents the preliminary study, and the final methods used in the design and construction of an F.M (frequency modulated) transmitter.

The aim of this project is to aid in eradicating or reducing ignorance to it minimum and tolerable level in the society through communication.

The report begins with a general introduction, which feature a brief historical background and a study of previous works in his field. This is followed by an insight in various electronic and fewer electrical components used in the construction of the circuit and their specific functions are made clear. The principle of operation of the system constructed and its uses were also discussed.

Any other suggestion and improvement in this work will be highly appreciated and welcomed.

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CHAPTER ONE

INTRODUCTION

Ignorance is one of the major problems of mankind and more prominent way of eradicating it to an acceptable and tolerable level is by communication, this is the act of transferring information from the source to a target or destination. The means/scheme by which this information is conveyed from its source, processed and delivered almost in the form it was to the destination some distance away is called the communication system. Below is a schematic block diagram of a communication system.

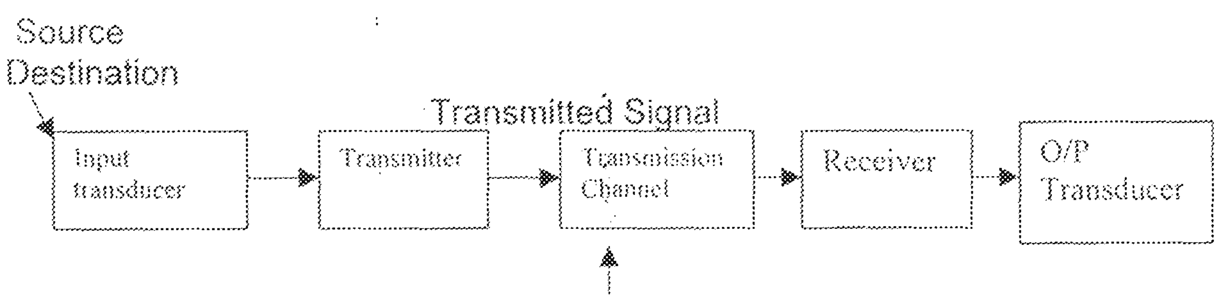


Fig. 1.0 Noise, Interference and Distortion

A schematic diagram of a communications system.

This project is based on the design and construction of a frequency-modulated transmitter with a well designed and constructed radio receiver.

Transmitter –this processes the input signal to produce the transmitted signal suitable for transmission through the transmission channel. The act of processing the input signal (message signal) by varying any of the parameters of the carrier wave (the parameters of the carrier wave are the amplitudes, frequency, and phase angle) is known as modulation. Varying the amplitude gives amplitude modulation (AM) and varying the frequency give modulation.

It is important and necessary to have a good idea of how radio waves are generated and transmitted wave, which is the main purpose of this project.

A radio wave is generated by a radio frequency oscillator, and radiated by an aerial or antenna. This radio wave or continuous wave called the carrier cannot convey any massage of intelligence of itself. It must be interrupted to form a code of some description (e.g Morse code); or some form of detectible signal most be impressed on the continuous wave. This is done by process or modulation.

There are two basic methods of modulation, amplitude modulation where the level (amplitude) of the carrier wave is varied in accordance to audio signal and frequency modulation, where the amplitude remains constant, but the frequency is wobbled over a small range in accordance with a radio signal.

It is the later that is being applied in this project (frequency modulation), in many ways a frequency modulated wave is one of the easiest to produce, but slightly more difficult to receive than an amplitude modulated wave.

The design of frequency-modulated transmitter can be subdivided in to (three) 3 major sections.

1. The audio input amplifier stage (class A)
2. The radio frequency oscillator (class A) and
3. The amplifier modulator stage (class C)

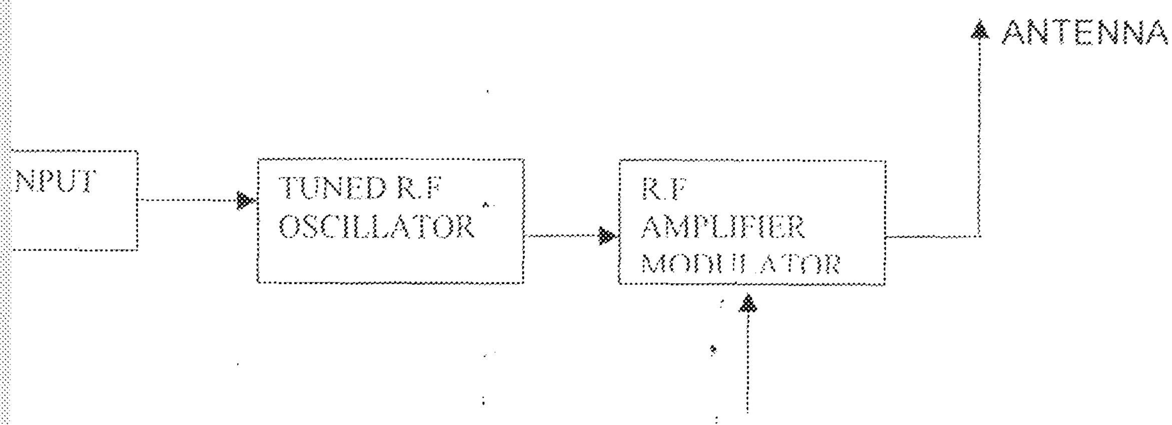


Fig. 1.1 A Block Diagram Of A Frequency Modulated Transmitter

The transistor TR_2, R_{B2}, R_{E2}, C_{13} and the tuned circuit C_{11}, C_{12} and L_1 acts as the radio frequency oscillator with a frequency of approximately 94MHZ. This frequency is variable over a small range by the trimmer capacitor, ct_1. Any variation in oscillation due to component tolerance e.t.c, can be accounted for and the frequency brought back in to the range of 88-108mh3, the range of FM receivers.

With no round input to the microphone, the oscillator just keeps on producing, an alternating voltage across the tuned circuit (while ever power is applied). A small amount of continuous wave. If we tap into the coil with an aerial of some sort, significantly more signals is radiated.

Since we are after transmitting sound (voice) to do this we use microphone, which produces a small voltage when it receives sound wave. This voltage, which is varying with input, is applied to the base of TR1 via C_5, while the voltage is small .It is enough to upset the balance of R_1 and R_2.

The signal is amplified by transistor TR_1, R_1, R_2, R_4, and R_3 which forms the first pre – amplification stage. The output is coupled to the input of the positive terminal, of the non-inverting op –amp (operational amplifier) JRC 4558 via capacitor C_6 which is the second stage of pre –amplification. The output is coupled further to the input of the negative terminal of the inverting op–amp operational amplifier) LM301 via capacitor C_8 which acts as the third pre –amplification stage and same time a low pass filter with capacitor C_{10} in parallel with R C_{F2} which only passes low frequency with cut off frequency of 2 .3KHZ .

The purpose of allowing low frequency only is in order not to distort the output of the operational amplifier which might be distorted by allowing high frequency above the cut off frequency of the op–amp.

The output voltage of this amplification stage though too small, is enough to cause the frequency of the oscillator to vary. The variation occurs as the voltage varies, and obviously if the voltage varies in sympathy with the sound input to the microphone. The frequency variation of the oscillator must contain the original sound patterns.

So the frequency variation produced by the oscillator are production of the sound received in other words the frequency is being modulated by the input voltage. Hence the name frequency modulation.

LITERATURE REVIEW

Radio is that means of communication that depends solely on the use of electromagnetic wave propagated through the space at the speed of light

In years ago men have tried to enhance communication by devising methods that are faster than carrying massage by foot or vehicle. The series of inventions that cumulated in radio system include drums, smoke signals, signal fires e.t.c used in many countries in both the old and new world.

THE HISTORY OF RADIO

The development of radio was a long process that included many steps and involved many peoples from various countries.

The existence of radio wave was predicted mathematically in 1864, long before they were actually discovered. An English man, James Clark Maxwell, made the prediction. In 1888 a German, Hein rich hertz, demonstrated that radio wave existed and that they travel through space. To honor hertz's discovery radio engines use his name in identifying frequency of radio waves.

Hertz's never communicated by radio. An English man, Ernest Rutherford (1871-1937), was the first person to succeed in sending radio signals. He sent the signal about 1,200 meters (3,900 feet) another English man Oliver lodge (1831- 1940), figured out the basic principle of tuner.

Guglicimo Macron, an Italian working in England, climbed further up the ladder and is considered the founder of radio communication. 1901 he succeed, on his first try, in sending and receiving massage

Across the Atlantic Ocean between England and Canada. Marconis radio really was a wireless telegraph, sending only dots and dashes. It could not transmit a spoken word. Radio program broad casting was made possible the development of the vacuum tube.

In 1904 the first vacuum tube was made john Ambrose Fleming(1849 – 1945), an England electrical engineer. This tube was a diode. In 1906 an American inventor, lee de forest (1873- 1961) added a third part to Fleming's vacuum tube. This new tube was called a triode or audio. I was much like vacuum tube used today. As time went on more and more we radio transmission were found, and ways in which to improve transmission were found, and ways in which to improve radio transmission were constantly developed. Today radio waves have been bounded off the moon. Radio communication with satellites and missile is being improved.

The information transmitted by radio is carried by an electromagnetic wave system called the "carrier wave". This carrier wave is varied in some fashion (modulation) by the electrical signal from the transducer, which is now representing the massage to be transmitted.

After modulation, the modulated signal is fed to the transmitting antenna, which then takes the electromagnetic wave into the space.

At the receiving end, a very small portion of the transmitted signal is captured by another antenna this signal is fed to the radio receiver, which separates the required massage from the carrier. The massage is then translated from electronic form to sounds, pictures or other forms.

2.4 TRANSMITTERS

The main elements of a radio transmitter are an oscillator, frequency amplifier, a modulator, a direct current (dc) power supply, a transmission line, and an antenna.

