# DESIGN AND CONSTRUCTION

# OF AN

# INDOOR WIRELESS AUDIO-VIDEO (AV)

# DISTRIBUTOR

## BY


## NLUMANZE.EMEKA.DONATUS
## 98/7090EE


**A PROJECT REPORT** submitted to the department of electrical and computer engineering, school of engineering technology, federal university of technology, Minna, in, partial fulfillment of the requirements for the award of bachelor of engineering degree (B.eng) in electrical and computer engineering.

NOVEMBER 2004

# DECLARATION

I, NLUMANZE, EMEKA, DONATUS hereby declare that this project report presented for degree of Bachelor of Engineering (B.Eng) is an original work and has never been presented either wholly or partially for the award of diploma or degree in any other instruction as far as I know.

The information derived from published work of others is acknowledged in the reference section.

6/12/09

Signature                                        Date

# DEDICATION

To Almighty God who has been my source of inspiration and guidance. Also to my parents Mr. & Mrs. D.O.NLUMANZE and family.

## ACKNOWLEGDEMENT

This project was a successful and rewarding one due to the assistance received from persons, which I'm grateful to. First to my supervisor, Mr. Ozomata David Ahmed, for his constructive criticism and advice contributed immensely to the success of this project. Then to my project partner, Odumodu N. Azubike, whose committed hard work ensured the success of this proiect? I am greatly grateful to my parents Mr. & Mrs. D.O.Nhmanze, for their care, encouragement and their spiritual backing. To my brother, sisters, nephews, nieces, cousins, uncles, aunts and in-laws. Thanks for your love and support.

To all members of NFCS, I can never forget you especially the year brethren (2002/2003 session). Electrical Computer Engineering students I love you all. I'll also like to acknowledge, a few of my friends who I remember. To my very treasured friends John Atebe, Edwin, Tayo, Roy, Sunny, Seyi, Nasiru, Tunde, Vivian, Nancy, Binta, Gloria, Edna, Uvie, Bimbo and too many others, I love you all.

To my inner caucus-Zubby, Maxwell, Femi, Bamaiyi, Don and Natho, We will get there I deeply appreciate you. You will never lack favors.

Lastly and most important, I give the greatest thanks to Almighty God for his inspiration.

# CERTIFICATION

This is to certify that this project "DESIGN AND CONSTRUCTION OF AN INDOOR WIRELESS AUDIO-VIDEO DISTRIBUTOR" was presented by NLUMANZE EMEKA. DONATUS of the department of Electrical Computer Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Minna and that he has met the required standard acceptable by the above named department.

