DESIGN AND CONSTRUCTION OF A 25 W FREQUENCY MODULATION TRANSMITTER

BY

BARNA THOMAS LASS
93/3541

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING,
SCHOOL OF ENGINEERING / ENGINEERING TECHNOLOGY.
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.
NIGERIA.

MARCH, 2000

A PROJECT REPORT ON

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN THE

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Certification

This is to certify that this project titled "Design and construction of a 25 W Frequency Modulation Transmitter" was carried out by Barna Thomas Lass under the supervision of Dr. Y. A. Adediran and submitted to Electrical and Computer Engineering Department, Federal University of Technology Minna in partial fulfillment of the requirements for the award of Bachelor of Engineering (B. Eng.) degree in Electrical and Computer Engineering.

Dr Y. A. Adediran
Project Supervisor

31/3/2022
Sign & Date

Dr Y. A. Adediran
Head of Department

31/3/2022
Sign & Date

Dr J. O. Oni
External Examiner

Sign & Date

APPRECIATION

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TABLE OF CONTENT

.CHAPTER ONE

INTRODUCTION.

Frequency Modulation is an angle modulation technique whereby the instantaneous frequency of the carrier signal is varied in accordance with the instantaneous value of the modulating signal. The amplitude of the carrier signal is kept constant.

Since the work on the generation of FM in the early 20^{th} century, a number of technical improvements on FM generation have allowed many successful development in direct FM generation.

In this project the design of a class A FM transmitter of 25W is presented. This set up allows one to work on a project which finds application in all spheres of portable and mobile FM transmitters.

1.1 OBJECTIVE.

The objective of this project is to design and construct an FM transmitter to meet the requirements of monaural and stereo transmission with the performance as stipulated by the Nigerian Communication Commission for a class A transmitter.

Output Power - 25W

Output Impedance - 50 Ω

Input Impedance - 600 Ω

Frequency deviation - ± 76kH $_z$

100% Modulation.

Modulation capacity - ± 100kH $_z$

Harmonic distortion - 0.2% or less, 30-3400 H $_z$

FM noise - 68db below 100% modulation referred to 400 H $_z$

1.2 LITERATURE REVIEW

At the end of the 19^{th} century, sparks produced by discharges from a Leyden jar through an induction coil fitted with a spark gap were observed on touching nearby metal objects. This was the first instance of energy transfer over a distance without wires.

In 1873 J. C. Maxwell formulated the four 'Maxwell' equations for electromagnetic waves. These waves were produced in 1877 by H. Hertz by adding a loop of wire to the

Leyden jar spark transmitter and so increased the distance over which sparks could be transmitted. Later, Ernest Rutherford in 1893 was able to transmit sparks over a distance of $\frac{3}{4}$ mile.

The invention of spark detector (coherer) by Branley and its subsequent improvements by Karl Braun, Adolph Slaby and Oliver Lodge made it possible to transmit telegraph by coding the sparks over a distance without wires. Guglielmo Marcomi (1895) with a spark induction coil and the coherer succeeded in sending telegraph messages over a distance of 100m and later across the Atlantic ocean. This marked the beginning of radio transmission.

Higher powers than possible with spark transmitters were obtained in turn by arc generators invented by Valdemar Ponlsen, and the Fessenden - Alexanderson high frequency generators. D. Ehret (1902) using the arc generators was able to demonstrate frequency modulation with U. S. Patent 185,303. Later Reginald Fessenden (1906) demonstrated the first Double-side band Amplitude modulation transmitter. These devices were noisy with poor frequency stability. The transmitters could not transmit speech.

The invention of vacuum tube diodes by J. A. Fleming (1906), and the triode by Lee De Forest (1913) made possible development of powerful transmitters with improved frequency stability. E. Howard Armstrong, using the diode and the triode, invented the regenerative circuit (1912), the superheterodyne (1918) and the super regenerative circuit (1920) for high frequency generation. This led to the first significant demonstration of speech transmission by J. R. Carson at AT &T (single side band communication) in1915. The first transmitter to broadcast speech and music was later developed by American Marconi company in 1916.

In 1925, E. H. Armstrong's work on the correction of static in radio, resulted in the achievement of FM that year, Dr J. R. Carson of AT&T Dev. And Research Dept. was the first to investigate FM transmission in 1927.

The work of W. G. Cady and G. W. Pierce of Harvard University (J an 1923) on automatic frequency control and that of H. S. Black in 1927 at Bell Laboratories on negative feedback circuit made it possible for Armstrong to set up the first FM station in Alpine, New Jersey.

Commercial operation of FM started in 1940 after the improvement on the frequency capabilities of the vacuum tubes: tetrode by Round (1926), pentode by

Tellegen and Holst (1928), Klystron by Randall and Boot (1939), magneton by Rosenthal (1939), and the development of phase locked loop FM generation technique by Foster and S. W. Seeley (1941).

Since the invention of transistors by J. Bardeen, W. Schockley, and W. H. Brattain in 1948 made possible the invention of the multiplex FM transmission by Armstrong in March 1953. FM transmitter has experienced a tremendous increase in popularity in Nigeria and the world as a result of the invention of integrated circuits by W. Kilby (1960) and the tamed FM transmission by N. Wiedenhof and J. M. Waa lwijk of Phillips Research Laboratories in Eindhoven in 1978.

1.3. METHODOLOGY

A typical frequency modulation transmitter is made up of an audio frequency processing and amplifier, a modulator, frequency multiplier, and a power amplifier. It has an automatic frequency control network which is made up of a discriminator, I. F. amplifier, mixer, frequency multiplier, and a crystal oscillator. See figure 1.1

In this project design, the transmitter consists of a microphone (which is a transducer for converting audible signal/voice signal to message signal)as an audio input. The microphone picks the voice and converts it to a message signal which is filtered and amplified by the audio frequency amplifier. The audio frequency amplifier is a linear amplifier circuit.

The amplifier message signal is then modulated by an inductive reaction modulator. This involves the alteration of the frequency of oscillation of an L. C. circuit by changing the value of the inductor in accordance with the message signal resulting to an FM signal. The modulation has a phase-shift network (negative feedback loop) to achieve an appreciable frequency and voltage stability in the system.

The FM signal is fed to a class A power amplifier (Driver amplifier) to boost its power level to an appreciable level. The signal is then further amplified by a class C power amplifier to a power level high enough for radiation by the antenna. See figure 1.2

