DESIGN AND CONSTRUCTION OF AN A.M TRANSMITTER(1W, 0.5- 1MHZ)

BY

JIMOH ISIAKA GBADEBO

REG NO :93/3969

A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE AWARD OF BACHELOR OF ENGINEERING IN ELECTICAL/COMPUTER DEPARTMENT.FEDERAL UNIVERSITY OF TECHINOLOGY,MINNA.NIGER STATE .NIGERIA.

DECEMBER 1998

CERTIFICATION

is project has been certified as meeting the partial requirements of the award of chelor of Engineering in electrical and computer Engineering ,School of Engineering d Engineering Technology,Federal University of Technology ,Minna.

ROJECT SUPERVISOR — DATE

EAD OF DEPARTMENT — DATE

STUDENT — 23/12/99 DATE

DEDICATION

THIS PROJECTIS DEDICATED TO MY NUCLEAR FAMILY.TITI(SPOUSE),AHMAD(SON),,AISHA(DAUGHTER)...

ACKNOWLEDGMENT

ish to express my profound gratitude to God almighty for seeing me through all the ing periods of the program.Special thanks to my supervisor and all the non-academic aff in the lab. for their support.All members of my family.I am indepted to the following ople for their inflinching support.Mr& Mrs Abdullahi.A.Jimoh, Mrs Aminu Osugboh odun A. Alani (Wonder Group of Companies, Minna Branch).

ABSTRACT

The aim of this project is to design and construct an AM transmitter within 5KHZ and 1MHZ of the output power of 1W.In this project a study of some of the components and stages of operation with their specific function are made clear. The principle of operation of the system constructed are also discussed.Suggestions and recommendations for improvement and maintenance of the project are highlighted.

Any other sugestions and recommendatios outside the ones suggested by the writer in order to improve this work are highly welcomed.

Any person going through this technical write up is believed to have a sound basic knowledge of analogue electronics.

LIST OF COMPONENTS USED AND THEIR SYMBOLS

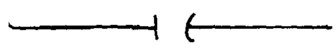
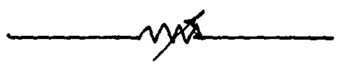
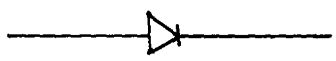
	COMPONENTS	*SYMBOLS*
1.	Capacitor	
2.	Resistor	
3.	Variable resistor	
4.	Inductor	
5.	Transistor	
6.	Diode(power)	

TABLE OF CONTENT

CHAPTER ONE

1.0.1 INTRODUCTION AND LITERATURE REVIEW

In any electrical communication system, the imformation to be transmitted is first of all transformed into an electrical time varyng quantity, e.g a current or voltage, which comprises the signal.In some cases the wave form of the signal is transmitted directly to the receiving point e.g telephone,in other case ,these signal is used to modulate the output of a high-friquency generator,so that some properties of the high frequency wave is altered in accordance with the signal.Transmission then take place by means of the modulated high frequency wave.Atthe receiving end the wave is subjected to a demodulating process,which enables the original modulating signal to be recovered.

The high frequency wave is spoken of as the carrier and after after modulation is refered to as amodulated carrier.

Modulation may at first sight seem an unnesecary complication in transmission system.Often,however,the modulation process is essential,when for example the transmission medium does not transmit the original frequency spectrum efficiently,if at all.In such a case itis clearly necessary that they occupy a frequency range acceptable to the transmission system.An illustration of this is provided by radio transmission,the efficiency of transmission is negligible at low frequency signals,such as speech.[2]

The separation of signals at receiving end then becomes a question of separating carriers.Modulation thus enables communication to be carried on at frequencies which differ from those of the original modulating signal.

1.0.2 WHAT IS MODULATION

Modulation is the process of translating a message into intelligence bearing signals so that the mnessage can be transmitted over an intervening medium.

Itis the process by which some properties of an rf signal is varied in accordance with the message to be transmitted.

OR

Modulation is the process by which the amplitude,frequency or phase of a carrier is modified in accordance with the characteristic of a signal.

1.0.3 IMPORTANCE OF MODULATION

(i) Translating the frequency of the intelligence bearing signal(message)to a frequency that is more suited fortransmission over the desired medium(free space,open wire line,coaxial cable etc).

(ii) Increasing the power of the intelligence frequncy signal so that the receiver circuitry can be simplified and cheaper.

(iii) changing the band-width(either increasing or decreasing)of the signal so as to obtain optimum balance between band-width and the signal-to-noise ratiocharacteristic system.

(iv) To maintain secrecy of transmission.

CHAPTER TWO

2.0 THEORY

2.0.1 AUDIO AMPLIFIER

The is any device where a small input signal is used to control alarger output power.It follows from this that an amplifier must consist of some active device,such as valve or a transistor;a source of power supply;and a load.The input signal is used to control the current that fllows through the active device.This current then develops a voltage change across the load resistor, so that the output poweris

$$P_O = V_O I_O \text{ watts}$$

The input power $P_i = V_i I_i$ watts

Power amplification,is given by the ratio of output to input power.