………………………… 6/12/04

PROJECT SUPERVISOR DATE

Mr.Ozomata.David.Ahmed

………………………… 6/12/2004

HEAD OF DEPARTMENT DATE

Engineer M.D Adullahi

………………………… ………………

EXTERNAL EXAMINER DATE

# TABLE OF CONTENTS

# ABSTRACT

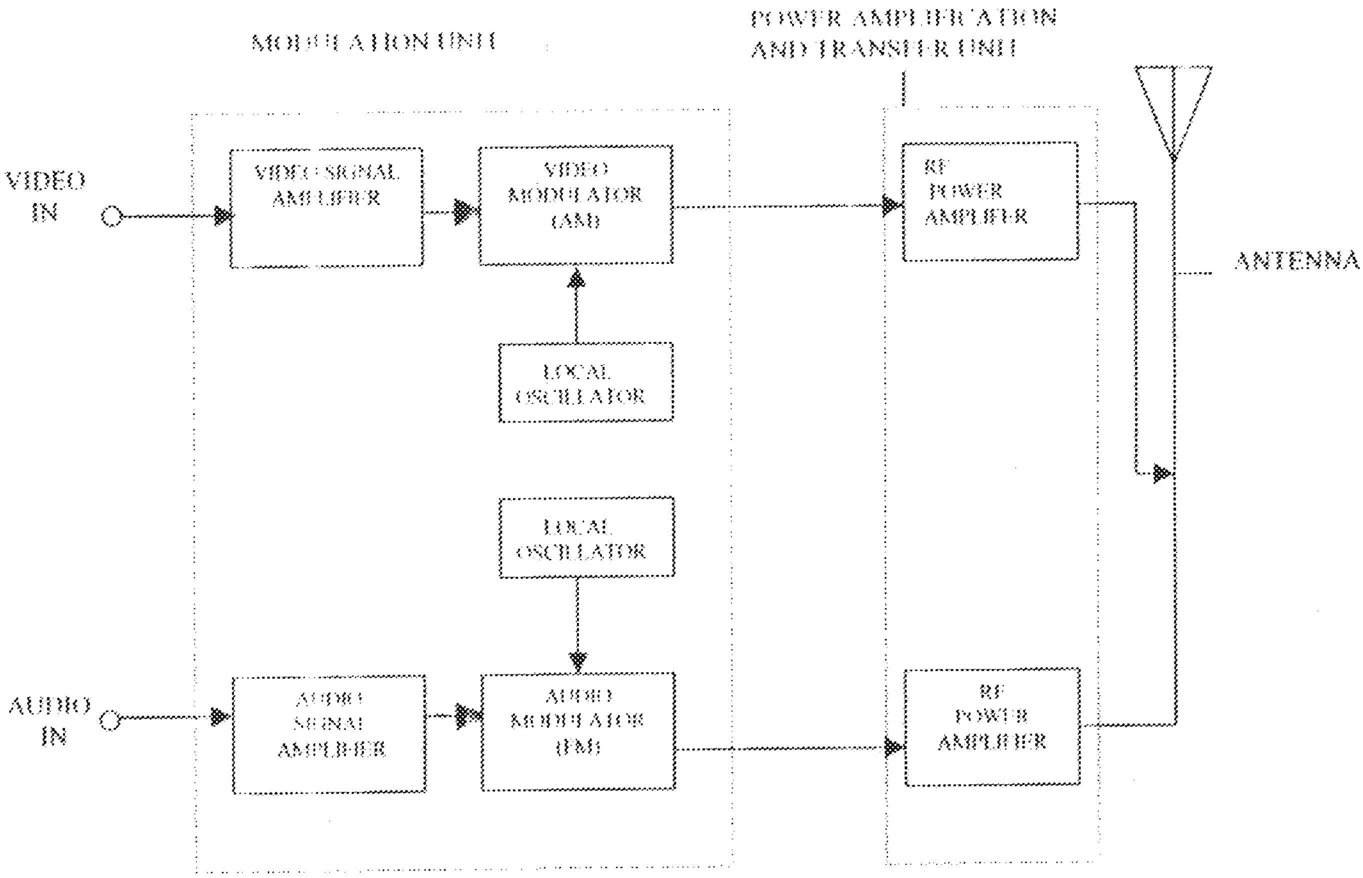
This report presents the design and construction of an Indoor Wireless Audio-Video (AV) Distributor an electronic circuit that distributes video content within a single facility via wireless means. The aim is to provide a situation where video from an input source satellite decoder, VCD/DVD player, VCR, etc can be received on different TV sets within a particular range without the use of cables; with economy, simplicity and good reliability. It features basically, a modulation unit and a power amplification and transfer unit; and its connection to an input source is made via AV ports. Recommendations for further work are also included in the report.

# Chapter One

## 1.0 Introduction

The indoor wireless audio-video (A/V) distributor is basically an electronic device that transmits video contents to televisions within a short radius of coverage. Its function is to distribute video within buildings such as hotels, halls, auditoriums, co-operate and residential buildings where ordinarily (and often) cables are used. Satellites, decoders, VCR's, VCD players, video cameras are among devices that could serve as AV sources For the device; their AV ports being the point of connection.

The circuit consists of two units that have different sections each as shown in fig.1.1, the modulation unit and the power amplification and transfer unit. The approach taken in this project is to assign the audio and video signals different carriers in which cases the modulation techniques applied are frequency modulation (FM) and amplitude modulation (AM) respectively, so that the standards for broadcast TV stations are taken after.