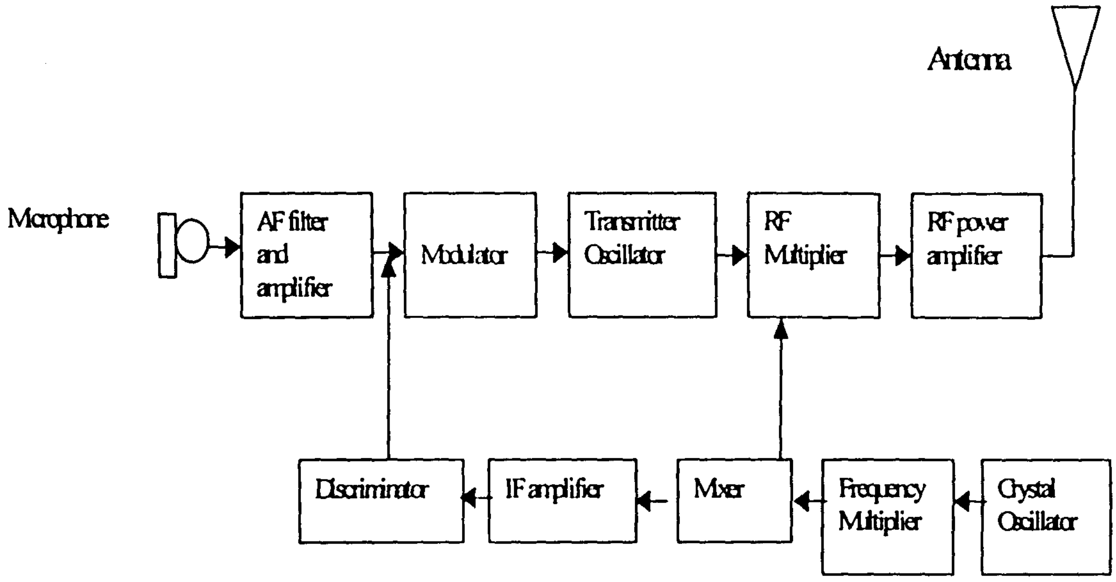

Fig 1.1 Block Diagram of a Typical FM sound transmitter

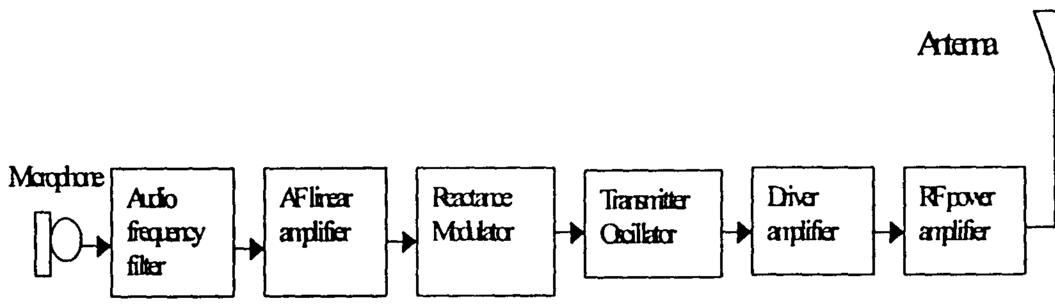

Fig 1.2 Block diagram of the designed FM sound transmitter.

1.3.1 CARRIER POWER

The average carrier power $P_c = \frac{J_1(\beta)}{J_0^2(0)} . P_t$.

Where P_t = transmitter power

$P_t = 25W$

J_n (β) is Bessel function of order n with β as its augument.

β - modulation index

J_1 (β) = 0 Bessel function of order 1 with a modulation index equal to zero.

J_o (0) = Bessel function of order zero.

J, (β) = 0 is equal to J_0^2 (3.8) = - 0.40 from Bessel function chart.

J_o (0) = 1.581 from Bessel function chart.

$$P_C = \frac{J_0^2(3.8)}{J_0^2(0)} X25 = 0.16X25 = 4W$$

P_C = carrier power

$P_{sB} = P_t - P_C = 25 - 4 = 21W.$

P_{sB} = power of the side bands.

1.3.2 FM Wave Shape

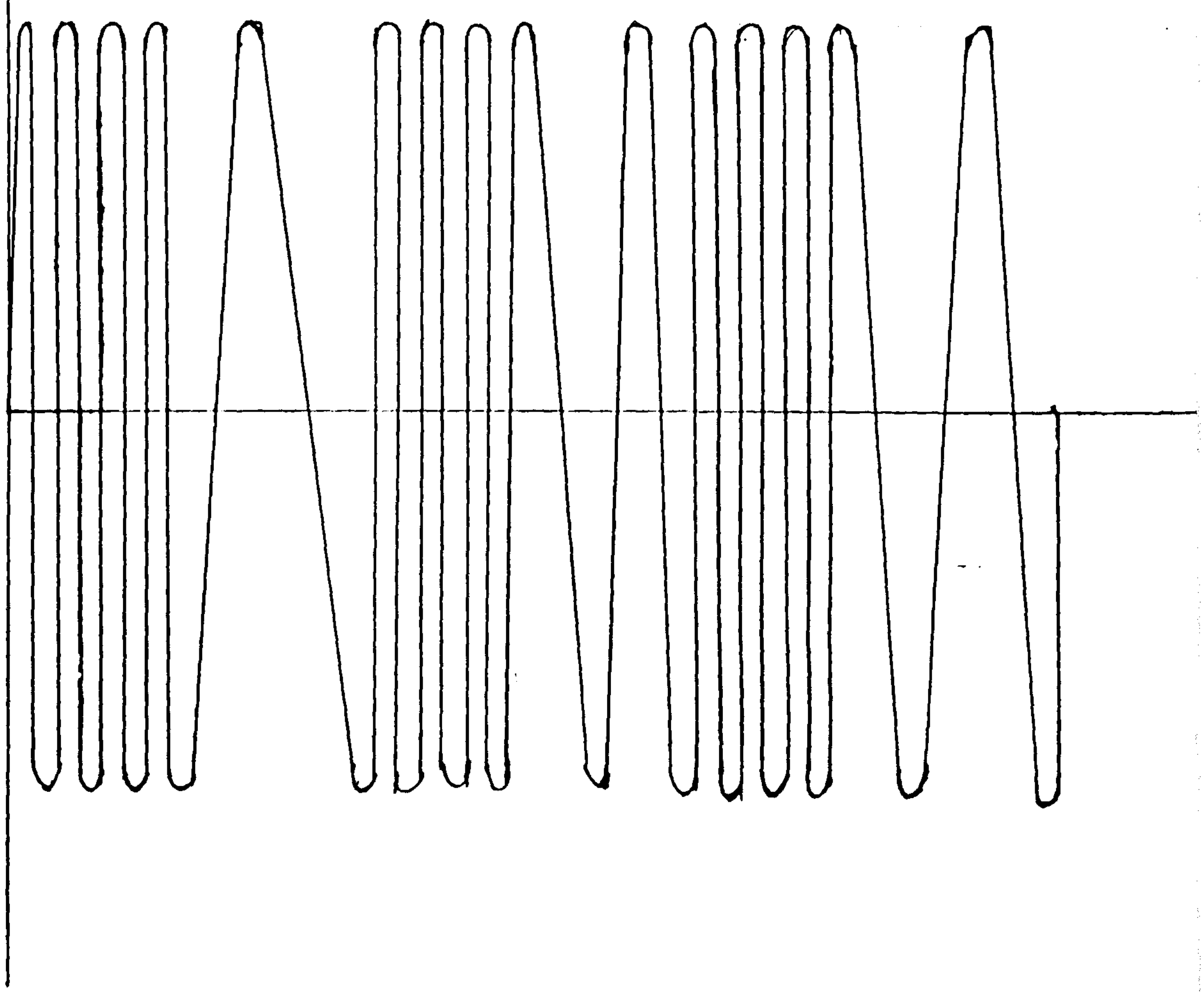

Fig. 1 The Wave Shape of an FM signal.

CHAPTER TWO

DESIGN AND CONSTRUCTION

2.1. DESIGN OF AUDIO AMPLIFIER CIRCUIT.

2.1.1 Design steps.

2. Selection of a suitable linear (class B) amplifier or audio frequency (AF) amplifier IC. (Integrated Circuit).
3. Proper biasing of the Integrated Circuit.
4. Determination of the voltage gain Av of the audio frequency amplifier.

2.1.1 Selection of a Suitable Integrated Circuit.

LM 386 IC was chosen.

The LM 386 is a low voltage audio frequency amplifier designed for use in low voltage application.