$$A_p = P_o/P_i$$

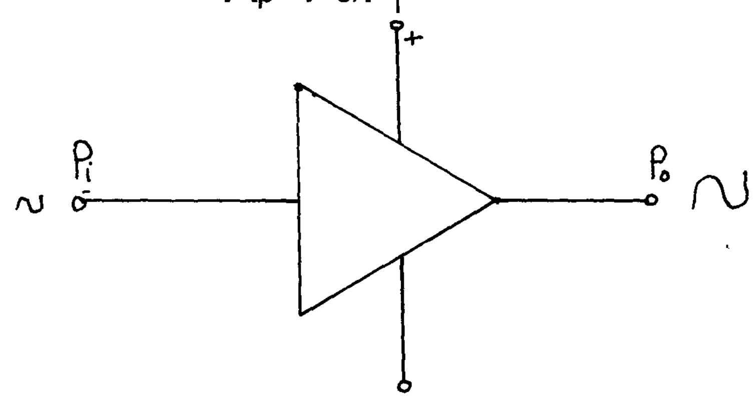


Fig. 2.1 The general symbol of an amp

2.0.2 TRANSISTOR

As an amplifing device, the transistor is required to amplify an input signal and then feed it into some load resistance R_L.Usually it will be desirable to isolate the load R_L from the d.c bias condition pertaining to the transistor.In particular,it is useful to be able to determine the operating point of the transistor independently of any load R_L that may be applied.Segregation of the d.c bias and a.c or signal load circuit is possible by a.c coupling[2].

The operating point may be deduce from the output characteristics using the load-line concept, consedring common-emitter amplifier stage below.

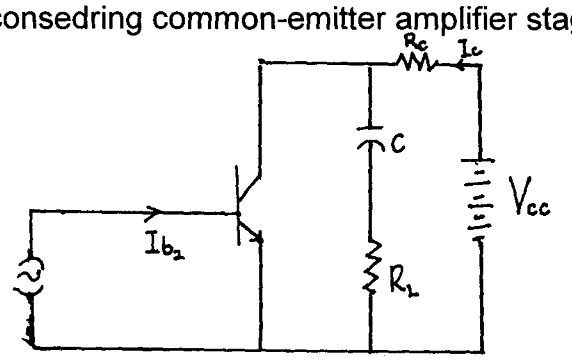


Fig 2.2 Single stage amplifier.

The quiscent collector current is given as

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

where

Ic =Collector current

Vcc=supply voltage

Vce=Collector-emitter voltage

Rc =collector resistance.

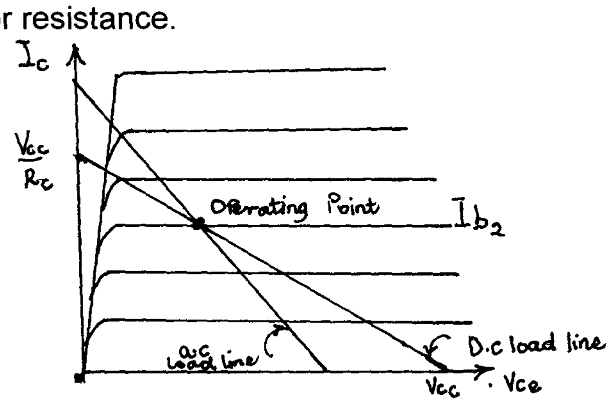


Fig 2.3 Load-line.

As shown from the load-line(d.c),the operating point is given by its intersection with the output characteristic corresponding to the base-current bias.Clearly an input signal causes the point (Ic,Vce)representing the instantaneous state of the output circuit to swing up and down the a.c load-line.Thus for any given variation of the input current I_b,the corresponding variation in Ic and Vce may be deduced from the load line.However,although in principle the load line method can be used to analyse the behaviour of an amplifier under small signal conditions,the equivalent-circuit approach is more convinient and is preferable whenever it is applicable.On the other hand to analyse the signal under a large-sgnal conditions recourse must be made to the static characteristics.An equivalent-circuitrepresentation with constant parameters is no longer possible owing to the inherent nonlinearities in the characteristics. [5]

Amplifiers can be classified into:-

(i) Audio frequency(AForLF)

(ii) Radio friquency(RF).tuned with narrow band-width

(iii) Wide band or Vedio amplifier

(iv) D.C amplifiers.

2.0.3 CLASSES OF OPERATION

(I) ***Class A:-***The active device(the transistor ro valve)isbiased so that a mean current flows all the time.This current is either increased or decreased about this mean value by theinput signal.This is the most commonly used class,typical example being small signal amplipiers.

(II) ***Class B***:-The active device is biased just to cut-off and is switched into conduction by one half-cycle of the input signal.This class of operation is widely used in push-pull power output amplifiers.

(III) ***Class C***:-The active device is biased beyond the point of cut-off sothe input signal must exceed a relatively high values before the device can be made to conduct.This classis used in pause switching and transmitter circuits.

2.1 OSCILLATOR

An oscillator is any device or circuit that produce an output which varies its amplitude with time.Theoutput may be sinusoidal,square,pulse,triangularor sawtooth.

Oscillator can be constructed using component that exhibit a negative resistance characteristic such as the unijunction transistor and the tunnel diode.

For positive feed back

$$Ac = \frac{Ao}{1 - \beta A_O}$$

so,if the loop gain BAo approaches unity

$$Ac = \frac{Ao}{0} \rightarrow \infty$$

The requirment for a circuit to produce oscillations are:-

(a) Amplification

(b) A positive feed back loop

(c) Some network to control the frequency

(d) A source of power supply.

Typical circuit are combinations of L and C, OR R and C.