## 1.1 The modulation unit

This unit involves two circuit and use of mixers.

### 1.1.1 The amplitude modulation circuit

The input video signal is amplified and gets it to modulate its carrier and then it is filtered.

### 1.1.2 The frequency modulation circuit

The circuit amplifiers the input audio signals which frequency modulates its carrier and then it is filtered.

### 1.1.3 The power amplification and transfer unit

The unit is basically for sufficient transmission power and maximum power transfer to the antenna .it involves the use of RF power amplifier for both Am and Fm signals. This unit is given a lot of consideration, since it involves the transmission of signals through ceilings and walls as the device is for indoor purposes.

## 1.2 Literature Review

The television system is one, which incorporates fundamentally, two points-the transmitter and the receiver. The receiver is the TV set itself, which is quite common and has become part of every day life. the transmitter sends the signals which the TV set displays, therefore the existence of one is dependent on the other transmitters usually are found in broadcast stations except in special cases(especially where long range transmission is not required).the TV set itself is an electronic device that displays received signal on a screen and reproduces received sound signals on a speaker.

Technology for TV was first developed in the 19$^{th}$ century, before commercial radio was conceived of in 1859 when Ferdinand Braun invented the cathode ray tube to produce images and four years later Dr Ambrose Fleming patented the two-diode thermionic valve.

In 1884 Paul Nipkow the German scientist invented the scanning disk, which was the basis for almost all (mechanical) television systems for the next 50 years. Charles Francis Jenkins an American scientist invented the motion picture projector, and founded the SMPTE. His mechanical television system ("radio movies") was simple, cheap to produce. Kenjiro Jakayanagi, a Japanese engineer, a contemporary of Zworykin and

Farnsworth, demonstrated an electronic television system at the Hamamtsu Technical College in May 1928. He is considered the father of Japanese television.

In 1927 Philo Taylor Farnsworth patented the dissector tube, which was the first workable electronic camera tube. Manfred Von Ardenne a German scientist invented the electronic flying-spot scanning technique (1930) using a CRT as the source.

In the early 1930's Ulises A. Sanabria, a Chicagoan whose company, western television, produced mechanical TV equipment which featured interlaced scanning (45 lines in 3 fields) to reduce flicker, later he did research leading to infrared sniperscopes.

Vladimir Zworkin, a Russian who had moved to the USA in 1919, patented his iconoscope - the first practical television transmission tube. It's at this point, (or rather the following year), that Baird came onto the scene in a big way.

Although he had been developing his own methods of televised images for many years it was in 1924 that he first demonstrated a mechanically scanned television system, which transmitted objects in outline. During the late 1930's and early 1940's he demonstrated high-resolution and color television systems, and during World War II was rumored to have done secret radar work.

Since the time of Baird, the unsteadily rapid development of the medium of television has taken most of the ideas by those early, far-sighted pioneers and solidify them into a unified whole which has arguably become one of the key cornerstones of modern society.

## 1.3 Design Goals

The aim of this project is to provide a means by which video can be distributed without having too much hardware – cables; and therefore connectors, shields amplifiers etc.The motivation however comes from the fact that any link which use cables but can be established via wireless mode would provide more convenience if the wireless mode is used; moreover, this trend is becoming more popular. The ease of operation is also a clear advantage in this case.

With all these therefore, the obvious expectations are that the project, compared to using wire transmission will be more economical; and as a composite hardware that provides a transmission means, more easily managed and maintained.

## CHAPTER TWO

### 2.0 DESIGNS AND ANALYSIS

This chapter constitutes the main sections of this project, the power supply unit, the modulation unit and the power amplification and transfer unit. All the sections are logically treated for simplicity. Each of the sections are analysed based on method/theory and the necessary calculations follow. The calculated values are approximately close to those utilised in this project as much as possible

### 2.1 THE POWER SUPPLY UNIT

The power supply distributed in this country is 240V, 50HZ sinusoidal voltage (ac) and most electronic components and circuits require low direct (dc) voltages of about 5-15V.A regulated DC supply is therefore used in the design. A centre-tapped 240Vrms step down transformer is used to obtain a 25V supply .The reduced voltage remains an ac voltage and is rectified to regulate the voltage to dc.