A block diagram of an frequency modulated (F.M.) radio telephone transmitter, is shown below:

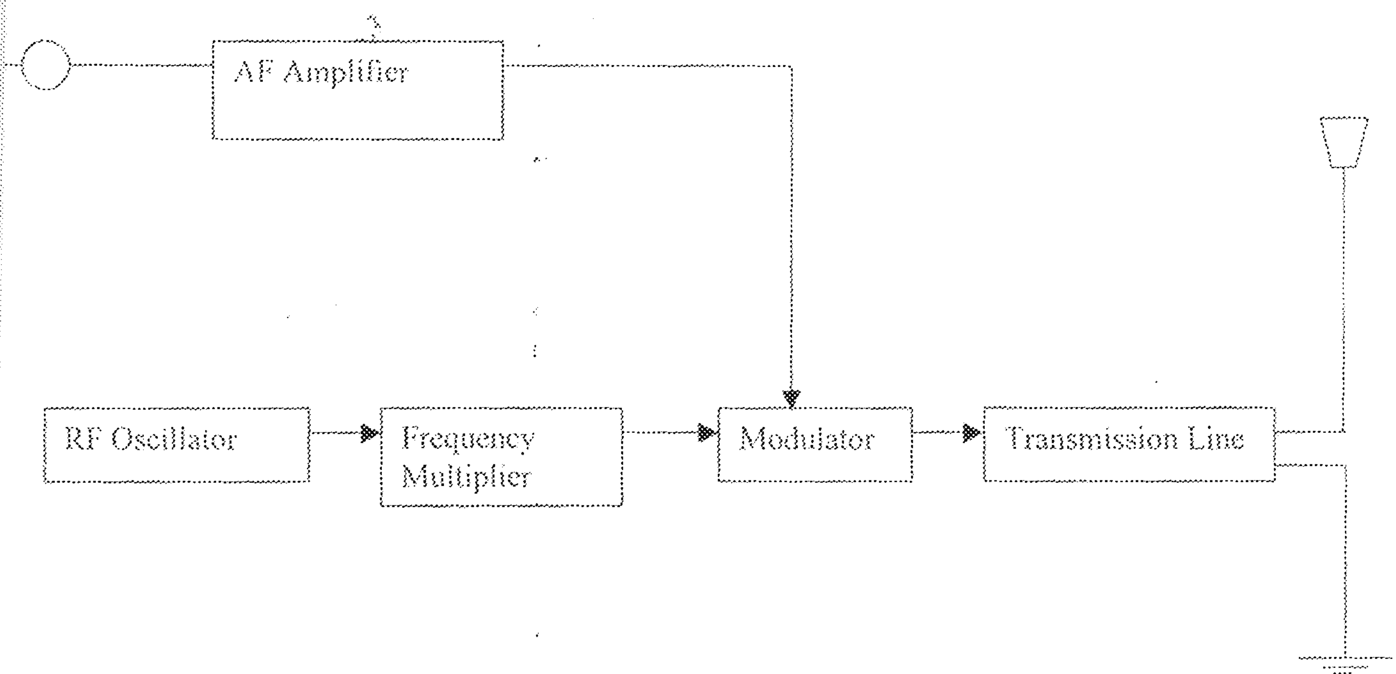


FIG 1.2 A BLOCK DIAGRAM REPRESENTATION OF FREQUENCY MODULATED (FM) TRANSMITTER.

CHAPTER TWO

2. AUDIO FREQUENCY AMPLIFIER STAGE

THEORY OF FIRST STAGE AMPLIFICATION

2.1 ONE STAGE RC (RESISTANCE-CAPACITANCE COUPLED AMPLIFIER CIRCUIT.

The audio frequency amplifiers used consists of three-(3) stage amplifier circuit.

The first stage is a one-stage resistance-capacitance (RC) coupled amplifier. It is also a class A amplifier.

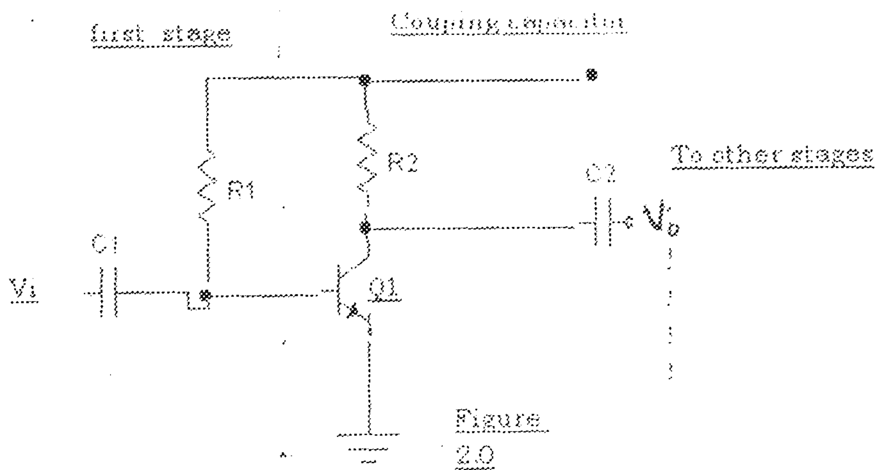


Fig 2.0 A Single Stage Rc Coupled Amplifier

The figure2.0 above shows a stage RC coupled amplifiers, which consist of single stage transistor amplifier using common emitter (CE) configuration. The coupling network

Consist of R_1 and capacitor C_2. Capacitor C_2 is the connecting link between the out put of the first stage, which is the transistor amplifier and the second stage which is the JRC 4558 operational amplifier. R_2 is the collector load of transistor Q_1.

C_1 couples the input signal while C_2 couples the out-put signal. R_1 provides the d.c bias.

The function of the Rc coupling network is in two fold. Firstly, to pass ac signal from one stage to the other and secondly to block the passage of d.c voltages from one stage to the next.

2.2 CIRCUIT OPERATION OF RC- COUPLED AMPLIFIER

2.3 The input signal Vi is amplifier by Q_1. The amplifier out put of the phase reversed and appears across R_2. The output of the first stage transistor amplifier is coupled to the input of the second stage which is an operational amplifier capacitor $C_1.C_2$ is some times referred to as blocking capacitor because, it blocks the passage of d.c voltage and currents. The out put signal v0 is the amplified replace 180 out of phase with Vi because of its phase inversion.

2.3 A.C EQUIVALENT CIRCUIT

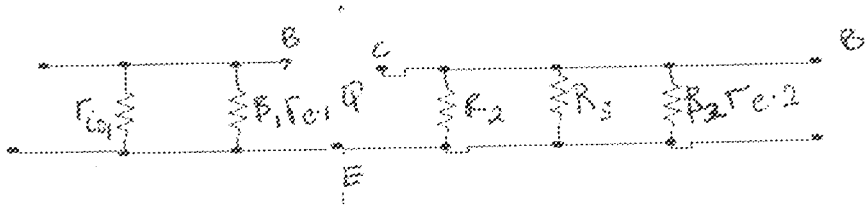


Fig. 2.1 An AC Equivalent Circuit.

The ac equivalent circuit is shown above.

In the figures $r_{i.1} = R_1 // \beta_1 r_{e.1}$.

This is the input impedance of the first stage and not r_{in} (base)

The output impedance of the first stage is $r_{01} = R_2 // r_{i.2}$

Where $r_{i.2} = R_3 \backslash\backslash \beta_2 r_{e.2} = \beta_2 r_{e.2}$

This is also because the input of the second stage forms a part of the output of the first stage.

$r_{e.1} = \frac{25mVolt}{I_{E.1}}$ and $r_{e.2} = \frac{25mVolt}{I_{E.2}}$

These are ac junction resistances of two stages but for one stage in which
we are conscience. The junction resistance is $\frac{25mVolt}{I_{E.1}}$

The voltage gain, A_v is given by

$A_v = A_{v1}$

$A_{v1} = \frac{\beta_1 r_{0.1}}{r_{i.1}}$

But $r_{i.1} = \beta_1 r_{e.1}$

$A_{v1} = \frac{\beta_1 r_{0.1}}{\beta_1 r_{e.1}} = \frac{r_{0.1}}{r_{e.1}}$

$A_{v1} = A_v = \frac{r_{0.1}}{r_{e.1}}$

2.4 ADVANTAGE OF RC COUPLING

Rc coupling requires no expensive or bulking components and no adjustments. Hence, it is small light and inexpensive.

The Rc coupling also have a light overall amplification item that of the other coupling. It has minimum possible non-linear distortion because it does not use any coil or transformers, which might pick up undesirable signals. Hence there are no magnetic fields to interfere with the signal

RC coupling has a very flat frequency versus gain curve that is it gives uniform voltage amplification over a wide range from a few hertz to a few megahertz because resistor values are independent of frequency changes. This is shown in the figures, below

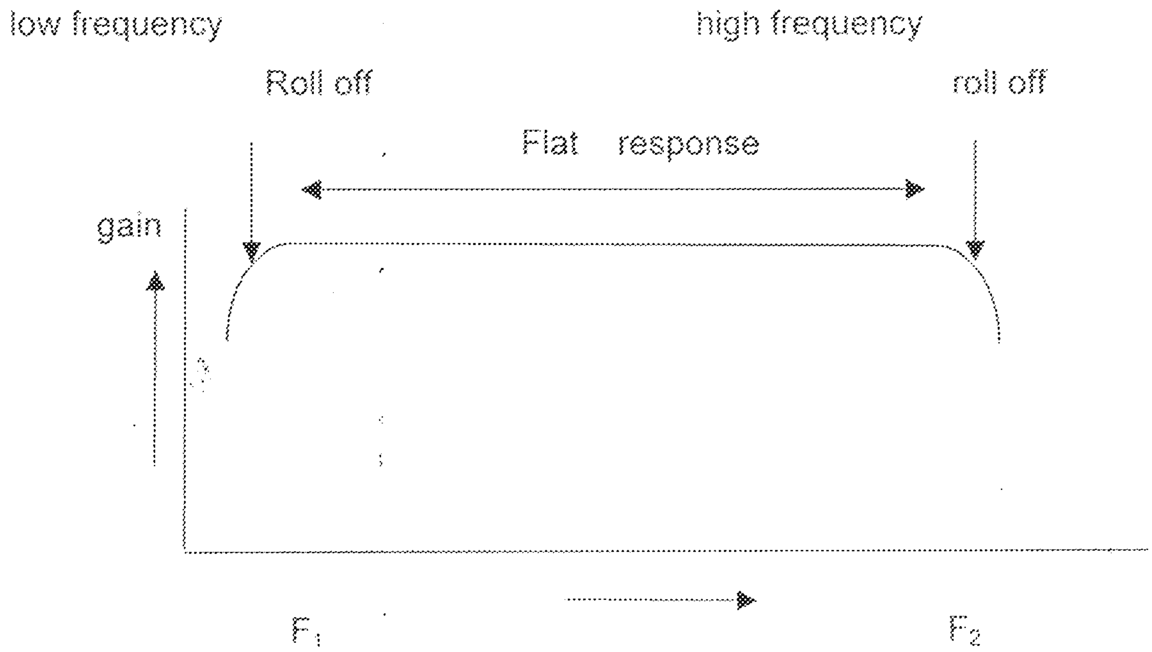


Fig 2.2 Frequency Response of the Amplifier

As seen in figure 2.2 above, the amplifier gain falls off at very low as well as very high frequencies is due to capacitive reactance of the first stage, input capacitance of the second stage and the stray capacitance.