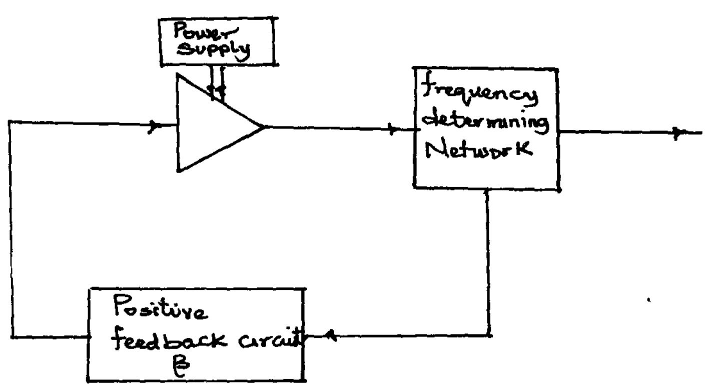


Fig. 2.4 Block diagram of a typical oscillator

For a tuned collector oscillator,circuit used in generating sine wave oscillating at frequencies from few kilohertz up to1MHZ.The amplification is provided by the transistor which is connected in common emitter mode.Bias components R_1,R_2 and R_3 causes the transistor to conduct,which then force the parallel tuned circuit to L_1C_1 into oscillation.This two component determines the operating frequency,which is given by the formula

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

These is because,at resonance frequency,the capacitive reactance is equal tothe inductive reactance. [6]

2.2 MODULATOR

Many application exist in mobile equipment for amplitude modulators with output powers from milliwatts to tens of watts.Transistor circuits are used almost exclusively for this circuits.Carrier frequency above 1GHz can be used in the lower -power transistor circuits.The most common method of amplitude modulation usedare class C collector -modulated stages with the rf applied in the common emitter or common-base configuration.Common -emitter provides the maximum power gain and excellent efficiency.common-base stages are used to increase the upward modulation capabilities,where the maximum modulation indices are important.Increase linearity can be achieved at the expense of efficiency by biasing the amplifier class be so that a nominal collector current flows under no modulation conditions.

2.2.2 POWER RELATIONSHIP

Unmodulated carrier rms level = E_o

Maximum rms output = $E_o(1+m)$, where m is the modulation index which can vary from zero to unity for symmetrical modulation.

Minimum rms output = $E_o(1-m)$

unmodulated power in to the load $R = P_o = E^2o/R$

The peak power into the load is

$$P_{max} = [E_o(1+m)]^2/R$$

The minimum is

$$P_{min} = [Eo(1-m)]^2/R$$

The average power in to the load for sinusoidal modulation is

$$P_{av} =(1+m^2/2) = (E^2_o/R)(1+m^2/2)$$

The unmodulated output power E^2_o/R is supplied by the class C amplifier,and the sideband energy

$$(E^2_o/R)(m^2/2)$$

is supplied by the class C amplifier.