Features

a. Wide supply voltage range of 4 - 12 volts.

b. Low quiescent current drain of 3mA

c. Voltage gains from 20dB to 200 dB

d. Ground reference input

e. Self - centering output quiescent voltage

f. Low distortion of 0.2% (90m V rms at Pin 3)

g. Eight pin dual-in-line package.

h. Voice operated gain adjusting device VOGAD

Absolute Maximum Ratings

1.	Supply Voltage	-	15V
2.	Package Dissipation	-	660mW
3.	Input Voltage	-	±0.4V
4.	Junction Temperature	-	+150°C
5.	Operating Temperature	-	0 to 70°C
6.	Storage Temperatures	-	-65 to + 150°C
7.	Lead Temperature	-	+ 300°C
8.	Output Impedance	-	16Ω
9.	Signal to Noise ratio	-	73 dB

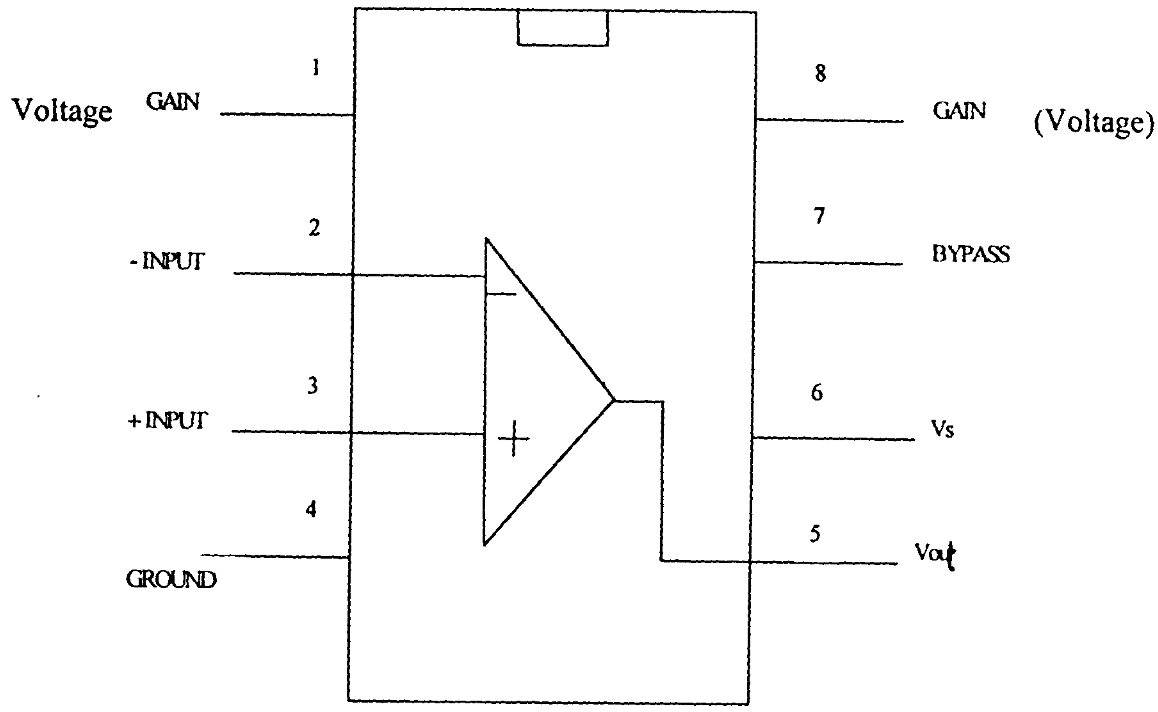

Fig. 2.1 pin configuration of LM 386 IC.

The features and the ratings of the IC,(e.g. the low distortion, low quiescent current drain of 3mA and wide supply Voltage range of 4 - 12 Volts and a low package dissipation), make the LM 386 suitable for our application.

It has an in built and a remarkable gain of 20 dB to 200 dB at pins 1 and 8. There is an excellent overload capability and a remarkable good signal-to-Noise ratio.

The frequency response is 15 Hz to 20 kHz 0.5dB and the distortion is less than 0.2% over the audio frequency band of 300Hz - 3.4kHz.

2.1.2 Biasing of the Integrated Circuit.

b. The input which is an audio input from a microphone either crystal or moving coil or carbon microphone feed through a jack is connected to a resistor (variable resistor R_1) .

c. The variable resistor R_1 of $10k\Omega$ was selected and is connected to the non inverting input (pin 3) of the LM 386.

d. Pin 2 is grounded.

e. A supply voltage of 10V is chosen to give a good operation with a minimal power drain of above 18mW, making it ideal for low voltage operation.

$= 100 \times 10^{6} - 1.97 \times 10^{14} \Delta L$

But $\Delta L < 3.289nH$

Hence $f_{min} < 100 \times 10^{6} - 1.97 \times 10^{14} \times 3.289 \times 10^{-9}$

$\therefore f_{min} < 99.35MHz$

$\Delta f = f_o - f_{min}$

$$\Delta f = f_{max} - f_o \approx f_o \frac{\Delta L}{2L} = 1.9768X10^4 \ \Delta L \leq 0.6MH_Z.$$

hence $f_{max} \leq 0.6X10^{+6} + 100X10^{6}$

$f_{max} \leq 100.6MH_Z$

$$\theta_0(t) = \frac{1}{\sqrt{LC}}(1 - \frac{\Delta L}{2L}) = \frac{1}{\sqrt{0.25x10^{-6}x10x10^{-12}}}(1 - \frac{\Delta L}{2x0.25x10^{-6}})$$

$$\theta_o(t) = 0.62869x10^9(1 - \frac{\Delta L}{2x0.253x10^{-6}}) = 0.62869x10^9 - 1.24x10^{15}\Delta L$$

When $\Delta L < 3.289X10^{-9} H$

$\theta_0(t) \qquad < 0.62869X10^9 - 1.24X10^{-9}$

$\therefore \theta_0(t) \qquad < 624.6x10^6$ rad

But $\theta_i(t) \quad = 2\pi f_0 t + 2\pi \frac{\Delta L}{2L} f_0 \int_0^t m(t)dt$

Since $|m(t)| \leq 1$

Then $\theta_i(t) \quad < 2\pi f_0 t + \pi \frac{\Delta L}{L} f_0 t$

$$< 2\pi f_0 t + \frac{L}{\pi} x \frac{3.289x10^{-9}}{0.253x10^{-6}} t$$

$$< 0.628x10^9 t + 4.0848x10^6 t$$

$\therefore \theta_i(t) \qquad < 632.08x10^6 t$ rad

The Shunt Capacitor Cs

The collector - emitter capacitance is very small and it changes with temperature, which may lead to frequency instability. This effect is minimized by the insertion of a small shunt capacitor across the collector - emitter junction. The value is 10pF.

2.2.4 Calculation of Inductor L_1 with Capacitor C_6 at Resonant.

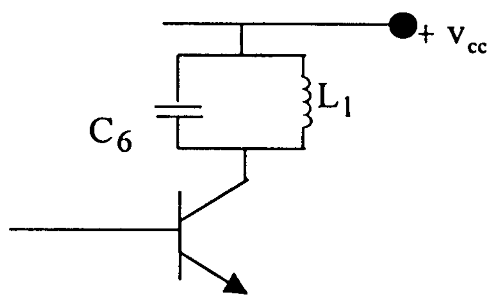

Fig. 2.5 frequency determine network

f_0 = operating frequency or resonant frequency

= 100 MH_Z.

C_6 = 10 pF selected.

L_1 =?

At resonance

$X_c = S_L$.