The design comprises of a full bridge rectifier, made up of four silicon diodes (Two conduct during the negative half cycle). As shown in figure2.1, the output of the rectifier is a full wave rectified voltage Vo .By calculation, we have:

$$V_0 = 2V_s\sqrt{2}/\pi \qquad (2.1)$$

$V_0$ = Output Voltage

$V_s$ = Supply Voltage = 25Vrms

$\therefore V_0 = 2 \times 25 \times \sqrt{2}/\pi = 70.711/\pi = 22.508V$

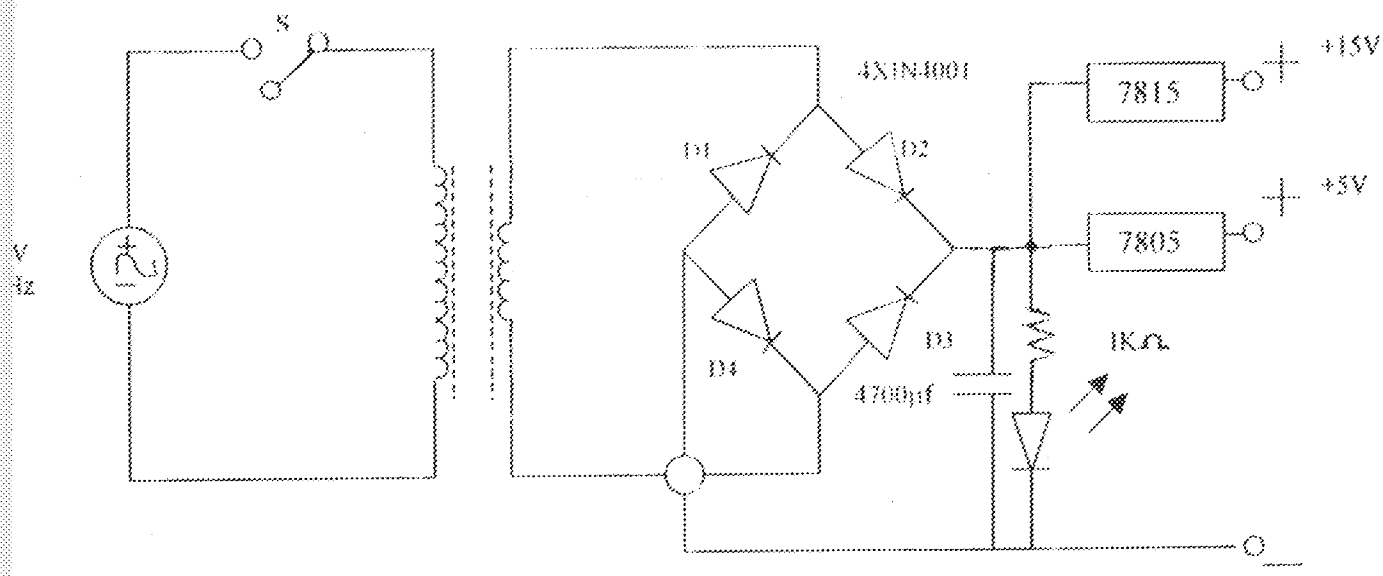



*Fig 2.1: Schematic Design Diagram of Regulated Power Supply Unit.*

The resulting voltage produced after rectification still has some ripples, which is not needed by the circuit components. They are removed by FILTERATION.

Filtration is the process of removing the unwanted ripples and pulses. To achieve this aim, a capacitor is used to produce the necessary smoothing. The capacitors used has a rating of 4700µF, 50V. This is because the working voltage of the capacitor should be at least twice that of the rectifier output. An almost ripple free unregulated dc power supply was produced at the output.