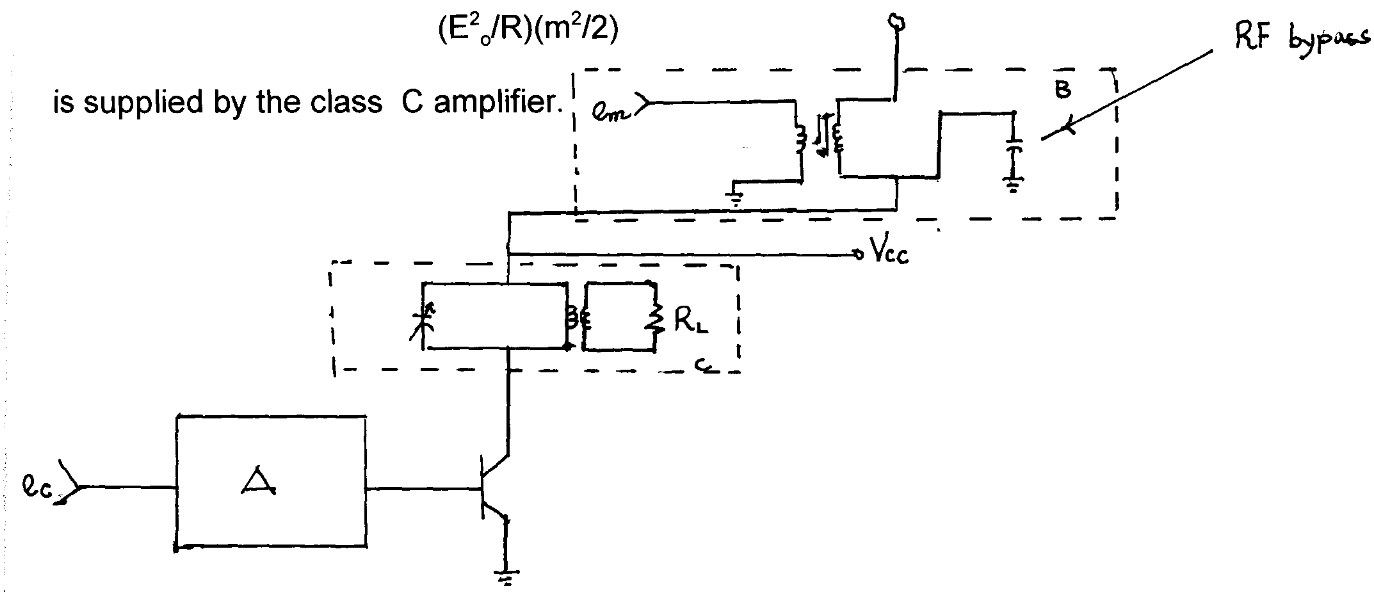


Fig. 2.5 collector-modulated transistor

A = input impedance matching network

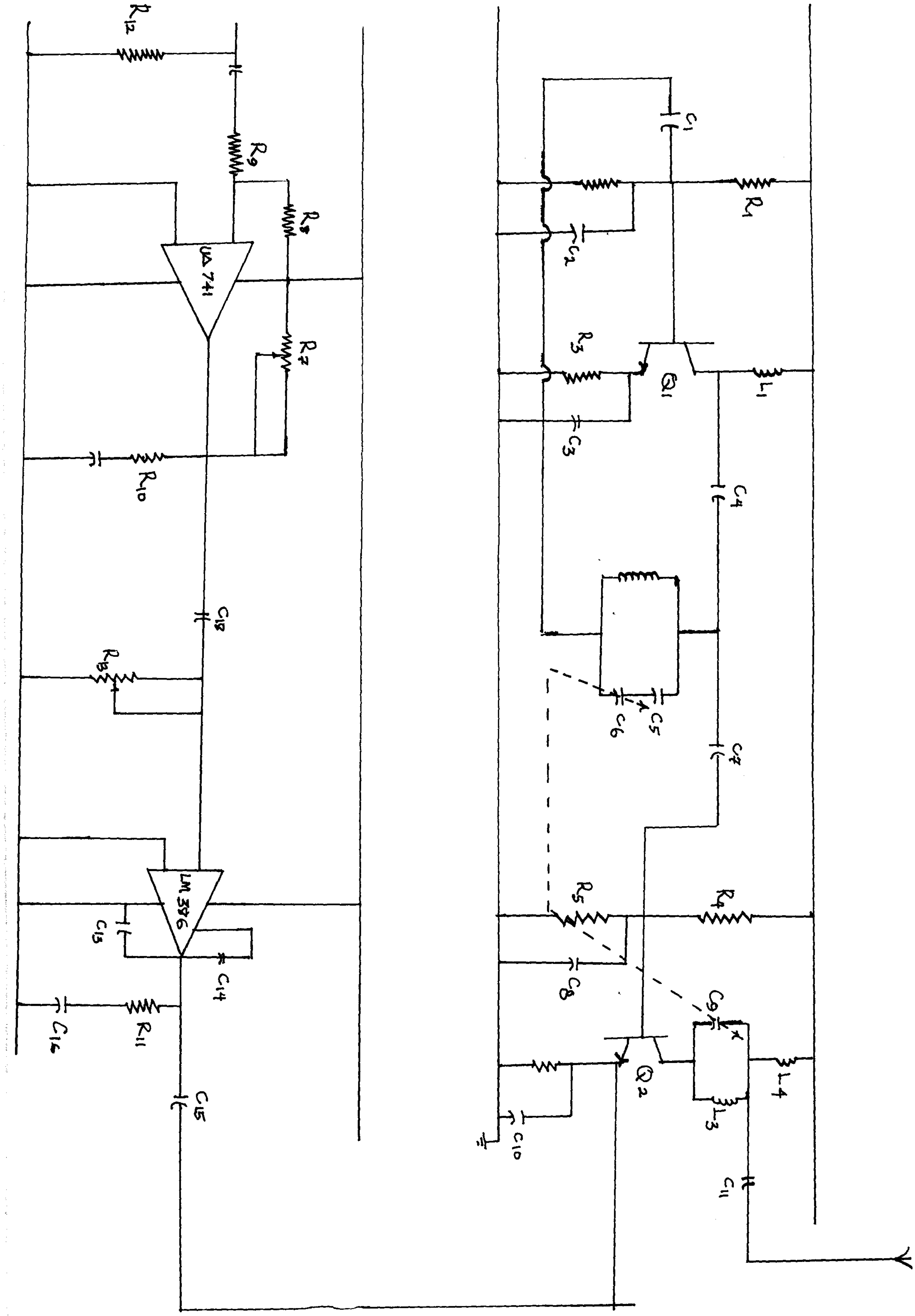
B = modulator circuit for producing Vcc which follows the modulating signal,em,and provide a low source impedance at fc.

C = frequency selecting network, $f_c \pm f_m$,and output impedance matching network.

2.2.3 HIGH-POWER LINEAR MODULATORS:

High-power linear modulators, 50W and up,are generaly constructed using class C plate-modulation vacuum-tube circuits.Some intermidiate power and frequency applications use paralleled transistor configurations with class C collector modulation.