Where X_c = capacitive reactance

X_L = inductive reactance.

$$X_c = \frac{1}{\omega C}$$

X_L =

ω_C = angular frequency

ω_C = 2πf.

$$\therefore \frac{1}{2\Pi f_0 c} = 2\Pi f_0 L$$

$$\Rightarrow f_0 = \frac{1}{2\Pi\sqrt{CL}} \quad \ldots\ldots\ldots\ldots\ldots\ldots 2.7$$

$$f_0 = \frac{1}{2\Pi\sqrt{C_6 L_1}}$$

$$f_0 = \frac{1}{2\Pi\sqrt{C_6 L_1}}$$

$$100 \times 10^6 = \frac{1}{2\Pi\sqrt{10\times10^{-12} x L_1}}$$

$$\therefore L_1 = \frac{1}{2\Pi^2(100\times10^6)\times10\times10^{-12}}$$

$$:.L_1 = \frac{1}{4\Pi^2(100x10^6)^2 x10x10^{-12}}$$

$$= 0.253 \times 10^{-6} H$$

$$= 0.253\mu H$$

2.2.4 Determination of the Stern Stability Factor K.

$$K = 1 + \frac{\beta R_{E1}}{R_{E1} + R_4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.8$$

$$= 1 + \frac{70x1x10^3}{1x10^3 + 100x10^3}$$

$$=1.693$$

$$:.K \approx 1.7$$

Hence the circuit is potentially stable since K > 1.

2.3. DESIGN OF DRIVER AMPLIFIER

2.3.1 Selection of a Suitable Transistor

C1923 is NPN silicon transistor was selected.

β = forward current gain

β = 70 typical

$I_{C_{max}}$ = maximum collector current

$I_{C_{max}}$ = 50mA

P_D = maximum dissipation power.

P_D = 0.25w

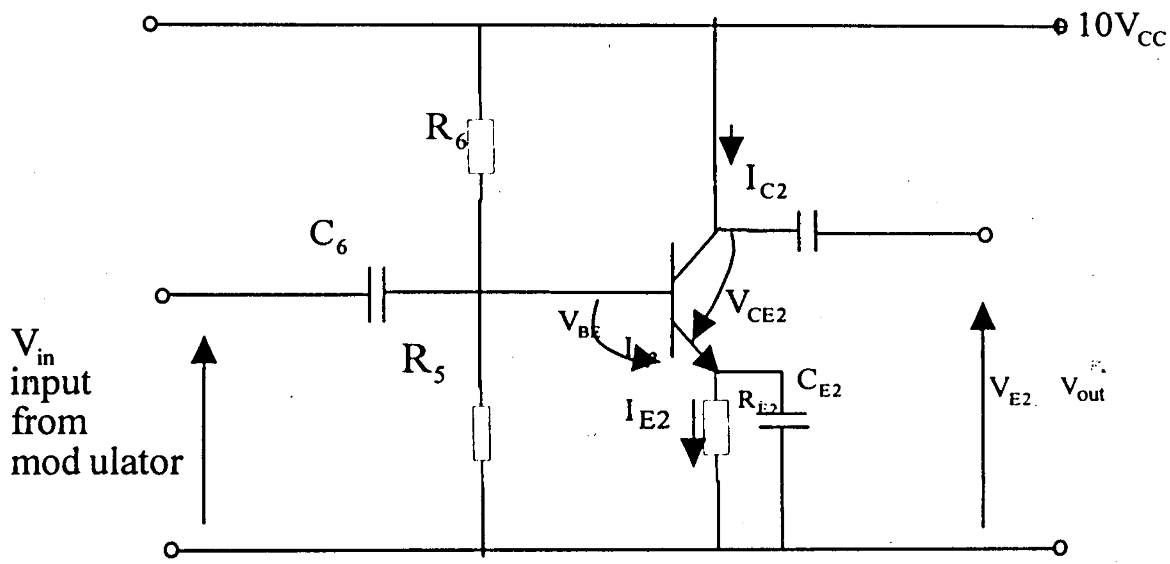

Fig 2.6 RF power amplifier stage

V_{cc} = + 10V chosen

I_c = 40mA chosen

V_{E_2} = 4V chosen

R_B = $R_6 \| R_5$

V_{B2} = $I_{B2}R_B$ 2.9

I_{E2} = $(\beta + 1)I_{B2}$ 2.10

From input equation.

$$V_{\beta 2} = V_{cc}\frac{R_6}{R_6 + R_5}$$ voltage divider theorem. 2.11

$$V_{B2} = V_{BE} + V_{E2}$$ 2.12

$$= 0.7 + 4$$

$$\Rightarrow V_{B2} = 4.7V.$$

∴ From equation 2.11

$$V_{B2} = V_{cc}\frac{R_6}{R_6 + R_5}$$

$$4.7 = 10.\frac{R_6}{R_6 + R_5}$$

$$\frac{4.7}{10} = \frac{R_6}{R_6 + R_5}$$

$$0.47 = \frac{R_6}{R_6 + R_5}$$

$$0.47\,(R_6 + R_5) = R_6$$

$$0.47R_6 + 0.47R_5 = R_6$$

$$0.47R_5 = R_6 + 0.47 = R_6$$

$$0.47R_5 = 1.47R_6$$

$$R_5 = \frac{1.47R_6}{0.47}$$

$$\therefore\; R_5 = 3.127659574R_6$$

But $R_B = R_6 \parallel R_5$

From (eqn) 2.9 and 2.10

$$V_{B2} = I_{B2}R_B$$

$$I_{B2} = \frac{I_{E2}}{\beta + 1}$$

$$I_{E2} \cong I_{C2} = 40mA$$

$$\beta = 70$$

$$\therefore I_{B2} = \frac{40mA}{70+1}$$

$$= \frac{40x10^3}{71}$$

$= 0.556338x10^{-3}$ A

$\Rightarrow I_{B2} = 0.563$mA.

$V_{B2} = 4.7$V calculated

$\therefore V_{B2} = I_{B2} R_B$

$4.7 = 0.563x10^{-3} R_B$

$$\therefore R_B = \frac{4.7}{0.563x10^{-3}} = 8.34 \text{ k}\Omega$$

$$R_B = \frac{R_6 R_5}{R_6 + R_5}$$

since $R_5 = 3.127 R_6$

and $R_B = 8.34$ kΩ

$$\therefore 8.34 = \frac{R_6 x 3.127 R_6}{R_6 + 3.127 R_6} = \frac{3.127 R_6^2}{4.127 R_6}$$

$$8.34 = \frac{3.127 R_6}{4.127}$$

$$R_6 = \frac{8.34x4.127}{3.127} = \underline{\underline{11\text{k}}}\Omega$$

$R_5 = 3.127 R_6$

$= 3.127 \times 11$

$R_5 = 34.4$ kΩ

selecting standard values. $R_5 = \underline{\underline{35\text{k}}}\Omega$

$V_{E2} = I_{E2} R_{E2}$.

$$\therefore R_{E2} = \frac{V_{E2}}{I_{E2}} = \frac{4}{40x10^{-3}} = \underline{\underline{100}}\,\Omega$$

2.3.2 Determination of Coupling and Decoupling Capacitors.

$$C_6 = \frac{1}{2\Pi f_0 \frac{R_B}{20}}$$

$f_0 = 100$MHz

$R_B = R_6 \| R_5 = 8.34$ kΩ

$$C_6 = \frac{1}{2\Pi(100x10^6)(\frac{8.34x10^3}{20})}$$

$$= \frac{1}{2.62x10^{11}}$$

$C_6 = 3.8\ 166 \times 10^{-12}$ F

selecting standard capacitor values.