2.5 THE AMPLIFIER BASED ON BASING CONDITION

This classification is based on the amount of transistor bias and multitude of the input signal. It takes into considerations the portion of the cycle for which the transistor conducts. The main classifications are.

Class–A Amplifier

(i) Class-B Amplifier

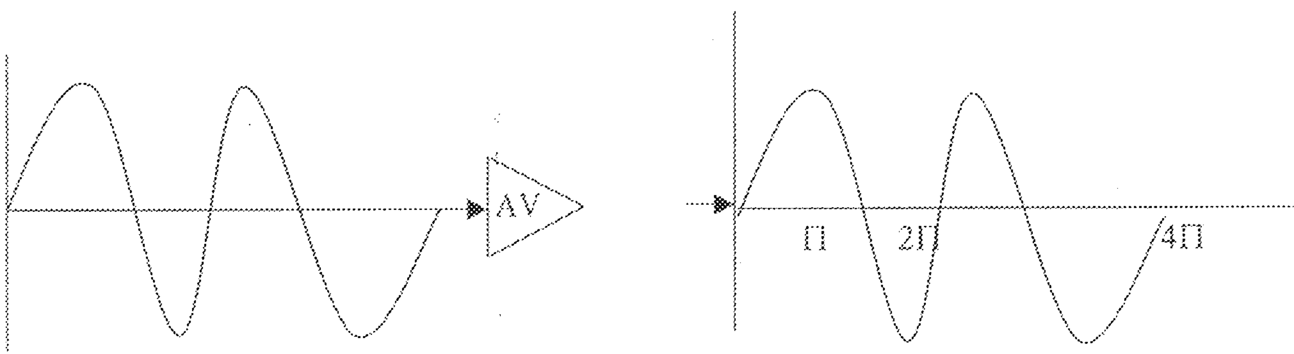
(ii) Class–C Amplifier

(iii) Class – AB Amplifier

The class of used in the first stage of amplification in this project is the class-A amplifier.

2.6 CLASS A AMPLIFIER

In this case, the transistor is so biased that the out-put current flows for the full-cycle of the input signal (360^0) as shown in the figure 2.3 below. In other words the transistor remains FR- biased through out the input cycle. Hence, its condition angle is 360^0



360° Conduction Class A

Fig 2.3

2.7 GRAPHIC REPRESENTION OF CLASS A AMPLIFIER

Since common- emitter is the most versatile and widely used configuration, we will used CE out put characteristic cures to differentiate between the main classes of amplifiers

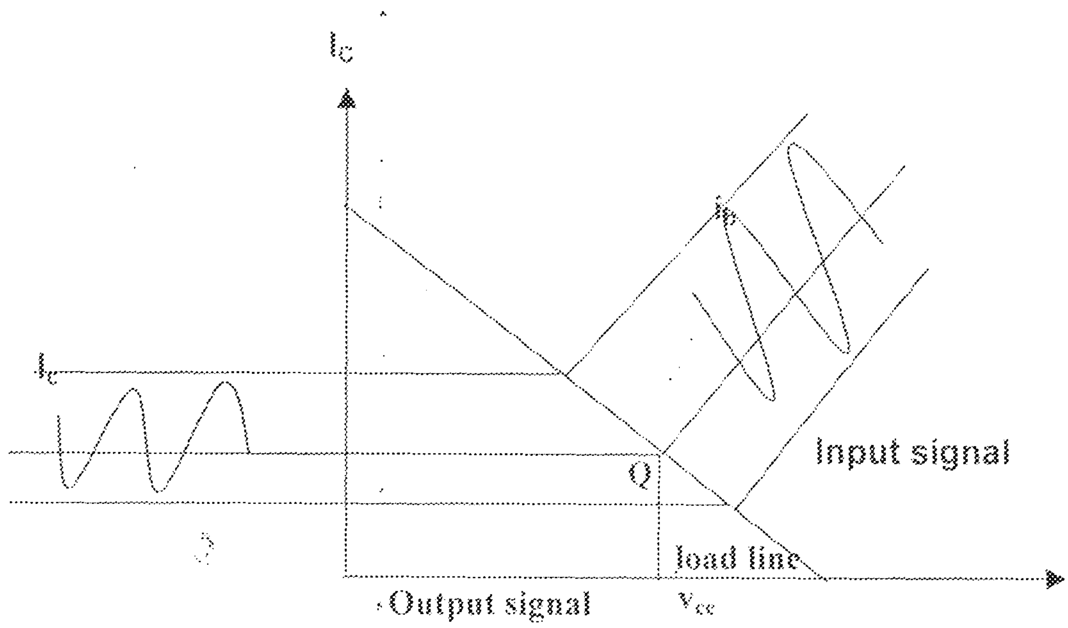


Fig 2.4 Biasing condition for a class A amplifier

The figure 2.4 above shows the biasing condition for class-A operation. It is seen that Q-point is located at the centre of the load line so that the out put (collector) current flows the complete cycle of the input signal (conduction angle of 360°). Because of centre Q-point the positive and negative shootings of the input signal are confronted to linear portions of the load line. In this linear region equal change in input base current produce equal changes in output (collector) current and voltage. Hence, hence output is an exact replace of the input. If the multitude of the input signal is so large as to drive the q- point closer to either cut- off or saturation region (where base current lines are not equally spaced.) the out put will not be an exact replace of the input, that is out put signal will be distorted.

2.8 **PRINCIPLE OF OPERATION OF THE FIRST STAGE AUDIO AMPLIFIER DESIGN (TRASISTOR AMP).**

It is the purpose of an electronic amplifier to accept very small signals at its input, amplifier them, and then use the resulting amplifier signal to perform some given function. For instance the input signal of an audio amplifier are obtained from the microphone, the pickup of a record player or the play back load of a tape recorder and when amplifier, are used to provide the current drive for a loud speaker. Such amplification requires amplification over a frequency of 30Hz to 20Hz with minimum amount of distortion. By corporation, amplifier for use in servo system and analogue computers are required to amplify down to zero frequency. In the specialist field medical electronic, amplified signals obtained from the brain, heart or nerves are used for display and recording purpose and, due to the very small signal available, amplifiers are required combine high gain with low noise.

The general approach to amplifier design is first to deal with the out put stage. Knowing the level of the signal required to drive it, to design the proceeding stage accordingly and this to work back from the output of the amplifier to the input. Amplifiers are coupled to previous stage by capacitors. So there is no problem about d.c level stage the stages in the design of amplifiers are as follows:

1. Select suitable transistor
2. Decide on a suitable value for the collector current in the absence of any signal. We call this the quiescent collector

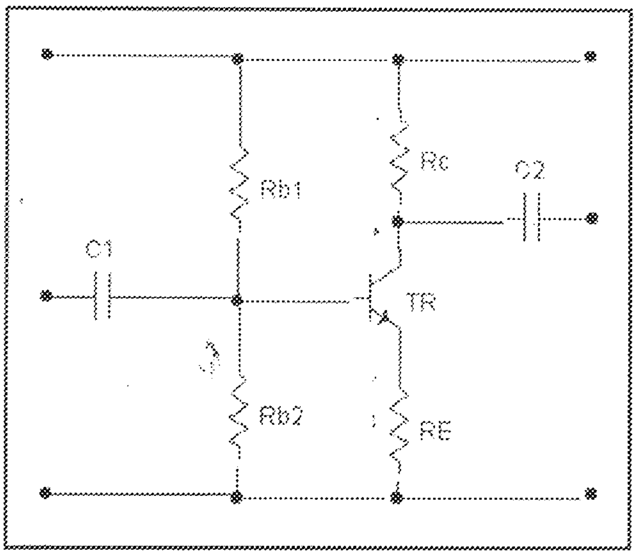
current. For low noise a value of IMA is often a good one to choose.

3. Select a value for collector resistance (R_c) so that V out has about half the value of Vii. This allows the signal to make V out swing freely in either direction without clipping the waveform.

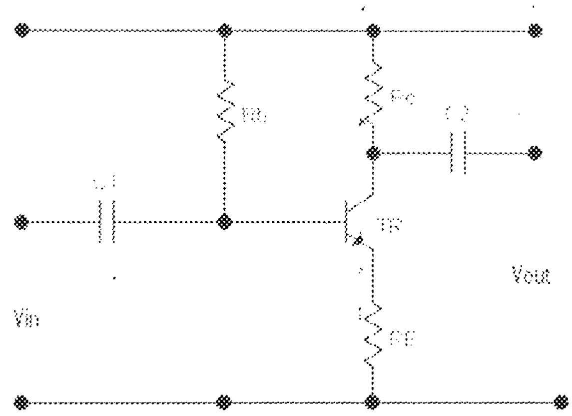
4. Choose value for R_B, and R_{B2} so that the quiescent value for I_B will produce the required value for I_c, given a typical value of life (F) for the transistor. Many pairs of values of R_B, & R_{B2} will produce the required potential, but there are two points to consider. If R_{B1} and R_{B2} are two high, the current flowing through them is small if this is of the same order as the vase current, the biasing potential is lower than calculated value. On the other hand, if R_{B1} and R_{B2} are too small in value the current is unnecessarily high and power is wasted. Also, the input impedances of the amplifier is low as a general rule, the current through R_{B1} and R_{B2} should be about 10 times the estimated I_B

5. Choose C_1 so that in combination with R_{B1} and R_{B2} it forms a high pass filter, which passes signals of all the required frequency. The same applies to the choice of C_2. If required emitter circuit. This is not bye-passed, so there feedback which limits the gain of the amplifier but gives stability. The transistor is biased by a voltage divider (R_{B1} \\ R_{B2}) diagram giving a stable voltage at the base. This is the most stable biasing method. If the amplifier is a simple one, the biasing resistor (R_B) will only be R_B positioned as in

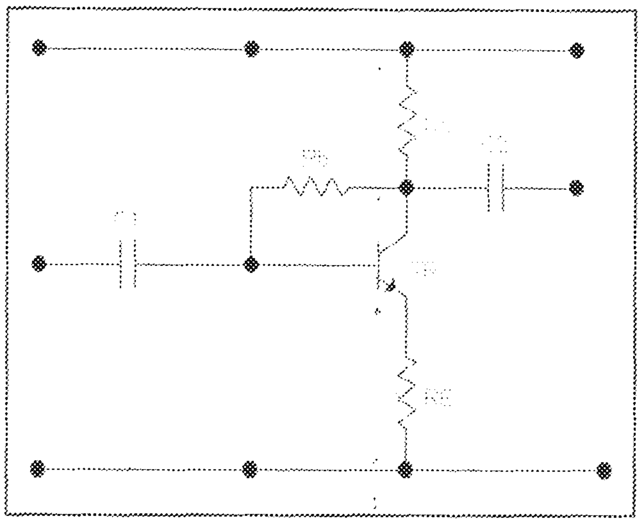
diagram (b) improved stabilization is obtained by using a resistor of half R_B value connected to the collector as in the diagram (c).