Triodes,tetroides,pentodes are used in the vacuum-tube circuits. [3]


R12
R9
R8
UA 741
R7
R10
C18
R13
LM 386
C13
C14
C16
R11
C15
C1
R1
C2
R3
Q1
L1
C3
C4
C5
C6
C7
R5
R4
C8
C9
Q2
L4
L3
C10
C11

CHAPTER THREE

3.0.1 DESIGN AND CONSTRUCTION

3.0.2 LOW POWER FREQUENCY AMP.

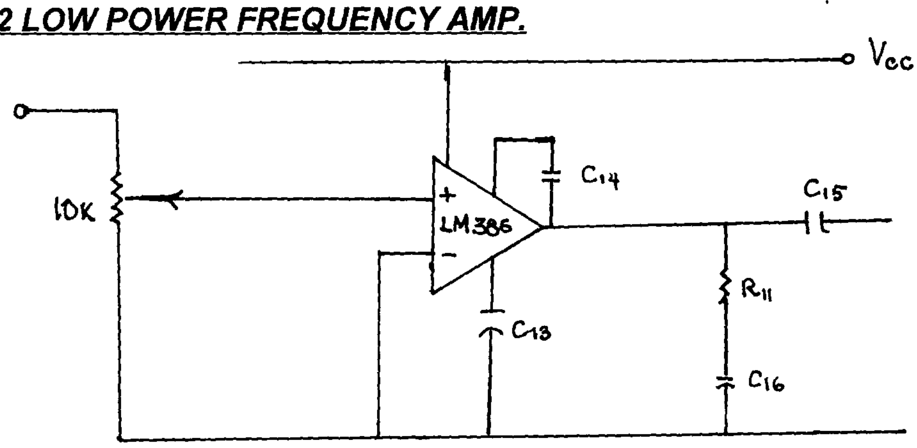


fig 3.1 Audio Amplifier Stage

From the information obtained from the data book

Max.gain = 26dB

In other to achieve this gain 10uf capacitor is needed at the feedback loop.

Hence C_{14} = 10µf

C_{13} is a bypass capacitor for low frequency below 20Hz.Choosing a frequecy of 10Hz and Xc to be 100Ω

c = 1/2ΠfXc

= 1/2x(22/7)x10x100

=159µf

For effective range coverage the value of the C13 to be applied will be 100uf.

C16 is a high pass filter capacitor.It allows frequencies above 20kHz.

Let Xc = 5kΩ

f = 30kHz

c = $1/2x22/7x30x10^3x500$

= .00000001

$C = 0.01\mu f$

Hence $C_{16} = 0.01\mu f$

Ct is also a coupling capacitor using lowest frequncy level of 20hz and Xc of 50Ω.

$$\text{Therefore } C_{15} = \frac{1}{2*(22/7)*20*50}$$

$C_{15} = 159\mu f$

Hence the preferable value of 220µf was chosen. R_{11} is a limiter resistor,a low value of 10Ω was used.

3.0.2 PRE- AMP STAGE

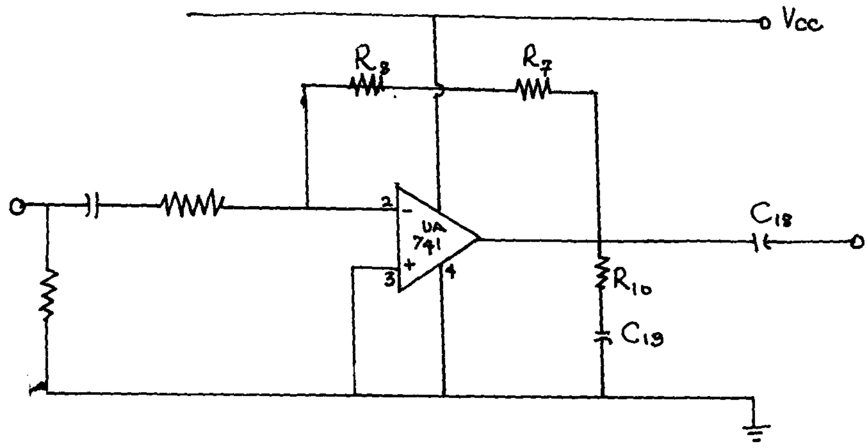


fig 3.2 Pre- Amp Stage

We assume our audio signal to be within the frequncy range of 20Hz-20kHz.The information provided in the data book for basic electronic components, the op-amp UA741 is taken to have a gain of 1000.

let $R_9 = 1k\Omega \rightarrow Zin$

Op-amp gain network

$$Av = \frac{Zf}{Zin}$$

$\Rightarrow 1000 = Zf/1k\Omega$

$$Zf = 1M\Omega$$

But $R_8 + R_7 = 1M\Omega$

assuming $R_8 = 500k\Omega$

Therefore $R_7 = 1M\Omega - 500k\Omega$

$= 500k\Omega$

$R_8 = R_7 = 500k\Omega$

Since op-amp was known to have a relatively high imput impedance, however this has to be reduced by an external resistors connected across the signal source.

The imput impedance of op-amp=2MΩ

$$1K\Omega = \frac{2M\Omega \, xR_{12}}{2M\Omega + R_{12}}$$

$$1kR_{10} + 2M\Omega * 1K\Omega = 2M\Omega \, R_{12}$$

$$2000M\Omega = (2M\Omega - 1K\Omega)R_{12}$$

$$\text{Therefore } R_{12} = \frac{2000M\Omega}{1999000}$$

$$= 1000.5\Omega$$

$$R_{12} \approx 1K\Omega$$

To calculate for the values of C_{17}, C_{19} and $C_{18.}$ assume the cut-off frequency of 20KHZ and

$$R_{10} = 10K\Omega$$

$$f_c = \frac{1}{2\Pi RC}$$

$$20KHz = \frac{1}{2*22/7*10*10^3*c}$$

$$C = \frac{1}{2*22/7*10*10^3*c}$$

$$= 0.00159$$

$$= 0.002\mu F$$

i.e $C_{19} = 0.002\mu F$

$$\text{Also } X_c = \frac{1}{2\Pi fc}$$

Let X_c = 1.5K and f = 10KHZ

$$C = \frac{1}{2\Pi fXc}$$

$$= \frac{1}{2*22/7*10*10^3*1500}$$

that is C_{18} = 10.6μF

But C_{18} = C_{17} = 10μF which are the coupling capacitors.