A light emitting diode (LED) is connected to the output as power output indicator. To obtain the value of the current limiting resistor for the LED, we have:

$R = V_0 - V_f / I$ where ______________(2.2)

$V_0$ = output voltage; $V_f$ = rated LED voltage, I = Rated LED current

=2V =20mA R= 22.508 –

2/20×10 = 20.508/20×10 = 10.3KΩ

A 1kΩ resistor is preferred.

The unregulated dc voltage 22.508 was regulated to 5V and 15V respectively. A constant dc supply is maintained by using an IC type regulator 7805 and 7815 for 5V and 15V dc respectively as required. These regulators are used because supply voltages are not constant and the dc voltage is directly proportional in magnitude to the value of ac supply.

## 2.2 THE MODULATION UNIT

### *2.2.1 Analysis of a typical VHF TV Channel*

The table below shows a typical industry standard for band allocation to channels.

| BAND | CHANNEL | FREQUENCY |
|---|---|---|
| Low – Band VHF | 2 – 6 | 54 – 72Mhz and 76 – 88MHz |
| High – Band VHF | 7 – 13 | 174 – 216 MHz |
| UHF | 14 – 69 | 470 – 806MHz |
| UHF | 70 – 83 | 806 – 890MHz |

*Table 2.1 : Band Allocation to Channels.*

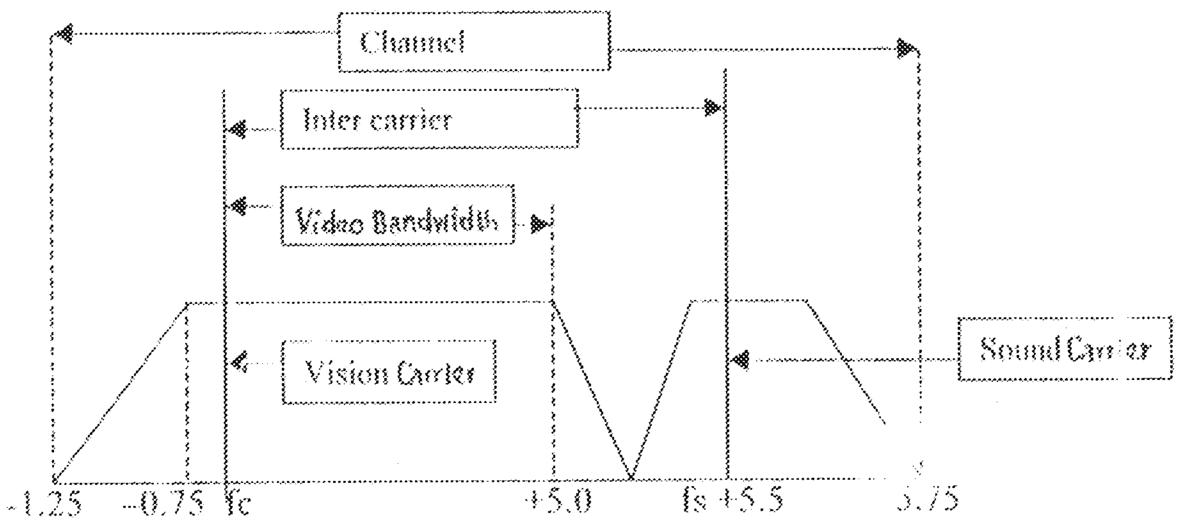



*Figure 2.2: Typical spectrum specification for VHF TV signal.*

From table 2.1 above, for this project design, the operating frequency is chosen from the High- Band VHF channels. Channel 7 is chosen as our working channel. It then coincides with the beginning of the vestige of the lower side band of the spectrum of figure 2.2, which is 174MHz. The spectrum of figure 2.2 is normally achieved with the vestigial side Band (VSB) approach of Amplitude modulation, but the employment of surface Acoustic wave (SAW) technique for the necessary filtering being part of it. With careful design however, combinations of reliable filtering are used in this design.