(A)



(B)



(C)

Fig. 2.5 Amplifier Biasing Methods

2.9 DESIGN CONSIDERATION

In an audio power amplifier there is a very real danger of thermal run away unless the biasing arrangement chosen is such as to prevent shift of d.c operating point. A class a audio power amplifier with common emitter common emitter configuration is used in this design, this will provide an acceptable degree of stability. The resistance Re is said to introduce negative feedback from the collector – emitter circuit into the base- emitter circuit. Good stabilization is accomplished by using large Re.

Re in conjunction with the base resistor R_B determines the value of the input voltage V_{BE} across R_E and reduces the base – emitter voltage. The base current is thus reduced, providing a large degree of compensation for the original case.

2.10 DESIGN STEPS AND CALCULATIONS

Making choice of transistor. Since the maximum theoretical efficiency obtainable is 50% the transistor with number BC 109 is chosen because of its low noise and high gain ability.

THE TRANSISTOR PARAMETERS

$V_{(O)CEO}$	25
F_T	150M
h_{FE}	348
I_{cMax} (A)	200m
C_{obomax} (F)	4.5p
I_{CBOmax} (A)	15n
P_{Dmax} (W)	600m
Toperma	175J
Package style	To 0-206AA

$V_{cc} = 12V$

$R_E = 100\Omega$

$R_C = 4.7K\Omega$

$$A_V = \frac{RC}{RE} = \frac{4.7K\Omega}{100\Omega}$$

$A_V = 47$

We also have that

$$A_V = \frac{V_R}{V_E}$$

$A_V = 47, \quad V_R = 6\text{volts}, V_E = ?$

$A_V V_E = V_R$

$$V_E = \frac{V_R}{A_V} = \frac{6}{47} = 0.128_V$$

$$I_C = \frac{(V_S - V_C)}{R_C}$$

$V_S = 12V, \; V_C = 6, \; R_C = 4.7K\,\Omega$

$$I_C = \frac{(12V - 6V)}{4.7K\,\Omega} = \frac{6V}{4.7K\,\Omega}$$

$I_C = 0.001277A \approx 1.28MA$

$I_B = \frac{I_C}{\beta} = H_{FE} = 348$

$I_B = \frac{1.28mA}{348} = 0.000003668$

$I_B = 3.7\mu A$

$I_2 = 10I_B \Rightarrow 10 \times 3.7\ \mu A$

$I_2 = 36.7\mu A$

$V_B = V_E + 0.7_V$

$V_B = 0.128 + 0.7$

$V_B = 0.828V.$

$R_2 = \frac{V_B}{I_2}$

$V_B = 0.828V,\ I_2 = 36.7\mu A$

$R_2 = \frac{0.828V}{36.7\mu A} = 22561.3\Omega$

$R_2 = 22.561K\ \Omega$

$R1 = \frac{V_S - V_B}{I_2 + I_B}$

$V_S = 12V,\ V_B = 0.828V,\ I_2 = 36.7\mu A,\ 3.7\mu A$

$R_1 = \frac{12 - 0.828}{36.7\mu A + 3.7\mu A}$

$R_1 = 276.645K\ \Omega$

$A_V = 47,\ V_{in} = 0.5mVolt$

$V_{out} = A_v V_{in}$

V_{out} = 47x0.5mVolt

V_{out} = 0.0235V

Vout now serves as the input signal to the next stage of amplification.

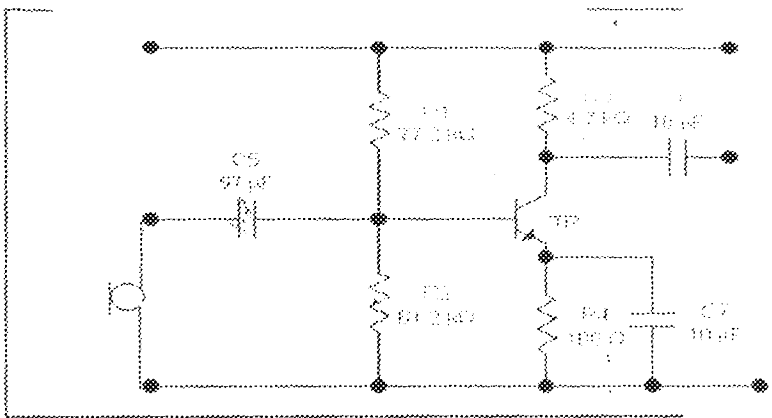


Figure 2.6 First Stage Audio Frequency Amplifier Circuit

CHAPTER THREE

The second and the third stages of audio frequency amplification are made up of operational amplifiers. The second is a non-inverting amplifier while the third stage is an inverting amplifier with a low pass filter.

3.1 GENERAL PRINCIPLE OF OPERATION OF AN OP-AMP

WHAT IS AN OP-AMP

It is a very high gain, high-r_{in} directly coupled negative feedback amplifier, which can amplifier signals having frequency ranging from 0Hz to a little beyond 1MHz. They are made with different internal configurations in ICs. An Op-amp is so named because it was originally designed to perform mathematical operations like summation, multiplication, differentiation and integration etc.

Typical uses of Op-amp are: - scale changing, analog computers operation, instrumentation and control system and a great variety of phase-shift and oscillation circuit.

Although an Op-amp is a complete amplifier, it is so designed that external component (resistors, capacitors etc.) can be connected to its terminals to change its external characteristics. Hence it is relatively easy to tailor this amplifier to fit a particular application and it is, in-fact, due to this versatility that Op-amps has become so popular in industry.

3.2 OP-AMP SYMBOLS AND CIRCUIT MODEL

The schematic symbol of an Op-amp denoting only the signal terminals is shown in the figure 3.0 below. The power supply connections are certainly required but are often omitted in circuit diagrams.

The circuit model of an ideal Op-amp is shown in the fig. 3.0(b) below.

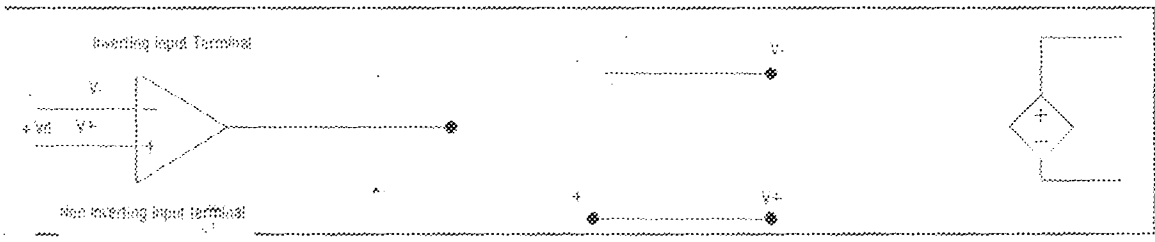


Fig 3.0

(a) Op-amp symbol and (b) Operation model of ideal Op-amp

All Op-amps have a minimum of five terminals

(1) Inverting input terminal

(2) Non-inverting input terminal

(3) Output terminal

(4) Positive bias supply terminal

(5) Negative bias supply terminal

3.3 POLARITY CONVENTIONS

In the figure 3.1(b) below the input terminals have been marked with minus (-) and Plus (+) signs. These are meant to indicate the inverting and non-inverting terminals only. It simply means that a signal applied at the negative input terminal will appear amplified but phase-inverted at the output terminals as shown in the figure 3.1(b) below similarly signal applied at positive terminal will appear amplified in phase at the output. Obviously this plus (+) and (-) minus indicates phase reversal only. It does positive voltages respectively.

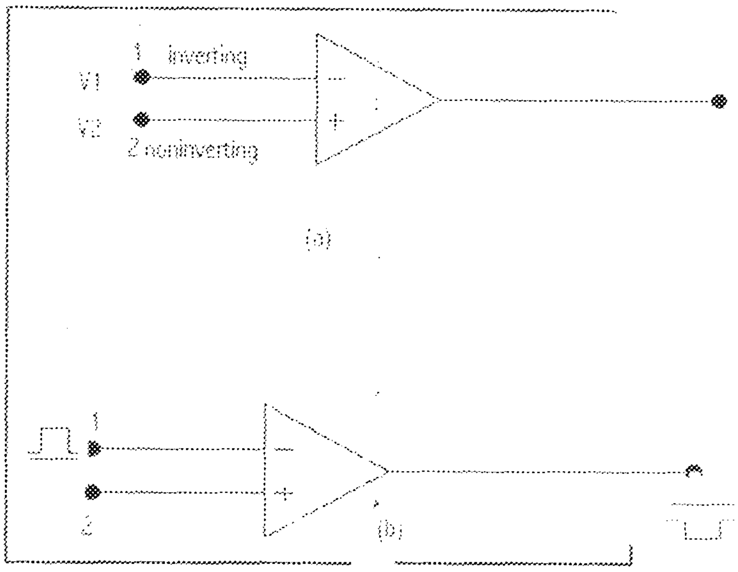


Fig. 3.1

3.4 IDEAL OPERAIONAL AMPLIFIER

When an Op-amp is operated without connecting any resistor or capacitor from its output to any one of its inputs (that is with feedback), it said to be 'in open-loop condition. The word open loop' means that the feed back part or loop is open. The specification of an Op-amp under such condition is called open loop specifications.

An ideal Op-amp has the following characteristics

(1) Its open loop gain A_v is infinite that is $A_v = -\infty$

(2) Its input resistance R_i (measured between inverting and non inverting terminal) is infinite that is $R_i = \infty$ ohm.

(3) Its output resistance (seen looking back into the output terminals) is zero that is $R_o = 0$ ohm

(4) It has infinite band width

3.5 VIRTUAL GROUND AND SUMMING POINT

In figure below is shown an operational amplifier, which employs negative feed back with the help of resistor R_f that feeds a portion of the output to the input.

Since input and feedback currents are algebraically added at point A, it is called the summing point.

The concept of virtual ground arises from the fact that input voltage r: at the inverting terminal of Op-amp is forced to a small value that, for all practical purposes, it may be assumed to be zero. Hence point A is essentially at ground voltage and his referred to as the virtual ground.