3.0.3 MODULLATOR STAGE

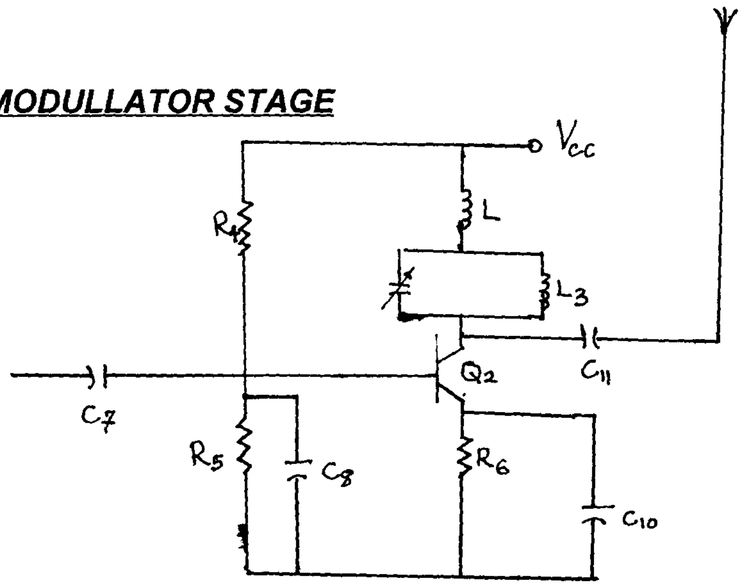


fig 3.3 Modulator Stage

From the data book, the parameters of transistor Q2 was given as stated below.

I_{cmax} = 111.1mA = I_E

H_{FE} bias = 100

V_{CC} = 9V

$V_E = V_{CC} - V_{CE}$

$= 9V - V_{CE}$

$V_{CE} = 1/2\ V_{CC}$

=1/2 *9V

= 4.5V

V_E = 9V - 4.4V

$V_E = 4.5V$

Also

$$V_E = I_E R_E$$

$$R_E = R_6 = \frac{V_E}{I_E} = \frac{4.5V}{111.1mA} = 4.5\Omega$$

But R_6 was chosen to be 56Ω

$$R_B = \frac{V_B}{I_B}$$

But $V_B = V_E + V_{BE}$

$= 4.5V + 0.7V$

$= 5.2V$

and $\frac{I_C}{I_B} = \beta$

$I_B = I_C/\beta = 111.1mA/100$

$= 0.001111A$ or $1.1mA$

$R_B = V_B/I_B$

$= 5.2/1.1mA = 4.7K\Omega$

Assumed value for $R_4 = 15k\Omega$

$$\text{But } V_B = \frac{R_5 * V_{CC}}{R_4 + R_5}$$

$$5.2V = \frac{R_5 * 9V}{15\Omega + R_5}$$

$$\frac{5.2}{9} = \frac{R_5}{15K\Omega + R_5}$$

$$0.578 * 15K\Omega = R_5 - 0.578R_5$$

$$R_5 = \frac{8.67}{0.422}$$

$= 20.5K\Omega$

But R_5 was chosen to be 10kΩ

$$X_c = \frac{1}{2\Pi fc}$$

$$\text{Let } X_c = 100\Omega$$

and $f = 546KHz$

$$c = \frac{1}{2\Pi fc}$$

$$= \frac{1}{2 * 22/7 * 546*10^3 * 100}$$

$$c = 0.003\mu F$$

Therefore C_7, C_8, C_{10} and C_{11} were chosen to be 0.003µF each.

RESONANT TANK 2

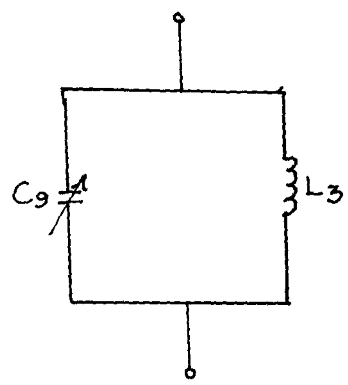


fig 3.4 Tank Resonant

For maximum frequency level, use 2.5pF range to obtain the corresponding value of L_3

$$\Rightarrow f = 1MHZ = 1 * 10\ 106\ Hz$$

$$C_9 = 2.5pF$$

$$L_3 = \frac{1}{4\pi^2 f^2 C}$$

$$L_3 = \frac{1}{4*(22/7)^{2}*(1*106)^2*2.5*10^{-12}}$$

$$= 10.1mH$$

Therefore $L_3 = 10mH$

Inserting L = 10mH and C = 8pF, the lowest frequency of operation was obtained.

i.e $$f o = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2*(22/7)*\sqrt{(10 * 10\text{-}3*8*10\text{-}12)}}$$

$= 549KHz$

which is still within the range of the required frequency.