$C_6 = \underline{3pF}$.

$$C_{E2} = \frac{1}{2\Pi f'_0 R_{E2.}}$$

$f_0 = 100MH_Z$

$R_{E2} = 100\Omega$

$$= \frac{1}{2\Pi(100x10^6)100}$$

$$= \frac{1}{6.283x10^{10}} \text{ F}$$

= 15.9pF

Selecting standard capacitance value. C_{E2} =20pF.

2.3.3 Determination of Stern Stability Factor K for the Circuit

$$K = 1 + \frac{\beta R_{E2}}{R_{E2} + R_B}$$

$R_{E2} = 100\Omega$

$$= 1 + \frac{70x100}{100x8.34x10^3}$$

$R_B = 8.34k\Omega$

$\beta = 70$

= 1 + 0.8 293

= 1. 829

$\therefore$ The system is stable (potentially stable) since K > 1.

2.4. DESIGN OF CLASS C RF AMPLIFIER

2.4.1 Selection of a Suitable Transistor and Operating Point

2SC3266 an. NPN silicon resistor with

β = 200 typical

$I_{C_{max}}$ = 5A

P_D = 0.75W

f_T = 150 MH_Z

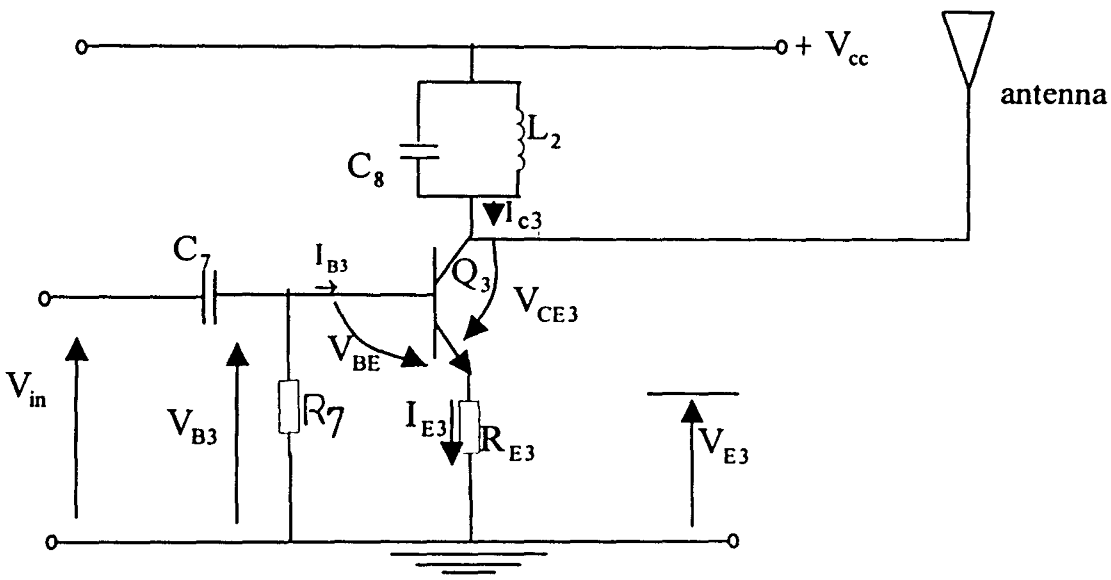

fig 2.7 RF power amplifier stage

Input Equation

$V_{B3} = V_{BE} + V_{E3}$

$V_{E3} = 6V.$

since V_{BE} = 0.7 for silicon transistor

$\therefore V_{B3} = 0.7 + 6$

$= 6.7V$

$V_{B3} = I_{B3} R_7$

$$\Rightarrow \quad R_7 = \frac{V_{B3}}{I_{B3}} = \frac{6.7}{I_{B3}}$$

$I_{B3} \approx I_{C3} = (\beta + I) . I_{B3}$

$$I_{B3} = \frac{I_{E3}}{\beta + 1}$$

$$= \frac{2.5}{200 + 1}$$

$$= \frac{2.5}{201} = 12.43 \text{ mA.}$$

$$R_7 = \frac{6.7}{I_{B3}} = \frac{6.7}{12.43x10^{-3}}$$

$R_7 = 539\Omega$

standard resistor values 600.

$$R_{E3} = \frac{V_{E3}}{I_{E3}} = ?$$

$V_{E3} = R_{E3} I_{E3}$

$$R_{E3} = \frac{V_{E3}}{I_{E3}}$$

since $V_{E3} = 6V$

$I_{E3} \approx I_{c3} = 2.5A$

$$R_{E3} = \frac{V_{E3}}{I_{E3}} = \frac{6}{2.5} = 2.4\Omega$$

standard resistor value $R_{E3} = 3\Omega$

2.4.2 Determination of the Coupling Capacitor

$$C_7 = \frac{1}{2\Pi f_o \frac{R7}{20}}$$ $f_0 = 100MH_Z$

$$= \frac{1}{2\Pi (100x10^6)(\frac{600}{20})}$$ $R_7 = 600\Omega$

$$= \frac{1}{9424777961} = 106.1pF.$$

Standard capacitors as C_7 = 100pF.

2.4.3 Determination of LC Circuit

$$f_o = \frac{1}{2\Pi\sqrt{L_2 C_8}}$$

$$L_2 = \frac{1}{4\Pi^2 f_0^2 C_8}$$

Chosen C_8 = 10pF

$$\therefore L_2 = \frac{1}{4\pi^2(100x10^6)^2 x10x10^{-12}}$$

$= 0.253 \times 10^{-6}$ H

$= 0.253$ μH .

$$Q = \frac{\omega L_2}{r} = \frac{2\pi f_0 L_2}{r}$$

r = resistance of the inductor L_2

= 2.2 Ω

$$Q = \frac{2\pi(100x10^6)(0.253x10^6)}{2.2} = 72.25663$$

$$B = \frac{f_0}{Q} = \frac{100x10^6}{72.25663} = 1.3839x10^6 H_z$$

$$\therefore B = 1.3839 MH_Z$$

$P_{dc} = V_{cc} I_c$

where P_{dc}= dc power output

= 10 x 2.5 = 25 W

$P_{ac} = P_{dc} - P_D$ = 25 - 0.75 = 24.25

P_{ac} = ac power output

P_D = dissipation power of the transistor

$$\eta = \frac{P_{ac}}{P_{dc}} x100 = \frac{24.25}{25} x100 = 97\%$$

η = efficiency

2.5. Choice of Antenna

The Hertzian dipole antenna is chosen.

Resistance = R_r (Ω)

l = antenna length (m)

λ = wavelength of the transmitted wave (m)

f = frequency of transmitted wave (H_z)

c = velocity of transmitted wave in (m/s)

P_d = power density (W/m^2)

r = distance from the transmitting antenna in (m)

P_t = transmitting power in (W)

α = attenuation in (dB)

$$R_r = 80\pi^2\left(\frac{l}{\lambda}\right)^2$$

$$\lambda = \frac{c}{f} = \frac{3x10^8}{100x10^6} = 3m$$

$$R_r = 80\pi^2\left(\frac{0.6}{3}\right)^2 = 31.58\Omega$$

$$P_{d1} = \frac{P_t}{4\pi r_1^2} \text{ where } r_1 = 50m$$

$P_t = P_{ac}$ of the RF power amplifier

= 24.25W

$$P_{d1} = \frac{24.25}{4\pi(50)^2} = 771.9X10^{-6} W/m^2$$

$$P_{d2} = \frac{P_t}{4\pi r_2^2} \text{ where } r_2 = 100m$$

$$= \frac{24.25}{4\pi(100)^2} = 192.975X10^{-6} W/m$$

$$\alpha = 20\log\left(\frac{P_{d1}}{P_{d2}}\right)$$

$$= 20\log\left(\frac{771.9X10^{-6}}{192.975X10^{-6}}\right)$$

$$= 20\log(3.99992362)$$

$$= 12.041dB$$

for the dipole antenna, an antenna with l = 0.6m is chosen.