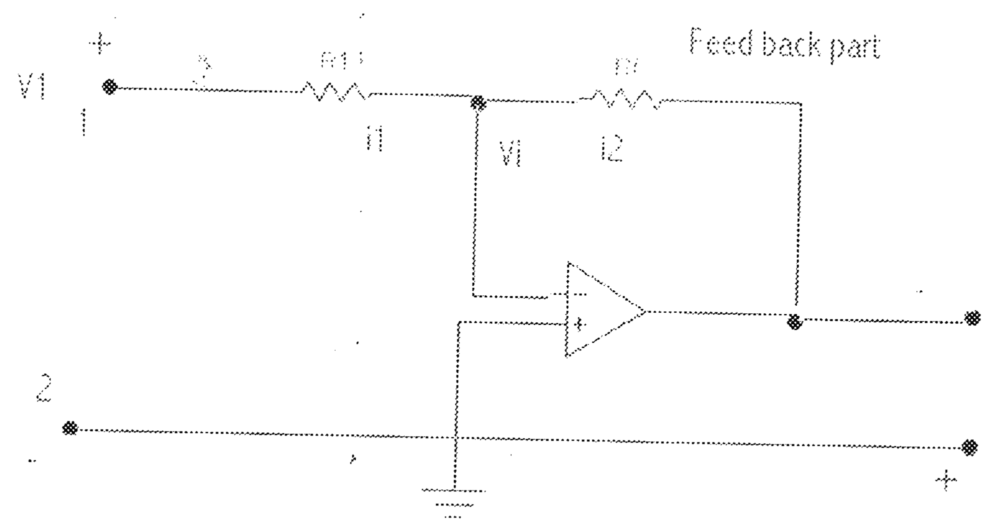


Fig. 3.2

Why V_i is Reduced To Almost Zero?

When V_i is applied, point A attains some positive potential at the same time V_o is brought in existence. Due to negative feedback to point A some fraction of the output voltage is feedback to point A anti-phase with voltage already existing thee (due to V_1)

The algebraic sum of the two Voltage is almost zero so that $V_i \approx 0$. Obviously, Vi will become exactly zero when negative feedback at A is exactly equal to the positive voltage produced by V_1 at A.

3.6 NON-INVERTING AMPLIFIER THEORY

This circuit used when there is need for an output, which is equal to the input, multiplied by a positive constant such a positive scalar circuit which uses negative feedback but provides an output that equals the input multiplied by a positive constant as shown in the figure 3.3 below. It is a form of a voltage controlled voltage source.

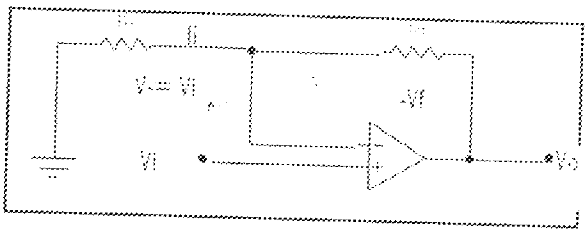


Fig. 3.3

The input signal is applied directly to the non-inverting input. Assuming stable linear operation, the deferential input voltage is forced to be zero, and thus,

$$V^- = V^+ = V_i$$

This voltage appear across the resistance Ri, so the current ii is readily determined as:

$$i_i = \frac{V_i}{Ri}$$

Since no current flows into or out of the op-amp inverting terminal, the current must be flowing through the resistance Rf from the op-amp output. A voltage Vo appears across Rf and is

$$V_f = R_f i_i = \frac{R_f}{R_i} V_i$$

The voltage Vi with respect to ground, the voltage V_f, and the output voltage Vo constitute a close loop, and a Kirchhoff voltage law equation could be written if desired. Either by this formal approach or by a more intuitive approach, it can be readily deduced that:

$$V_o = V_i + V_f = V_i + \frac{R_f}{R_i} V_i = (1 + \frac{Rf}{R_i}) Vi$$

This close loop voltage gain A_{CL} is then given by:

$$A_{CL} = \frac{V_o}{V_i} = 1 + \frac{R_f}{R_i} = \frac{Ri + R_f}{R_i}$$

3.7 SECOND STAGE AMPLIFICATION DESIGN CALCULATIONS

We have that $A_{CL} = \frac{Vo}{V_i}$

$A_{CL} =?$, $V_{in} =$ 0.0235V

This is the output voltage of the transistor amplifier first stage amplification.

$$V_{out} = (1 + \frac{R_f}{R_i}) V_i$$

$$V_{out} = (1 + \frac{400}{47})\, 0.0235\ V$$

$$V_{out} = (1 + 8.5)\, 0.0235\ V$$

$$V_{out} = \underline{0.22325\ V}$$

$$A_{CL} = \frac{0.22325}{0..0235} = 9.5$$

$$I_i = \frac{V_i}{R_i} = \frac{0.0235V}{47K\Omega} = 0.5\mu A$$

V_f = the amount of voltage fed back into the input

$$V_f = R_f \frac{V_i}{R_i} = 400K\Omega \times 0.5\mu A$$

$V_f = 0.2V$

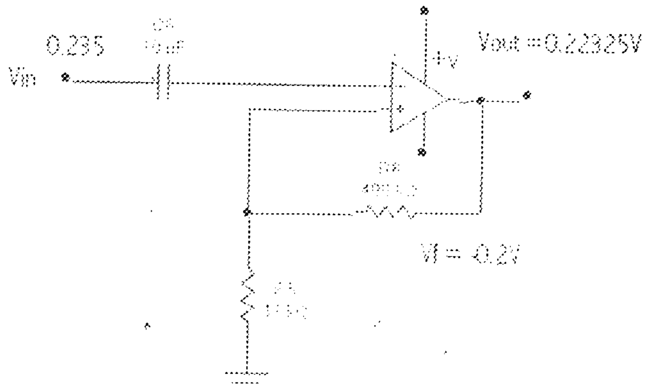


Fig. 3.4 Second Stage audio frequency amplifier circuit.

THE THIRD STAGE OF AUDIO AMPLIFICATION

3.8 GENERAL INIVERTING GAIN CIRCUIT.

Circuits that are designed specifically to create frequency – dependent gain functions utilize reactive elements in addition to resistance. In theory both capacitors and inductors could be used. In practice, however, capacitors tends to be much more ideal in frequency range for which op-amp circuits are most often used.

In general virtually any realizable frequency-shaping function can theoretically be created with resistance, capacitance and op-amps. Occasionally, inductors are used in some special op-amps circuits, which are usable at high frequency.

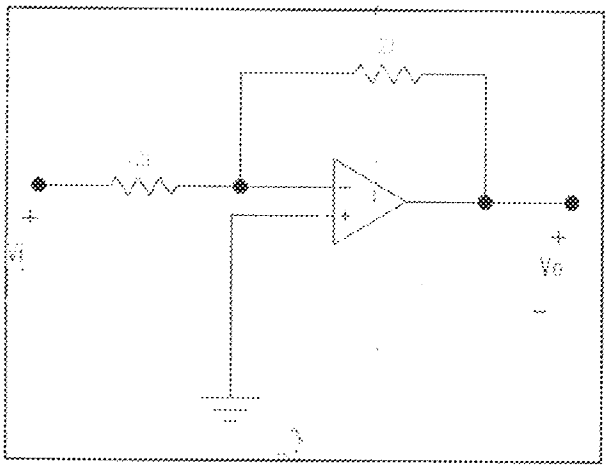
One form of an op-amp circuit widely used for certain frequency dependent operation is the INVERTING OP-AMPS. A schematic diagram is shown as below, in this case, the input and the feedback circuit are shown as blocks, which represent complex impedances. The steady-state impedance of the input block Z_i and the corresponding impedance of the feedback block is Z_f. Each of the blocks may contain just one element or each may contain a combination of two or more elements.

Since the blocks are impedance, it is necessary to use the transfer function concept to an algebraic relationship between the output and input. We have

$$H(jw) = \frac{V_o}{V_i} = -\frac{Z_f}{Z_i}$$

When $Z_f = R_f$, $Z_i = R_1$

This obviously reduces block to the inverting amplifier gain, in which case H(jμ) becomes A_{CL} the close gain



INVERTING OP-AMP CIRCUIT FORM WITH ARBITUARY IMPEDANCE

3.9 ac INTEGRATOR

This obviously reduces back to the inverting amplifier gain.

The inverting amplifier circuit used here is an ac integrator, where the resistance R_f is placed in parallel with the capacitor as shown in the figure below. The input resistance is now denoted as R_i. Since a capacitor is an Open circuit at de, the circuit reduces to a simple inserting amplifier with gain $-R_f/R_i$ at d.c

3.10 FREQUENCY RESPONSE OF AN ac INTEGRATOR

The ac integrator circuit is analyzed by the steady-state phasor approach. The circuit is first converted to steady-state form as shown in the figure 3.6(b) below. The feedback impedance is the parallel combination of Rf and i/jμc, which is

$$Z_f = Rf \,//\, \frac{I}{(i/jwc)} = \frac{R_f x(i/jwc)}{R_f(i/jwc} = \frac{R_f}{1+jwRfc}$$

The input impedance his simply given as

$Z_i = R_i$

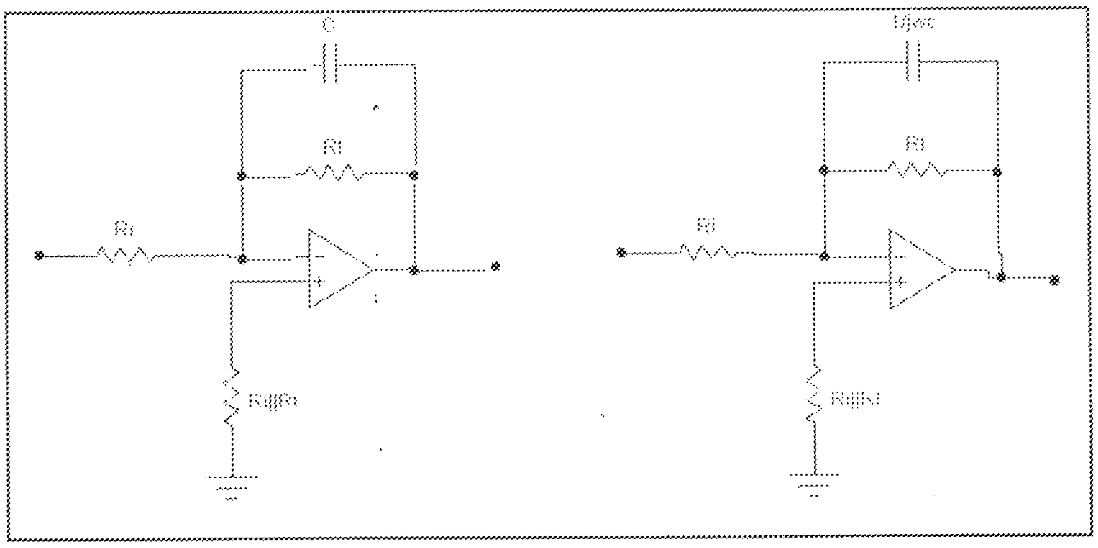


FIG.3.6 TRANSFER FUNCTION IS THEN

$$H(jw) = \frac{-R_f/R_i}{1+jwRfC} = \frac{-R_f/R_i}{1+jwRTf}$$

Where $T_f = R_{fc}$ is the time constant of the feedback circuit. The transfer function above is a one-pole low pass form.