From figure 2.2, fC, is therefore obtained by: fc= operating frequency (vision Carrier), we have,

$f_c = 174 + 1.25$

$= 175.25MHz$ ____________ (2.3)

The sound carrier $f_s$, as seen also from fig 2.2 lies 5.5MHz above the vision carrier, therefore

$f_s = 175.25 + 5.5$

$= 180.75MHz$ ____________ (2.4)

Therefore fc and fs are the frequencies for video and audio carriers to be used in this design.

### 2.2.2 The Amplitude Modulation Unit

Amplitude modulation is used for modulating video signals. It is a technique in which the amplitude of the carrier signal is linearly varied in accordance with the instantaneous value of the modulating signal.

*The Amplitude Modulation Circuit is given below for detail analysis.*

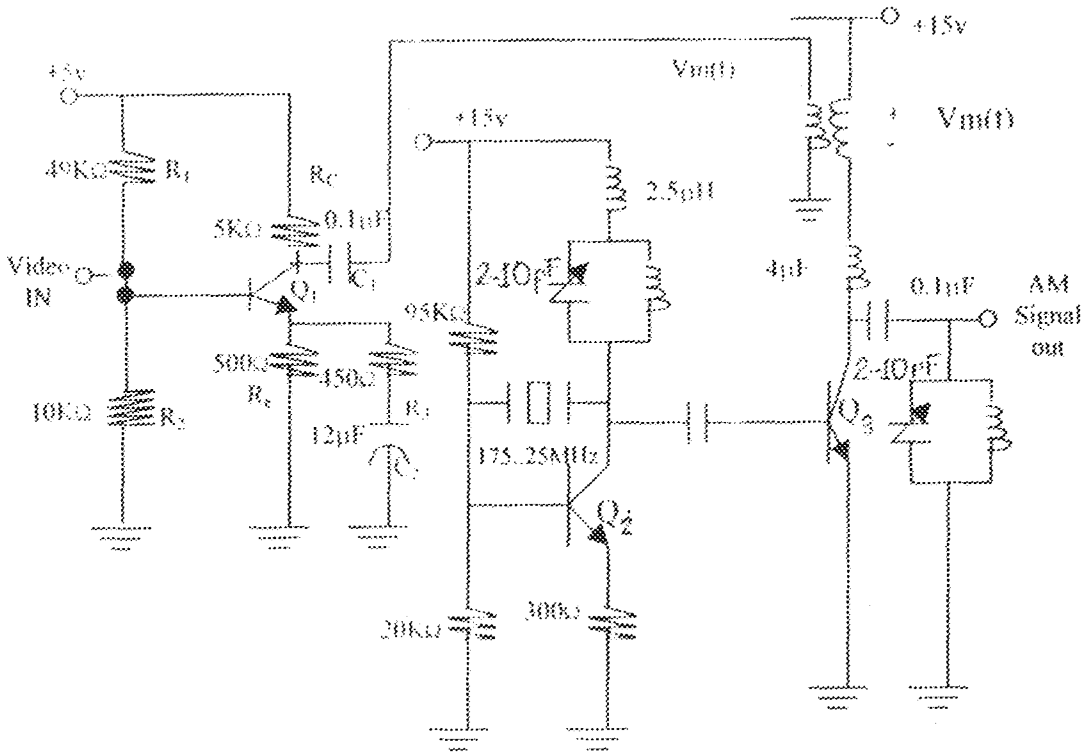



*Figure 2.3: Amplitude Modulation Circuit.*

The general from of a single - tone amplitude - modulated wave is mathematically expressed as

$$V_{AM}(t) = V_C ( 1 + m.Cos\omega mt) Cos\omega ct \quad \text{......} \quad (2.5)$$

Where the ratio $M = kVm/V_C$

M = Modulation depth of the AM signal

K is a constant of proportionality and a parameter of the circuit

$V_C$ = Amplitude of the carrier wave

Vm Amplitude of the modulating signal.