2.6. DESIGN OF POWER SUPPLY

2.6.1 Choice of Components.

A 240 /12 V transformer 50Hz step down transformer was selected.

A PBP205 bridge rectifier is selected with the following characteristics:

Prv =600v (peak reverse voltage)

peak forward surge current = 60A

Io = 2A (average rectifier forward current)

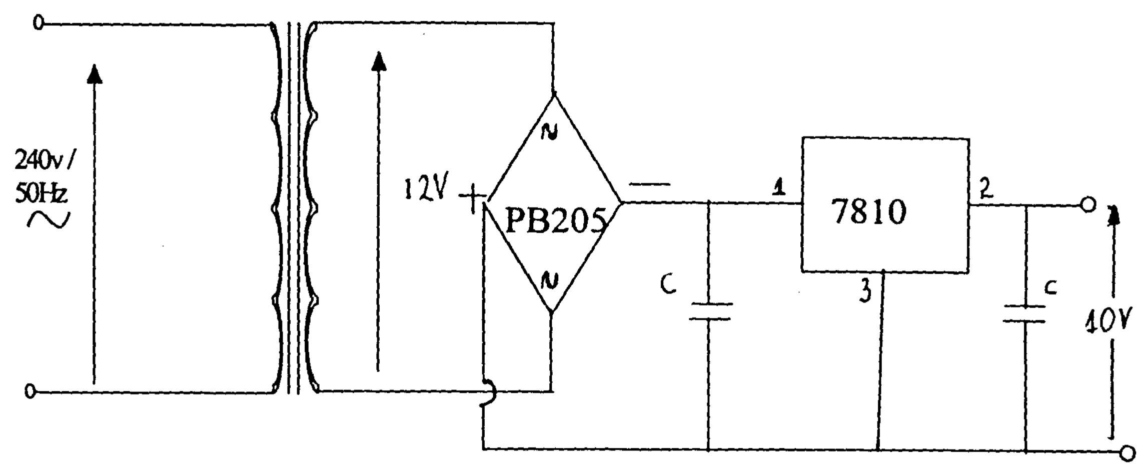

Fig. 2.12 Power supply circuit

2.6.3 Choice of Filter Capacitor

The simple capacitor filter provides very good filtering action at low currents and often used in high voltage low current power supplies.

r- ripple factor.

f - frequency of a,c

C - capacitance

R_L - Load resistance

I_{dc} - dc output current

V_p - peak voltage

Let choice of a ripple factor r = 2.0×10^{3}

$$r = \frac{1}{2\sqrt{3}}\frac{1}{FR_l c}$$

$$V_P = \sqrt{2}Vrms$$

V_{rms} = 240v

$V_p = \sqrt{2}\ .\ 240 = 339.4$v

I_d = 500mA

$$R_L \cong \frac{V_p}{I_{dc}} = \frac{339.4}{500 \times 10^{-3}} = 678.82\pi$$

f = 50Hz

$$r = \frac{1}{2\sqrt{3}}\frac{1}{fR_l c}$$

$$2.0 \times 10^{-3} = \frac{1}{2\sqrt{3}} \frac{1}{50 \times 678.8 \times C}$$

$$2.0 \times 10^{-3} = \frac{1}{117571.6C}$$

$$C = \frac{1}{117571.6 x 2.0 x 10^{-3}} = 4.2527 x 10^{-3} F$$

$= 4252.7 \times 10^{-6}$ F
$= 4252.7\mu$ F.

Using standard capacitors of 2200μF connecting two capacitors of 2200μ F in parallel to achieve a value of 4400μF.

2.6.4 A..C. ANALYSIS

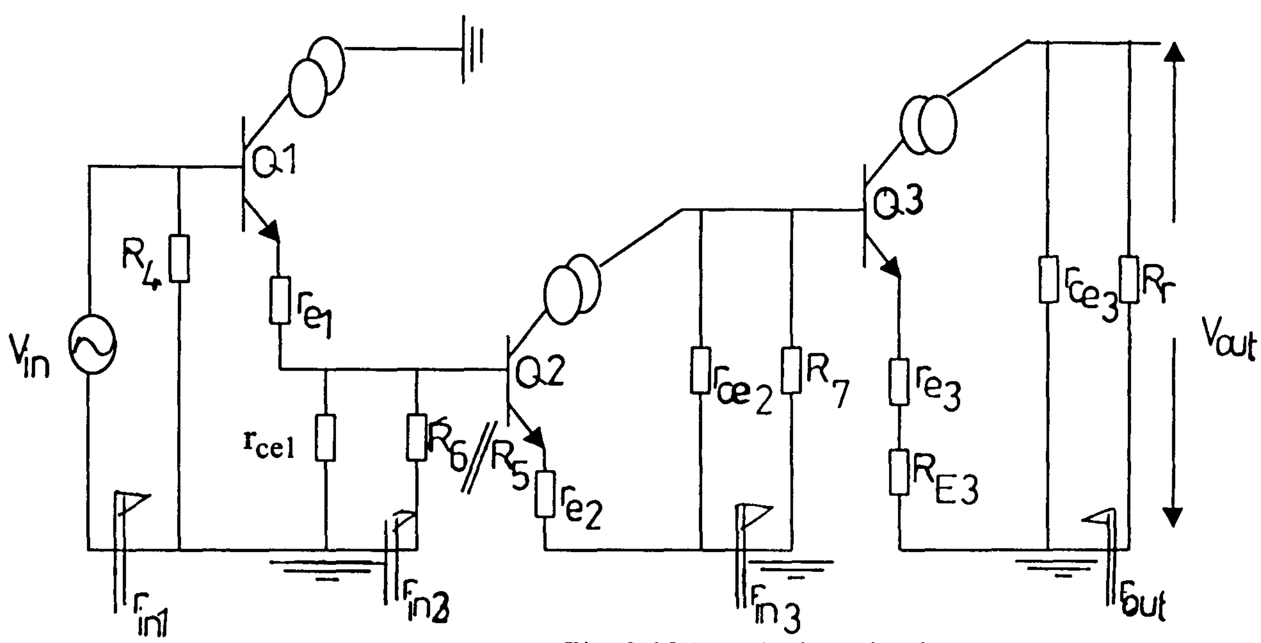

Fig. 2.13.C equivalent circuit

$$AV_3 = \frac{r_{ce3} // R_r}{r_{e3} + RE_3}$$

A_v = voltage gain

$$= \frac{V_{out}}{V_{in}}$$

$r_{e3} = \dfrac{26}{I_{E3(mA)}}$

$I_{E3} = 2.5A$

$= 10.4m\Omega$

A_I = Current gain

$= \dfrac{i_0}{I_{in}}$

r_{in} = input reistance

r_{out} = output resistance

r_{ce3} is quite large in the order of $200k\Omega$

R_r = antenna resistance calculated

$R_r = 31.58\Omega$

$$\therefore AV_3 = \frac{200K\Omega \; // \; 31.58\Omega}{10.4m\Omega + 2.4\Omega}$$