3.1.1 DESIGN CALCULATION OF THE THIRD AUDIO FREQUENCY AMPLIFICATION STAGE.

We have that

$$Z_f = R_f // \frac{I}{jwc} = \frac{R_f \times (I/jwc)}{R_f + (I/j\mu c)} = \frac{R_f}{1+jwcRfC}$$

Where $R_f = 69.5k\Omega$

F = 2.29kHz

$C = I\mu f$

$$Z_f = \frac{69.5 \times 10^3}{1+j2\Pi \times 2.2.9 \times 10^3 \times 69.5 \times 10^3 \times 1\mu f}$$

$$Zf = \frac{69.5 \times 10^3}{1+j1000} \times \frac{1-j1000}{1-j1000}$$

$$Zf = \frac{69.5 \times 10^3 - j69.510^6}{10^6}$$

$$Zf = \underline{69.5 - j69.5}$$

$$Zf = \sqrt{0.0695)^2 + (-j69.5)^2}$$

$\sqrt{0.0048 + 48302.5}$

$Zf = 219.78$

$\tan \phi \ \frac{48302.5}{0.48} \qquad \phi = \tan^{-1} \frac{48302.5}{0.0048} = 89.99^\circ \approx 90^\circ$

$\underline{Zf} = 219.78 \angle 90^\circ \approx 250^\circ \angle 90^\circ$

$A^{CL} = \frac{V_o}{V_i} = \frac{Z_f}{Z_i} = \frac{250^\circ \ 190^\circ}{44} = 5.68 \angle 90^\circ$

$A^{CL}\ 2 \ 10 \angle 90^\circ \quad V\cdot = A^{CL \times Vi}$

$V_{\cdot 0} = 10x\ 0.5 = \underline{5V}$

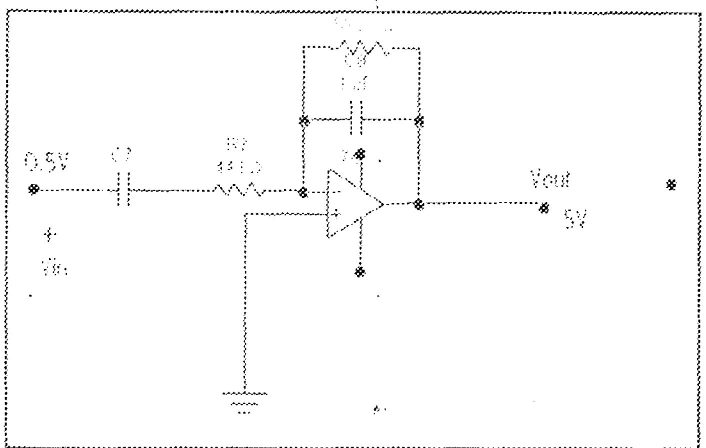


FIG. 3.7 THIRD STAGE AUDIO FREQUENCY AMPLIFIER CIRCUIT

CHAPTER FOUR

4.0 OSCILLATOR/MODULATOR CIRCUIT

4.1 INTRODUCTION:- An electronic Oscillator is a device which, obtain power from a d.c source and uses it in providing an alternating output without altering the circuit configuration by means of mechanical switching.

The electronic oscillators may be divided broadly into two groups as follows:

(i) Non-sinusoidal (or relaxation) oscillators – they produces an output, which has square, rectangular or saw-tooth waveform or is of pulse shape.

(ii) Sinusoidal (or harmonic) oscillators, which produces output having sine wave forms

4.2 PRINCIPLE OF OPERATION OF THE SCILLATOR/ MODULATOR CIRCUIT.

The heart of the harmonic oscillator is made up of capacitors and inductors in parallel. Electrical energy is always made available to the circuit to keep it oscillating at its natural frequency. It is the resonating action of this circuit that rise to the output of the oscillator.

The diagram of the resonant circuit can be seen in the figure below, the capacitor becomes charged and discharged repeatedly. The rate at which this happens depends on the capacitance and inductance of the two components.

The frequency at which the circuit repeats itself is the resonant frequency. If the capacitance is C and the inductance is L, the resonant frequency is given by

$$\frac{1}{2\Pi\sqrt{(CL)}}$$

To keep the circuit oscillating, there must be a steady supply of energy to the circuit. We must take care to supply the energy in the right way; hence clap oscillator arrangement is used in this project. Here the resonant circuit consist of V_c two fixed capacitor and an inductor L. the V_c (Variable capacitor). Which allows the circuit to be set to operate one of the ranges of different frequencies. As the circuit resonates, a positive feed back signal also passes to which is capacitatively coupled to amplifying transistor TR2. The emitter potential of TR2 is held constant by the biasing resistors R_9 and R_{10} together with the stabilizing action of C_3 and C_4 therefore the base emitter p.d alternates and this causes the base current to increased and decreases the collector current to oscillate too. The oscillation in the collector potential supply energy to the resonant circuit, thus keeping it oscillating. The output of this oscillation is a sine wave.

4.3 DESIGN CONSIDERATION

The main consideration in the design of clap oscillator is in the choices of transistor and the setting up of the resonance circuit. This is important because the required operating frequency must be in mind during the design.

4.4 MAKING CHOICE OF TRANSISTOR

The main consideration is the out-off frequency of the transistor. Commonly R.F transistors are used in fixed frequency oscillator up to 1.25 times the out-off frequency. While in variable frequency oscillators the limit is usually about 0.8 times the out-off frequency. Hence a transistor C809 that is RF/AF Oscillator amplifier with the following parameters is chosen for this project.

4.5 THE RESONANCE CIRCUIT

The resonance circuit is mad up of a fixed inductor, two fixed capacitors and a trimmer capacitor. The trimmer capacitor is arranged in parallel with inductor with the other fixed capacitor in series with the inductor to enhance frequency stability and eliminates the effect of transistor's parameters on the operation of the circuit.

$$f = \frac{1}{2\pi\sqrt{LC}}$$

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

If f and L are fixed at 94MHz and 15.82 UH respectively, then

$$C = \frac{1}{4\pi^2 F^2 l} = \frac{1}{4\pi^2 X\ 94x10^6 x\ 15.82x10^{-6}}$$

$$C = 1.8 \times 10^{-13} = 18PF$$

$$\approx 20PF$$

The resonance of the circuit is given by

$$X_{LC} = \frac{X_{L} x X_C}{X_{L} + X_c}$$

Where XL = 2ΠfL

$$X_L = 2\Pi\ X\ 94X10^6\ X\ 15.82X10^{-6}$$

$$X_L = 9343.6$$

$$X_C = \frac{1}{W_c} = \frac{1}{2\Pi fc}$$

$$X_C = \frac{1}{2\Pi\ X\ 94X10^6\ X20PF} = \frac{1}{0.0118}$$

$$X_C = 84.67$$

$$X_{LC} = \frac{9343.6\ X\ 84.67}{9343.6 + 84.67}$$

$$X_{LC} = 83.9 \approx 84$$

4.6 CALCULATION OF POWER TRANSMITTED

$R_E = \frac{V_E}{I_E}$

$R_E = 100\Omega$, I_E =? V = 6.0 Volt

$R_E I_E = V_E$

$I_E = \frac{V_E}{R_E} = \frac{6}{100} = 0.06V$

$V_E = V_B - 0.7$ Volt

$V_B = V_E + 0.7$ Volt = 6.0 + 0.7 Volt = 6.7 volt

$I_B = \underline{I_C}$

Where β = 300 and $I_C \approx I_E$

$I_B = \frac{60mV}{300} = 0.0002A = 0.2mA$

$R_{10} + R_{11} = \frac{Vcc}{I_B \times 10} = R_1 + R_2 = \frac{12}{0.002}$

$R_{10} + R_{11} = 6000 = 6k\Omega$

$\frac{R_{11}}{R_{11} + R_{10}} = \frac{6.7}{12}$

$12R_2 = 40200$

$R_{11} = \frac{40200}{12} = 3350\Omega = 3.350K\Omega$

$R_{10} + R_{11} = 6000\Omega$

$R_{10} = 6000 - 3350 = 2650\Omega = 2.650K\Omega$

To get the voltage gain (Av) of the circuit

$A_v = \frac{r_L}{r'_e}$

$r_L \approx X_{LC} \approx 84$

$r'e = \frac{25mV}{I_E}$

$r'e = \frac{25mV}{60mA}$

r'e = 0.4167

$Av = \frac{84}{0.4167}$

Av = 201.58 200

Ap = Output Power = Ai x Av

Ai = 300 Av = 200

Ap= 300 x 200 = 60.000w = 60kw

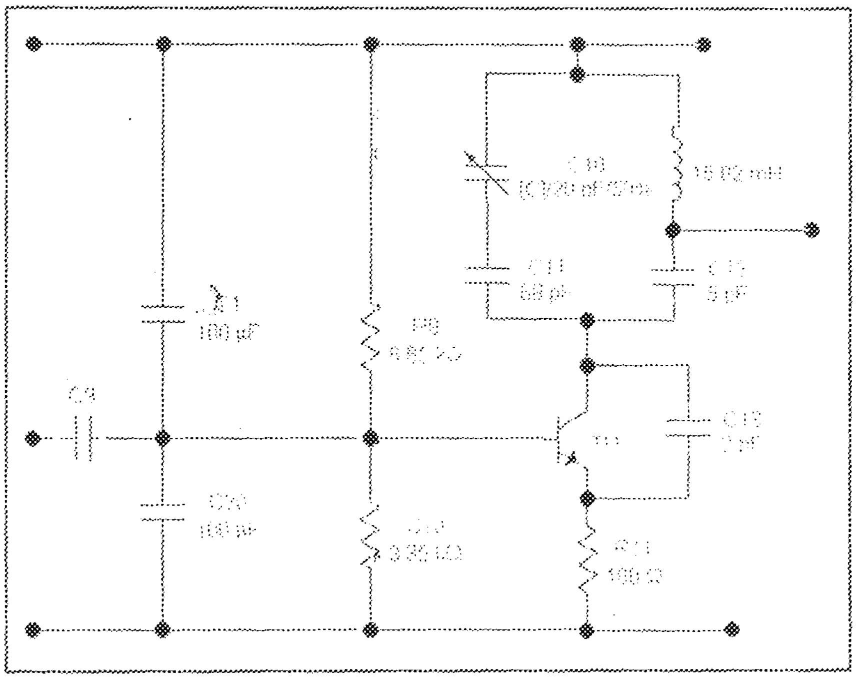


FIG. 4.0 OSCILLATOR/MODULATOR CIRCUIT

CHAPTER FIVE

5.0 AERIAL/ANTENNA

Antenna is the class of positive components of radio broad casting, communication, navigation, radio, television and other systems.