Q3 is a collector - modulated circuit that works as a power amplifier, which is used to achieve this. The modulating signal is applied in series with the dc supply voltage, the total low frequency supply voltage for the transistor is now:

$$V = V_{CC} + Vm\,(t) \quad \text{......} \quad (2.6)$$

$= V_{CC} (1 + m \cos \omega mt)$

Provided

$$V_m (t) = mV_{CC} \cos m\omega t \quad \text{.......................} (2.7)$$

The changing transistor supply voltage modulates the output signal amplitude proportionally, and the output voltage becomes

$$V_0 = V_{CC} (1 + m\cos \omega mt)\cos \omega ct$$

The power amplifier keeps $V_{CC} \cong V_C$ , therefore eqn(2.6) $\cong$ eqn (2.7) the LC tank at the output is tuned to the carrier frequency which the crystal oscillator circuit produces.

For the common-emitter amplifier circuit with Q1, the input video signal is amplified as required.

$I_C = 0.5mA$ is set

To center Vout (Vc) for $I_C = 0.5A$

$V_C = V_{CC} - I_C R_C$; $R_C = V_{CC} - V_C/I_C$

$V_C = 0.5V_{CC} = 0.5 \times 5 = 2.5V$

$R_C = 2.5/0.5 \times 10^{-3} = 5k\Omega$

$R_E = 500\Omega$ is chosen

$V_E = I_C R_E$

$= 500 \times 0.5 \times 10\text{-}3$

$= 0.25V$

$V_B = 0.25 + 0.6$

$= 0.85V$

For the ratio $R_1 : R_2$, to put $V_B = 0.85V$

$V_{CC} - V_B = 5\text{-}0.85$

4.15V

$R_1/R_2 = 4.15/0.85 \Rightarrow R_1/R_2 = 4.88$

$R_2 = 10K$ is chosen, $R_1 = 4.88 \times 10K = 48.8k\Omega$

$r_e = 25/Ic$ (mA)

$\Rightarrow r_e = 25/0.5 = 50\Omega \Rightarrow r_e = 50\Omega$ at $I_C = 0.5mA$

For a gain of 10

$Av = R_C/(r_e + (R_E // R_3))$

$10 = 5000/(50 + R_3)$ (the effect of $R_E$ is negligible )

$500 + 10R_3 = 500$

$R_3 = (5000 - 500)/10 = 4500/10 = 450\Omega$

Where the letter symbols used are defined as:

$V_{CC}$ = Collector supply voltage

$V_C$ = Collector voltage

$I_C$ = Collector current

$I_{CQ}$ = Quiescent collector current

$R_C$ = Collector resistance

$R_E$ = Emitter resistance

VBE = Emitter-Base voltage (≈0.6V for silicon)

$r_e$ = Intrinsic emitter resistance

The circuit $Q_2$ is a crystal oscillator circuit that generates the carrier frequency of 175.25MHz. While the LC tank is tuned to the same frequency. The combination of the two provides for good stability.

For the LC tank

$f_0 = 1/2\pi\sqrt{LC}$ ; $f_0$ = 175.25MHz

$LC = 1/(2\sqrt{f_0})\ 2 = 1/2\pi \times 175.25 \times 10^6)^2$

$8.25 \times 10^{-19}$

L is fixed at 0.1μH, $C = 8.25 \times 10^{-9}/0.1 \times 10^{-6}$ = 8.25pF

Therefore the variable capacitor chosen should be around this vicinity.

A 10pF variable capacitor is chosen.

C1 allows easy passage of the AM signal and provides good filtration.

The bandwidth of an AM signal BW = 2 fm.

Video signal range: 0 - 5MHz = fm

Maximum bandwidth BW = 2x5MHz = 10 MHz.