$$\cong \frac{31.58}{2.4104} = 13.10$$

$$r_{out} \approx r_{ce3} \; // \; R_r$$

$$\cong 200k\Omega \; // \; 31.58\Omega$$

$$\approx 31.58\Omega$$

$$r_{in3} = R_7 = 600\Omega$$

$$AI_3 = AV_3 \cdot \frac{r_{in3}}{R_r}$$

$$= 13.1 \times \frac{600}{31.58}$$

$$AI_3 = 248.89$$

$$\therefore AV_2 = \frac{r_{ce2} \; // \; r_{in3}}{r_{e2}}$$

$$r_{e2} = \frac{26}{I_{E2}(mA)} = \frac{26}{40} = 0.65\Omega$$

$$AV_2 = \frac{200R\Omega \; // \; 600\Omega}{0.65}$$

$$\cong \frac{600}{0.65} = 923.01$$

$$r_{out_2} = r_{ce_2} \,//\, r_{in_3}\ 200k\Omega \,//\, r_{in_3}$$

$$= 200k\Omega \,//\, 600\Omega \approx 600\Omega$$

$$r_{in_2} = R.6 \,//\, R_5$$

$$= 11\ K\Omega \,//\, 34.4K\Omega$$

$$r_{in_2} = 8.34k\Omega .$$

$$AI_2 = A_{V_2} \cdot \frac{r_{in2}}{r_{out2}} = 923.07x\frac{8.43k\Omega}{600\Omega}$$

$$= 12830.673$$

$$AV_1 = \frac{r_{ce1} \,//\, r_{in2}}{r_{e1} + r_{ce1} \,//\, r_{in2}}$$

$$r_{e1} = \frac{26}{I_{E1}\ (mA)} = \frac{26}{4} = 6.5\Omega$$

$$AV_1 \approx \frac{200K\Omega \,//\, 8.34K\Omega}{6.5\Omega + 200K\Omega \,//\, 8.38K\Omega}$$

$$\therefore AV_1 \cong \frac{8.34K\Omega}{6.5 + 8.34K\Omega}$$

$$AV_1 \approx 1$$

$$r_{out1} = r_{e1} + r_{ce1} \,//\, r_{in2}$$

$$\cong 6.5\Omega + 8.34k\Omega$$

$$\cong 8.3465k\Omega$$

$$r_{in1} \cong R_4 \approx 100K\Omega$$

$$\therefore AI_1 = AV_1 . \frac{r_{in1}}{r_{out}} = 1x\frac{100k\Omega}{8.3465k\Omega} = 11.981$$

CHAPTER THREE

3.0 CONSTRUCTION AND TESTING

3.1 Construction

The construction of the transmitter started with the soldering of the LM 386 IC on the vero board. The audio input was tapped from the variable 10kΩ resistor connected to pin 3 of the IC. Pin 2 and 4 are connected to the ground while pin 6 is connected to the positive 10 volts supply. Pins 1 and 8 are connected together via a series connection of a 1.2kΩ resistor and a 10 μF capacitor and to the ground. Pin 5 of the IC is the out put to the oscillator stage.

A transistor Q_1(C1923) is soldered to the circuit board having its base biased by a 100kΩ resistor to the positive supply and a 472pF capacitor to the ground. Also connected in series to the base terminal is a 2.2μF electrolytic capacitor. Its negative terminal is connected to the base of the transistor while the positive terminal is connected to pin 5 of the LM 386. The resonance circuit of a parallel connection of a 10pF capacitor and the supply voltage. Similarly a parallel connection of a 1kΩ resistor and its decoupling 10pF capacitor is connected between the emitter and the ground.

Transistor Q_2 (C 1923) is soldered into the board. The biasing resistor is made up of a parallel connection of a 11kΩ resistor to the supply and the base as well as 35 kΩ resistor between the base and the ground. Q_2 is coupled to Q_1 by a 30 pF capacitor between the emitter of Q_1 and the base of Q_2. The collector is connected directly to the supply (Vcc) while a 100Ω resistor is connected between the emitter and the ground. A 20 pF capacitor was also connected between the emitter and the ground to decouple it.

Transistor Q_3 (C3266) is mounted on the board, a 600Ω resistor is connected between the base and the ground to bias it, while a 60 pF capacitor is used to couple the collector of Q_2 to the base of Q_3. The replica of the resonance circuit as in Q_1 is connected between the collector of Q_3 and the supply (Vcc). At the emitter terminal, a 2.4 Ω resistor is connected to the ground. The output is tapped from the collector to the antenna.

In order to enhance the stability of the system, a 10pf capacitor is connected between the collector and the emitter of Q_1. This equally serve as a positive feed back.

3.2 CONSTRUCTION OF THE POWER SUPPLY UNIT

The secondary circuit of 240/12 volts transformer is connected to a bridge rectifier (PB205) while the primary circuit is taped out for A.C. input. However, not without a 3A fuse interface between the transformer and the A.C. main.

The DC output from the rectifier is fed to the filter capacitor 2200µF/25V. For a regulated DC output of 9 volt, an I. C. 7809 (9 volt regulator) is connected having its pin 1 connected to the positive terminal, Pin 2 to the ground and Pin 3 as the positive output, the DC out put voltage is re-filtered again by the connection of another 2200µF/16V capacitor across the circuit, thus generating a ripple free DC output of 9.28v.

N. B.

(1) The 9.28V output as the supply voltage against the designed 10V is occasioned by the non availability of a 7810 IC regulator on the shelf, thus a 7809 regulator was used instead. However the voltage level deficiency have no interference with the performance.

(b) All the construction where initially experimented on the bread board before transferring to the vero board for a permanent soldering when the desired output was achieved.

3.3 CONSTRUCTION OF CASING AND ASSEMBLY.

The construction of the system casing involved the use of a $\frac{1}{4}$ plywood sawn into various dimensions as follows:-

(220mm x 120mm) x 2 for top and bottom cover.

(120mm x 80mm) x 2 for front and end elevation.

(220mm x 80mm) x 2 for the two sides elevation.

For the plywood to be fastened together into the cuboid shape, a 1" plywood measuring:-

(1) (12mm x 10mm x 80mm) x 4

(2) (12mm x 10mm x 220mm x 4

were sawn. Two pieces of the 12mm x 10mm x 80mm and two piece of the 12mm x 10mm x 220mm were nailed to the four sides of the two piece of the 220mm x 80mm each accordingly. Subsequently, the front and the end elevation piece of plywood were fitted to the two ends by nail as well as the bottom, but the top was screwed unto it. However a hole of Ø 6mm is drilled on the top cover for the antenna. A 15mm x 5mm and 16mm x 5mm cut were made on the front view for the ON/OFF Switch and battery DC/AC Switch respectively while a Ø 3mm hole was drilled on the front cover for the power "ON" LED display, another Ø 3mm hole was drilled for the ac cord input to the circuit board.

Holes of Ø 2mm were drilled at the upper half of the two side elevations to permit air circulation into the box to keep the system at room temperature . Also drilled on the front panel is a Ø 3mm hole for microphone input jack.

For the internal connections and the mounting of the circuit board in the box, two piece of wood were nailed to the Button of the box and the circuit board is subsequently screwed into place. However before the mounting, the following electrical connections were made:-

i The A. C. power cord is connected to the primary of the transformer via a 3A fuse

ii The ON/OFF Switch is connected to the circuit board by two cables, red to the positive and black to the ground cables respectively.

Iii The negative pole from the 9V battery source and that from the power circuit supply (Ac source) were connected to the ground of the circuit and the positive to the common (Pin2) of the switch. The source positive is connected to Pin 1 while the battery positive is connected to Pin 3 respectively to switch between the two sources.

Iv The input jacks were connected between the ground and the 10kΩ variable resistor connected in series with Pin3 non - inverting input of the LM 386 IC

V The positive of the LED is connected to the positive supply circuit via a 2kΩ biasing resistor while the negative pole is connected to the groung.

Vi Finally the antenna output is coupled to the antenna pole on the top cover.