Antenna can be said to be an assemblage of conductors, di-electronics and ferrites, the main aim/objective of radiating electromagnetic wave into the space and also receiving them from the space. State of the art antennas also provide special filtration to signals, thereby assuming the required directional characteristics of radio system, or ensure the location and ranging of objects in radar applications, or the location of radiation sources.

The performance of the antenna is stated in terms of wide range of radio engineering, structural, services and economical parameters and characteristics. The design and required performance of an antenna depends on a substantial way on the frequency ban or band in which it his to operate. Antennas can be classified into long wave (OLF) medium-wave (or FM), short wave (or HF), VHF/UHF, SHF, and Optical wave. It can also be classified based on the manner in which the radiated field pattern is formed, listed below is four types.

(1) Small radiators ($<\leq\lambda$)

(2) Traveling wave antennas

(3) Antenna arrays

(4) Aperture-type antennas

In the course of this project, the small radiators ($<\leq\lambda$) is used which is Applicable for frequencies within the range of $10KH_3$ to IGH_3.

The class includes single diode and slot radiators, strip and micro-strip antennas; loop antennas and frequency – independent radiators.

5.1 ANTENNA DESIGN

Having obtained the frequency of transmission, which is 94MHz, the length of the antenna required for the appropriate transmission of the signal is given by the formula

$$\lambda = \frac{V}{F}$$

λ = wave length of the signal

F = frequency at which the signal is to be transmitted

V = velocity of sound in space = 3x108 m/s

$$\therefore \lambda = \frac{3x108m/s}{94MHz} = 3.2$$

For greater efficiency of the antenna, that is for the antenna to radiate greater fraction of power supplied, the length of the antenna should tend towards a quarter of the wavelength of the transmission frequency.

$$\frac{\lambda}{4} = \frac{3.2}{4} = 0.798 \approx 0.8$$

For satisfactory and more efficient operation of wireless communication appliances, a proper choice as well as good antenna location is necessary. Therefore the antenna should be placed at a reasonable height above the ground for better efficiency.

5.2 POWER SUPPLY UNIT

Electronic devices and circuits required a d.c source for their operation. Dry cells and batteries are a form of d.c source and they have the advantage of being portable and ripple-free. However, the voltages are low, they need frequent replacement and are expensive as compared to conventional d.c power supplies. The most convenient and economical source of power is the domestic ac supply. The process of converting ac voltage into dc voltage is called rectification. The block diagram of a typical dc power supply unit is shown below.

AC input

DC output

FIG. BLOCK DIAGRAM OF A POWER SUPPLY UNIT

A typical dc power supply consists of the stages shown above in the block diagram.

(1) TRANSFORMER: It steps down the ac supply voltage to suit the requirement of the electronic devices and circuit fed by the d.c supply. It also provides isolation from the supply line.

(2) RECTIFIER: it is a circuit, which uses one or more diodes to convert ac voltage into pulsating dc voltage.

(3) FILTER: This circuit element eliminates the fluctuations or pulsations (ripples) present in the output voltage supplied by the rectifier.

(4) VOLTAGE REGULATOR:- its main function his to keep the terminal voltage of the d.c supply constant even when ac input voltage to the transformer varies or when the load varies.,

There are three main types of rectifiers, they are as follows:

(1) Single-phase half wave rectifier

(2) Single-phase full-wave rectifier

(3) Full-wave bridge circuit.

In the course of this project, the FULL-WAVE BRIDGE CIRCUIT Rectifier is used.

This is the most frequently used circuit for electronic d.c power supplies. It requires four diodes, but the transformer is not centre-tapped and has a maximum voltage of Vsm.

The full-wave bridge rectifier comes in 3 varieties

(1) Four discrete diodes

(2) One devices inside a four-terminal case

(3) As part of an array of diodes in an IC

The circuit diagram and the waveforms of eh full-wave bridge rectifier are shown below.

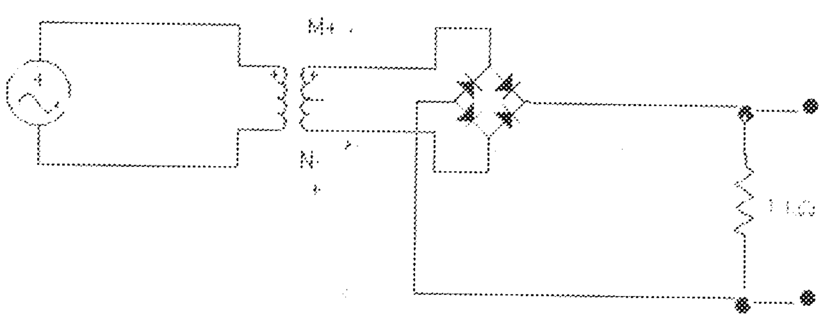
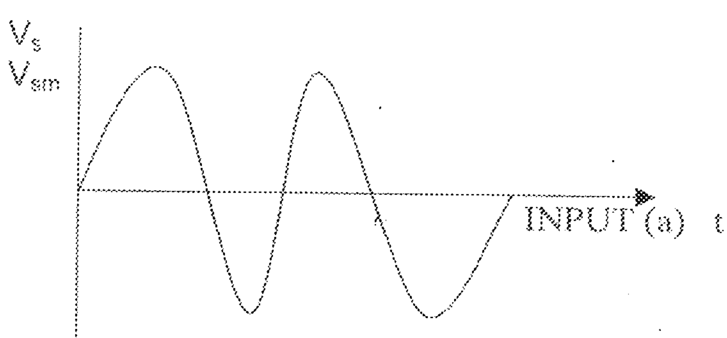
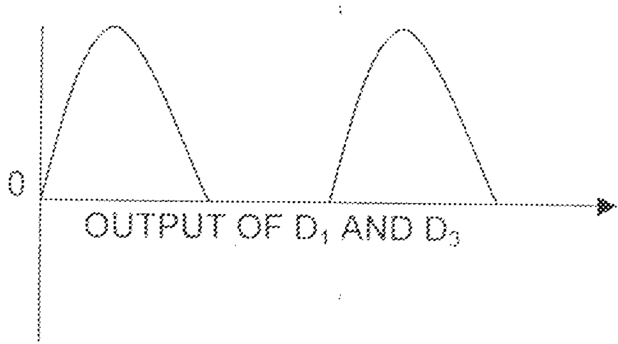
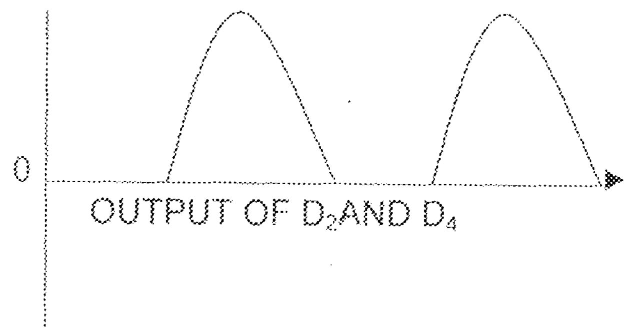
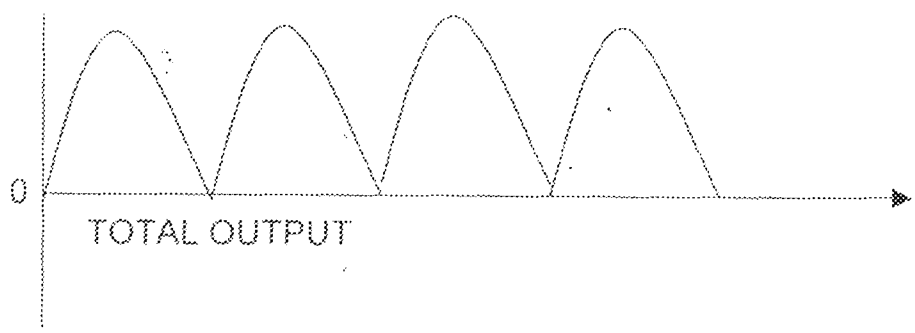


FIG. 5.1









5.3 HOW IT WORKS

During the input half-cycle, terminal M of the secondary is positive and N is negative as shown separately in the figure below (a). Diodes D_1 and D_3 becomes forward-biased (ON) whereas D_2 and D_4 are reversed-biased (OFF). Hence, current flows along MEABCFN producing a drop across R_2. during the negative input half-cycle, secondary terminal N becomes positive and M negative. Now, D_2 and D_4 are forward-biased. Circuit current flows along NFABCEM as shown the figure below (b). Hence, we find the current keeps flowing through load Resistance RL (in this project RL is the in tier circuit of the FM TRANSMITTER) in the same direction AB during both half circle of the input supply. Consequently, point A of the bridge rectifier always acts as an anode and point C as cathode. The output voltage across R_2 is as shown in the figure below (b) its frequency is twice that of the supply frequency.

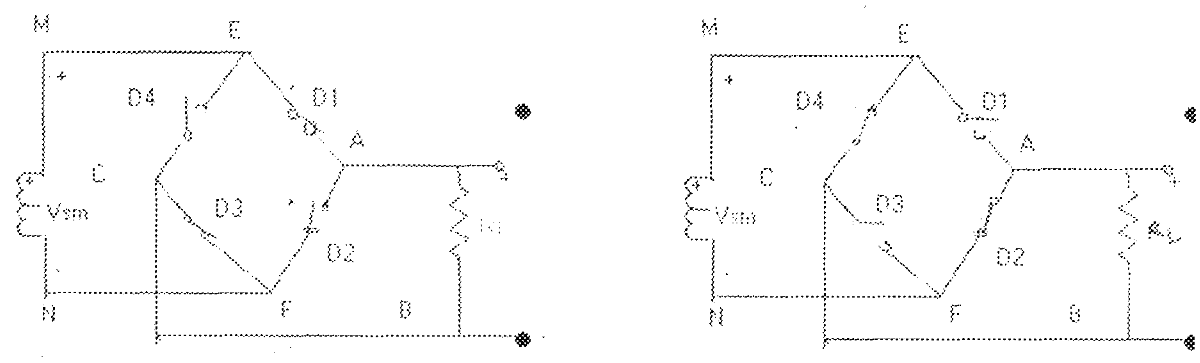


FIG. 5.3

In powering some electronic devices like the operational amplifiers, which needs both positive and negative voltage to be applied to the device's corresponding positive and negative terminals, as applicable in this project. Use is been made of a split transformer secondary, which a centre tap is been grounded and assists in obtaining the positive and negative voltages output from the full wave bridge rectifier which are taken to the positive and negative terminals of the Op-amps respectively. The capacitors C_1 and C_2 are used to remove the ripples present before taking the voltage regulator, which maintains and assures a steady 12V output, which is now used to power the circuit.