3.0.4 OSCILLATOR STAGE

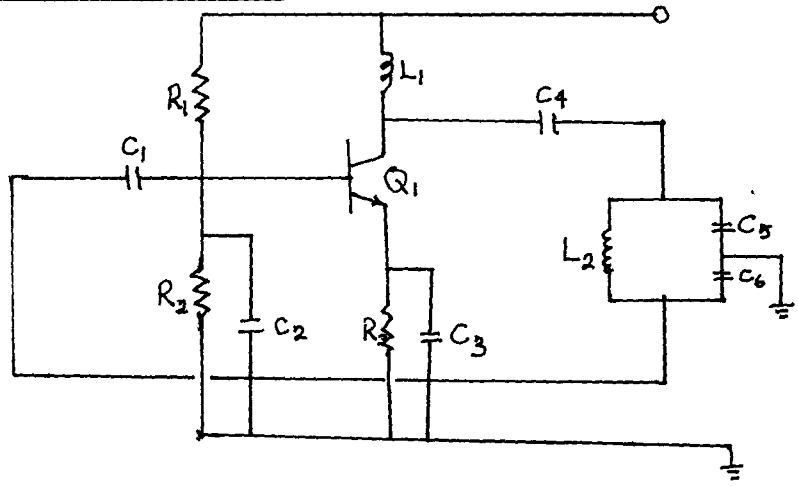


fig 3.5 Oscillator

Parameter obtained from the data book for Q1

$$I_{cmax} = 300mA$$

$$h_{FE} = 30mA$$

$$P_{Tot} = 2WC$$

$$V_{CC} = 9V$$

Assuming $X_{L1} = 0\Omega$

$$P = VI$$

$$P_{Tot} = V_{CC} * I_{C(sat)}$$

$$2W = 9V * I_{C\,(sat)}$$

$$I_{C(sat)} = \frac{2W}{9V} = 0.227A$$

$$\text{But } I_{C(sat)} = I_E$$

$$V_{CE} = 1/2V_{CC}$$

$$= 1/2 * 9V$$

$$\Rightarrow V_{CE} = 4.5\ V$$

$$\text{Also } V_E = V_{CC} - V_{CE}$$

$= 9V - 4.5$

$= 4.5V$

But $V_E = I_E R_E$

$$R_E = R_3 = \frac{V_E}{I_E} = \frac{4.5V}{200mA} = 22.5\Omega$$

Hence $R_3 = 22\Omega$

$V_B = V_E + V_{BE}$

For silicon transistor $V_{BE} = 0.7V$

$\Rightarrow V_B = (4.5 + 0.7)\ V$

therefore $V_B = 5.2V = 5V$

For the base voltage

$$V_B = \frac{R_2 V_{CC}}{R_1 + R_2}$$

Choosing $R_1 = 47K\Omega$

$5V = R_2 * 9V$

$47K\Omega + R_2$

$$\frac{R_2}{47K\Omega + R_2} = \frac{5}{9}$$

$= 0.55$

$47k\Omega\ (0.55) = -0.55R_2 + R_2$

$26.1K\Omega = 0.44R_2$

$$R_2 = \frac{26.1K\Omega}{0.44}$$

$= 58.75K\Omega$

Hence $56K\Omega$ was chosen for R_2

Values of capacitors

$$X_c = \frac{1}{2\pi fc}$$

For the minimum frequency level,

f = 546KHZ

Let $X_c = 50\Omega$

Then , C= $\frac{1}{2\pi f Xc}$

= $\frac{1}{2\pi f Xc}$

= $\frac{1}{2 * (22/7) * 546 * 10^3 * 50\Omega}$

= 0.005μF

C1 and C5 are coupling capacitors and 0.005μ F were chosen.

Choosing $X_C = 100\Omega$

C = $\frac{1}{2*(22/7)* 546*10^3 * 100}$

= 0.002μF

The resonant tank 1

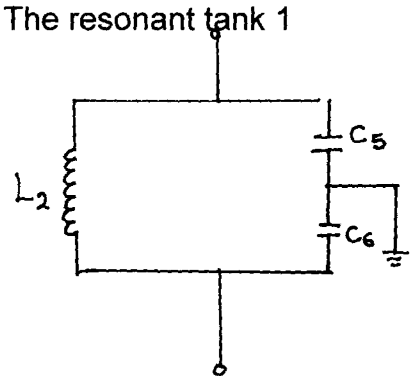


fig 3.6

Choosing the available value of an inductor.

L_2 = 10mH

For a low fraquency level of 546KHZ

$C_{EFF\ max} = \frac{1}{4\pi^2 f^2 L}$

= $\frac{1}{4* (22/7)*(546*10^3)^2*10*10^{-3}}$

= $8.4*10^{-12}$F

$$C_{EFF\,max} = 8.4pF$$

For a higher frequency of 1MHZ

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

$$= \frac{1}{4*(22/7)*(1*10^6)^2 *10*10^{-3}}$$

$$= 2.5* 10^{-12}F$$

$$C_{EFF\,min} = 2.5pF$$

Therefore , the effective capacitance range is (2 - 8)pF.