The assembly is completed by screwing the top cover accordingly as shown in figure 3.1 and plate 1

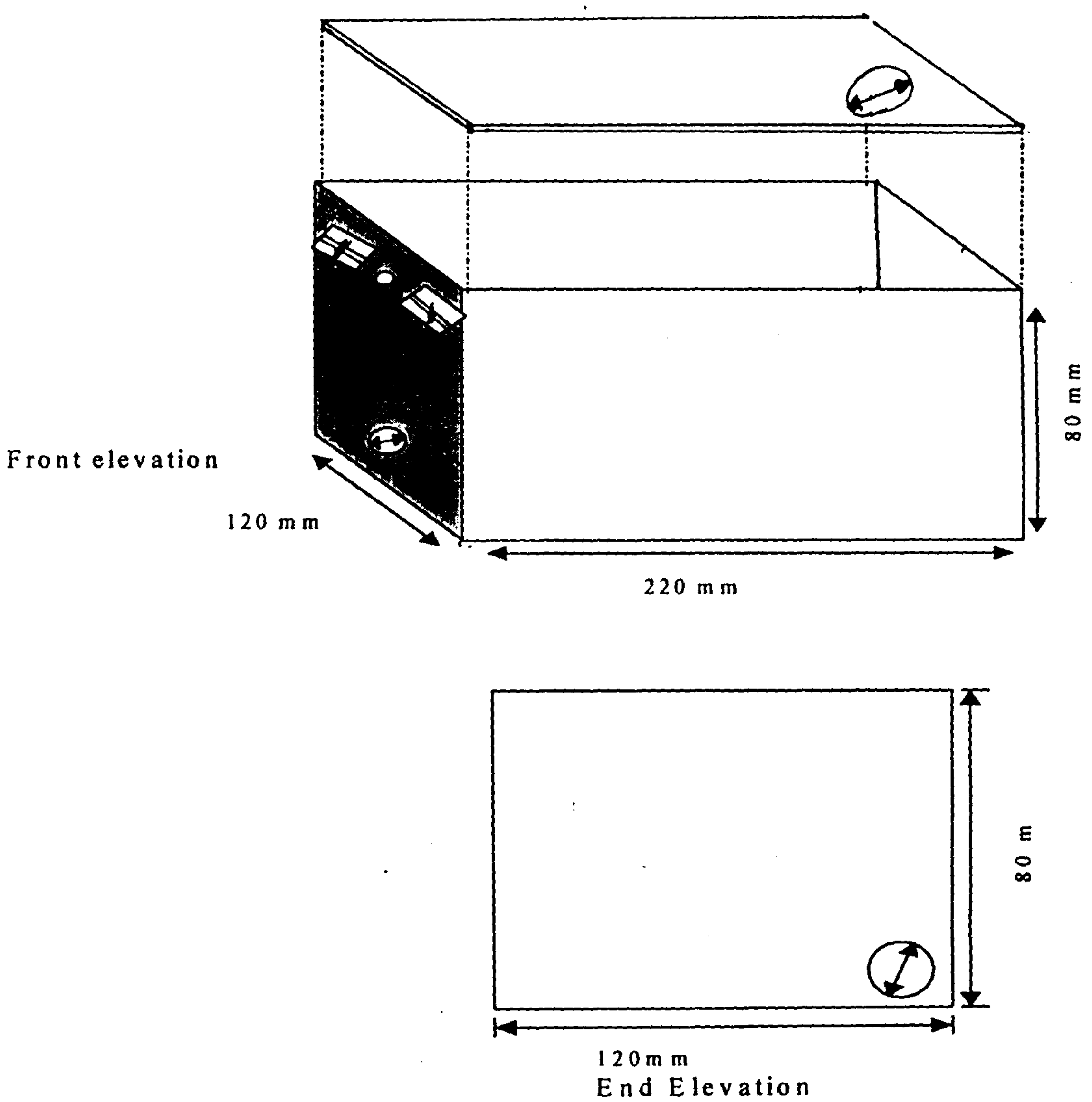

Fig 3.1 Construction of the casing

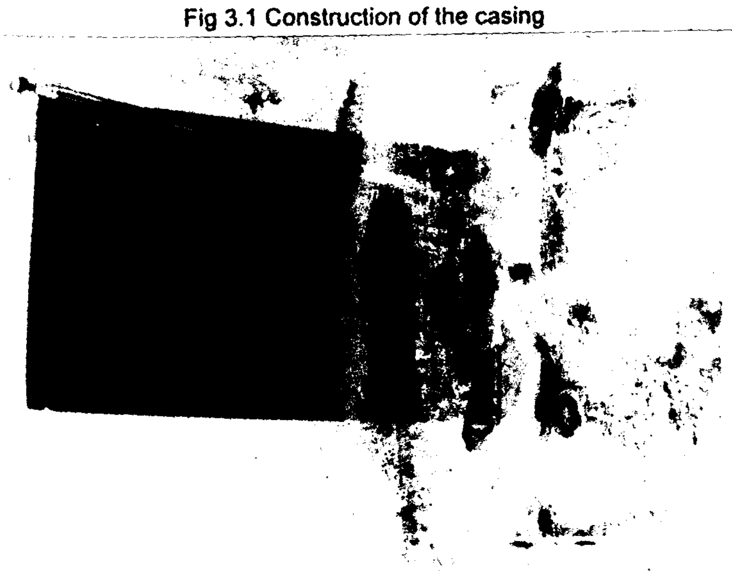

Plate 1 Photograph of the assembled system

3.4 TESTING.

Since the transmitter is designed to meet the requirements of monoaural and stereo transmission, it has to be tested to ascertain whether it conforms to the performance of a class A monoaural and stereo transmitter as stipulated by the Nigerian communication commission (NCC) and in the design objective

The testing was carried out by powering the system from an AC source and from a D.C. battery source, successively, the output between the antenna and the ground was fed to the oscilloscope to view the wave shape, and possible harmonic distortion. A digital multi meter was also used to measure the output voltage and current and the reading noted. With a radio receiver set, the coverage distance was measured.

3.5 RESULT

i. Output voltage 8.5V

ii. Output current 0.427A

iii Actual frequency of operation 98MH $_z$

IV Coverage distance 100 - 150 m

3.6 DISCUSSION OF RESULT.

The result obtained is consistent with the expected performance. Although the little discrepancies observed are not unconnected with the components used in the construction against those recommended in the calculated result. This is as a result of the non-availability of the calculated component values. Thus the approximated values were used. The output wave-shape expected from the oscilloscope was not possible due to the fact that the capability of the oscilloscope is limited to measuring a maximum of 20 MHz frequency.

CHAPTER FOUR

4.0 CONCLUSION AND RECOMMENDATION

The objective of the design was achieved in the construction. The constructed transmitter performs quite excellently for our chosen application. It is clear that the performance predicted from our design calculations and the measured results shows that they are in good agreement.

Although there are some discrepancies, most especially the output impedance and the operational frequency of the transmitter. The measured frequency is 98MH$_z$. This led to the examination of the measured and calculated properties of the transmitter in detail to identify the source of the discrepancies. The problem lies with the construction rather than the design considerations.

It is clear that a high degree of performance for a monoaural FM transmitter with ability for stereophonic transmission was achieved.

4.1 RECOMMENDATION

Students should be grouped to improve this project to cover multiplex transmission, with AFC (Automatic Frequency Control) network with greater output power of 1KW and later to 10 KW to cover Minna, the state Capital in the future.

The school authority should encourage the students who wish to under take this task with finance.

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Fig. 4.0 The 25W FM transmitter circuit diagram