CHAPTER SIX

CONSTRUCTION:

Before construction of the FM transmitter, the circuit to be constructed is first designed based on the theories and principles of operation of each subsystem (circuit) and each component both active and passive in the circuit.

After the desige the components to designed in the circuit are purchased according to the calculated/designed values in the system circuit.

The components are mounted as shown carefully in the circuit diagram below. First the resistors and the capacitors are placed and soldered. The resistors are mounted/placed carefully to save space. Extra care is taken to ensure that the capacitors are placed in the right polarity.

Sure is been made that all components are neatly placed and properly dressed before soldering them`in.

The trimmer capacitor CT1 is soldered in place. Adequate care is been taken here to avoid any mistake as it has to be forced in.

Now the microphone is been connected and soldered in place, with the red lead to the positive tract, the white lead to the negative side of C1 and shield to the negative track.

The transistor TR1 (the BC 109) NPN and TR2 (C809) NPN. Noting that it is the right number first. The collector terminal of TR1 goes to R_3 while that of TR2 goes to the tank oscillating circuit. A heat sink clip as used when soldering to prevent damage to the transistors due to over heating.

The IC (OP amps JRC4558 and LM301) is now connected in place in the circuit.

For the first IC (JRC 4558) while will be used as the non-inverting amplifier, the input from the transistor amplifier is been lead in through the non-inverting input terminal (which his the number two terminal). The inverting input terminal is the number one terminal carries the feed back signal into the amplifier. This feedback signal is a part of the output signal. The terminal three which is the output terminal carries the output-amplified signal by the gain constant. The terminals 4 and 5 are the positive bias and negative bias supply terminals, which are connected accordingly to the power supply.

For the inverting Op amp the connection is almost similar except that non-inverting input terminal (two) is been grounded and the input signal is been taken on the inverting terminal (which is terminal number one).

The power supply is the connected soldered with hared (positive) lead going to the tve of the amplifiers and black (negative) lead going to the –ve of the amplifiers.

The regulator are now connected carefully and soldered. The circuit diagram is carefully followed for each connection made. Before connecting the power supply it was decked gain properly to make sure all the components are placed in the right position correctly oriented and soldered in properly. All excess leads were been clipped off carefully

6.1 TESTING

With no sound input to the microphone, the oscillator just keeps on producing an alternating voltage across the tuned circuit. As long as power been applied across the circuit.

After connecting the power supply, switching on the transmitter, a nearby FM (frequency modulated) receiver over its band, it was heard so very quiet in one (and possibly more) tuning positions. Talking into the microphone and voice was heard coming from the receiver.

Difficulties may arise receiving the voice, the receiver is returned and the trimmer capacitor CT1 adjusted, until the voice is heard again.

DISCUSSION OF RESULT

From the circuit analysis it can be observed that the following results were obtained from the designed of the FM Transmitter.

A voltage gain (A_v) for the first pre-amplification stage is 47 from

$$\frac{Rc}{RE} = \frac{4.7k\Omega}{150\Omega} = 47$$

Collector Current = 1.20MA

Base current = 3.7μA and the output voltage

$V_{out} = A_v V_{in} = 0.0234V$

For the Op-Amps in the second and third stage of amplifications.

- Closed loop voltage gain V_{CL} = 9.5 (for the 2nd amplifier)
- Feedback voltage = 0.2V

Closed loop voltage gain for the 3rd amplification

$= 10\backslash\underline{90^{\circ}}$

Output voltage = 5V

The power Transmitted is 10W from a gain of 60,000 of the modulating circuit, which could only be received from a distance of 200M radius from the transmitter.

CHAPTER SEVEN

7.0 CONCLUSION

The primary objective of this project was achieved which is to design and construction of an FM (FREQUENCY MODULATED) TRANSMITTER.

Although some challenging difficulties were encountered in the course of the research, design and construction, the experience gained is invaluable.

The frequency modulated transmitter (FM) was designed and constructed, which can receive massage (voice signal) through the microphone processed it in an FM mode and pass the transmitted signal through the transmission channel which can be received with a well designed FM receiver some fewer meter away from the transmitter.

The design procedure was carried out in such a way that after having the general design, the system was broken down into subsystems and each of the subsystems constructed separately. The advantage of this approach is to ensure that the problem of each subsystem is localized and can be easily solved.

Looking at the circuit it can be seen that there are some other better ways of biasing the transistors or even a completely different and more efficient design of some of the stages present. Nevertheless, with the engineering objective of making judicious use of what is available to obtain what is desired, the work presented is working within a reasonable degree of efficiency.

7.1 RECOMMENDATION

It is in deed very necessary and important that engineering students first-degree final project be a practically oriented one, however the problem of construction such as the time period and finance should not be over looked

The period of the project has been a strong factor affecting the performance of the students in project work.

As a student, and final student for that matter, with bulk of academic work lord and project work all on the student. There is the problem of limited time of research and study, which will affect the overall performance of the student in the project work.

So I recommend a larger and enough period of time for the project work.

There is also the problem of finance. Many students have due to finance deviated from areas where they have brighter ideas, some even due to inadequate finance could not use the best and the most appropriate equipment components for a particular work which in return will effect the over all performance of the system.

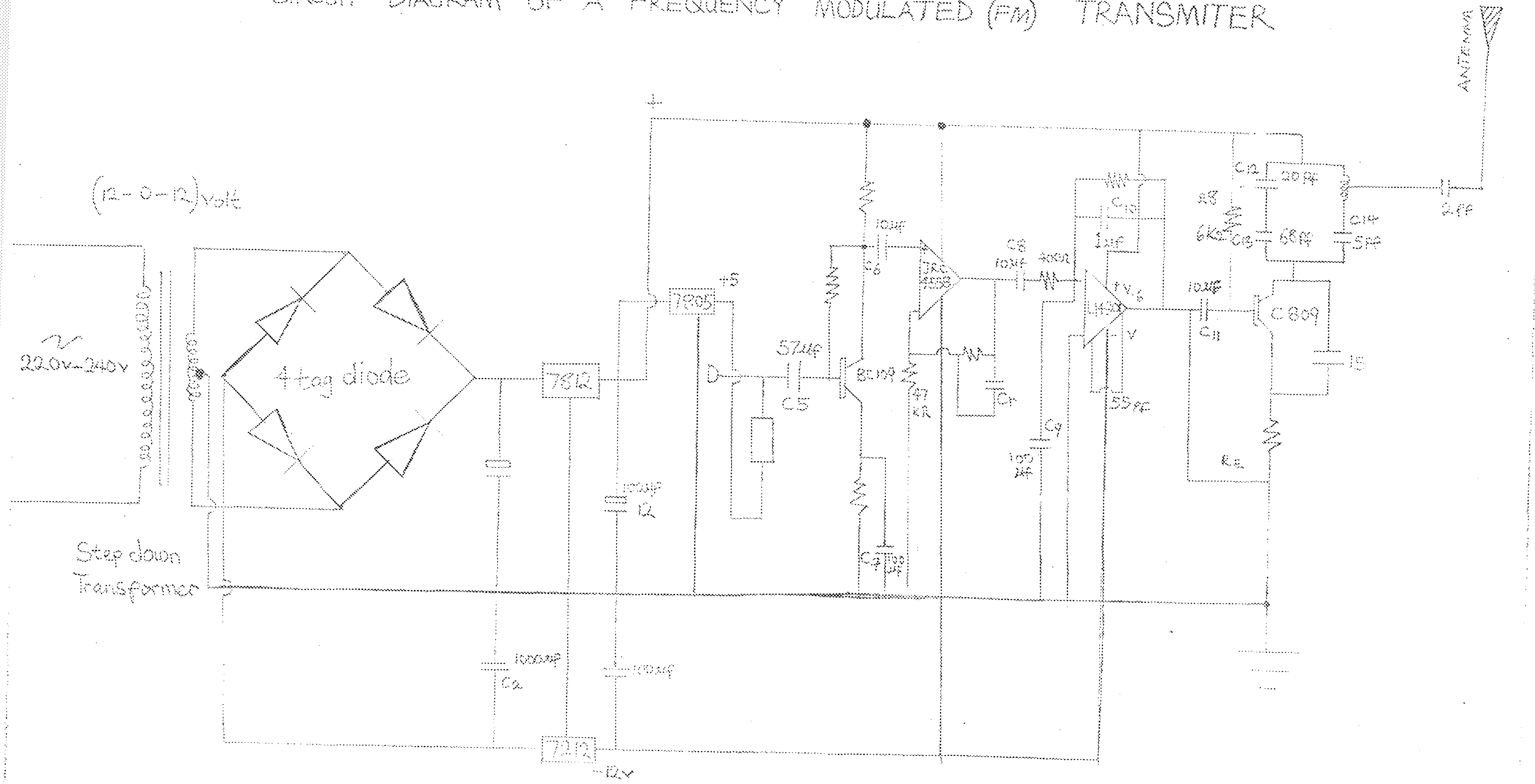
As a lasting solution to this problem I recommends that the school in conjunction with government should approve some amount of money as allowance to final year student carrying out project work.

There is also the problem of inadequate facilities and research centre. I also recommend the government and the school to provide adequate facilities and well equipped research centre at the reach of the students to enhance the performance of the student both. In project work and other academic work.

These had been the obstacles in my own case. I believe that if proper attention is given to these recommended solutions it will go a long way in improving the final year first degree engineering project.

FIG. 7.1

CIRCUIT DIAGRAM OF A FREQUENCY MODULATED (FM) TRANSMITER



LIST OF COMPONENTS USED

S/N	NAME OF COMPONENT	QUANTITY	RATING
1	Step down transformer	1	240/12V
2.	Diodes	4	1N4001
3.	Electroet Microphone	1	
4.	Transistors	1	C109NPN
5.	"	1	C809NPN
6.	Operational amplifier	1	JRC 4558
7.	"	1	LM 301
8.	Regulators	1	7812
9.	"	1	7912
10	"	1	7805
11	Resistors	2	100Ω
12.	"	1	4.7K Ω
13.	"	1	47k Ω
14	"	1	400k Ω
15	"	1	44k
16	"	1	69.5k Ω
17	"	1	6k Ω
18	Capacitors	2	1000μf
19	"	4	100μf
20	"	3	10μf
21	"	1	57μf
22	"	1	1μf
23	"	1	68Pf
24	"	1	5Pf
25	"	1	2Pf
26	Trimmer capacitor	1	6-20Pf
27	Hook up wire		
28	Mounting Board		

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