For the minimum effective range .

$$C_{EFF\,min} = \frac{C_5 * C_6}{C_5 + C_6}$$

Chosen $C_5 = 4pF$

$$2.5\,pF = \frac{4pF * C_6}{4pF + C_6}$$

$$10(pF)^2 + 2.5pFC_6 = 4pFC_6$$

$$10(pF)^2 = (4pF - 2.5pF)C_6$$

$$C_6 = \frac{10(pF)^2}{1.5pF}$$

$$= 6.6pF$$

Similarly for the maximum effective range

$$C_{EFF\,max} = \frac{C_5 * C_6}{C_5 + C_6}$$

$$8.4\,pF = \frac{4pF * C_6}{4pF + C_6}$$

$$33.6(pF)^2 + 8.4pFC_6 = 4pFC_6$$

$$33.6(pF)^2 = (4pF - 8.4pF)C_6$$

$$C_6 = \frac{33.6(pF)^2}{4.4pF}$$

$$= 7.6pF$$

3.0.5 CONSTRUCTION OF CASING

A ply-wood of 2.5cm thickness was obtained.Two plains of (7 by 4)cm were cut.These two plain ply-woods were used for the top and bottom covers.Also cut were (7 by 2)cm pair of woods and then (4 by 2)cm pieces where are also two in number.

The six pieces of woods were joined to form a casing which perfectly contain the circuit.

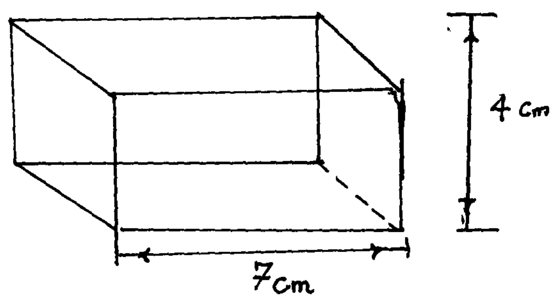


fig.3.7 casing

The wood work was carried out using the following tools.

(i) Plan- jack:-For smoothing the rough surface of the work piece

(ii)Hack-saw:- For cutting work piece

(iii)A meter rule:-For taking measurement.

(iv)Hammer:-For pushing the nails through the work piece to form a single unit.

CHAPTER FOUR

4.1 RESULTS AND DISCUSSION

Result obtained from Pspice program with regard to circuit designed given in the preceeding page.It gives the following analysis.

(i)The nodal analysis

(ii)The transient analysis

(iii)and the voltage analysis

It thus shows that the circuit is working perfectly and that there will be signal fllow from one stage to the other.That is,audio signal from the audio amplifier when when amplified by the pre-amp stage before modulation is carried out at the modulator stage.The carrier signal was able to generate the required frequency of (0.5-1)MHz with the output of one watt.The output wave form is given below.

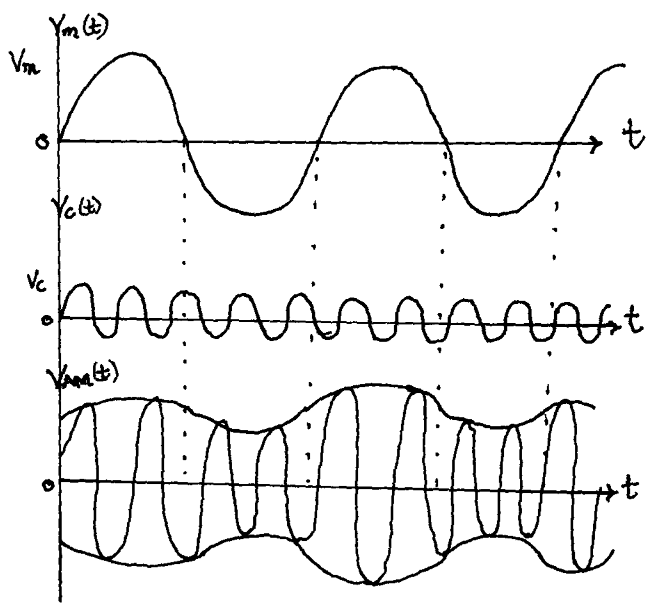


fig.4.1 The output wave form.

4.0.2 CONCLUTION

Having achieve the aim of this project which was successfully constructed,the exercise really broading my knowledge practically.The transmitter constructed was able to meet the specification[Frwquency of operation (0.5-1)MHz,1W].

however,the problem of distortion encountered can still be improved upon by any one hoping to impliment a transmitter using the circuit designed as a project.

4.0.3 RECOMMENDATION

Because of lots of research work carried out in realising this project and how relevant itis to my course of study,exposure to many theoretical analysis and the use of Pspice to analyse circuit.II would rather recommend tha the project should be repeated by graduating student.

Any correction or suggestion is highly welcomed by any person going through this write-up.

REFERENCES

1. DOUGLAS V. HALL — MICROPROCESSOR AND DIGITAL SYSTEMS 2ND EDITION, BY McGRAW HILL

2 .P HOROWITZ & W. HILL, — THE ART OF ELECTRONICS 2ND EDITION ,BY CAMBRIDGE UNIVERSITY,

3.THERAJA B.L & THERAJA A.K ,ELECTRICAL TECHNOLOGY (1995) 21st EDITION, BY NIRJA CONSTRUCTION AND DEV.CO LTD.

4.THOMAS W. THORP, — COMPUTERISED CIRCUIT ANALYSIS WITH SPICE EDITION BY JOHN WILEY AND SONS, INC.

5. GEORGE LOVEDAY, — LOGIC DESIGN PROJECTS (1991) EDITION, BY COOL

6. BART TREPAK , — PRACTICAL ELECTRONICS, FEB, 1982 EDITION. PART 1