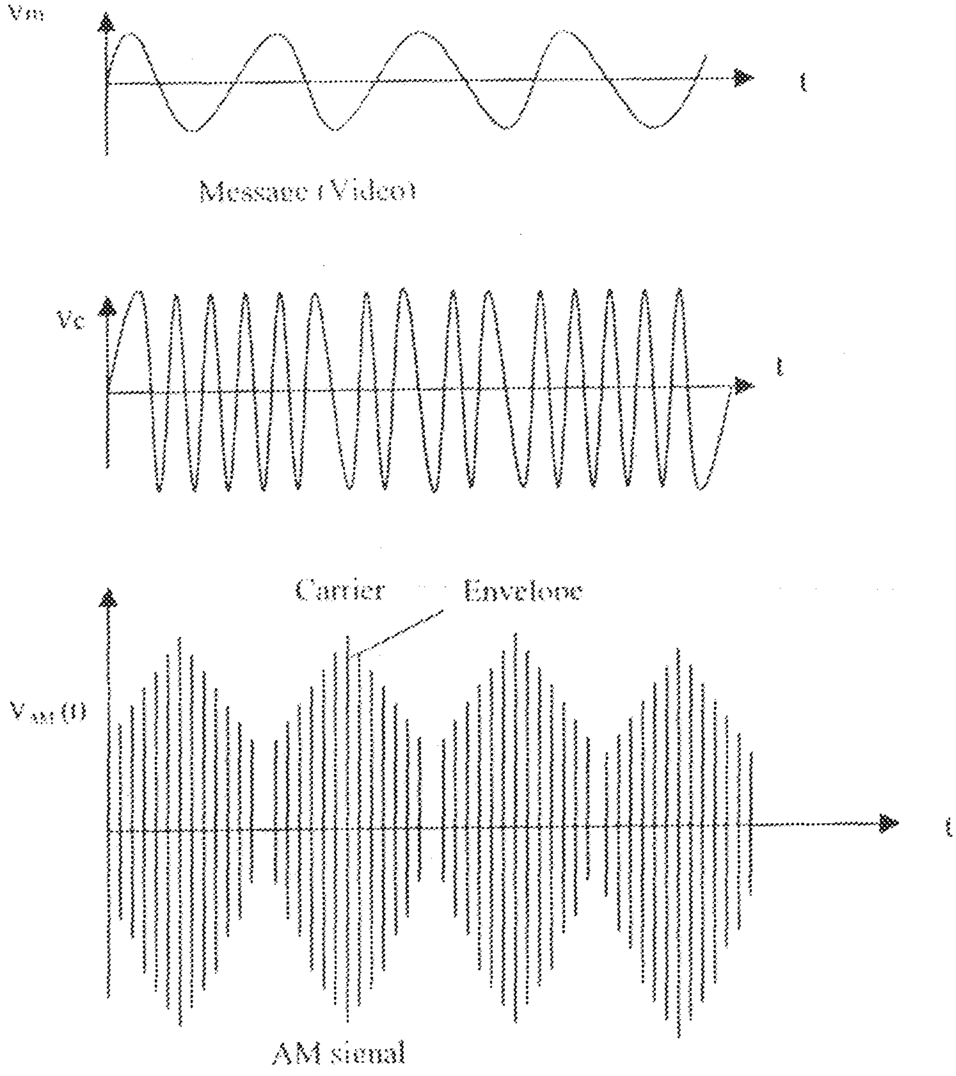



*Figure 2.4: Waveforms for Amplitude Modulation.*

### 2.2.3 The Frequency Modulation Unit

Frequency Modulation is used for the modulation of the sound carried by the audio signal. It is a process in which the instantaneous frequency $\omega(t)$ of the modulated wave is equal to the un-modulated carrier frequency $\omega_c$, plus a time-varying component that is directly proportional to the modulating signal.

***The Frequency Modulated Circuit***

From the definition given in 2.2.3,

$\omega(t) = \omega c + K_f Vm(t)$ ........................................(2.8)

Where $K_f$ =frequency sensitivity of the modulator circuit and measured in radians per volt-second if Vm(t) is a voltage signal.

Vm = Amplitude of the message signal

In relation to equation (2.8) the instantaneous frequency of an FM signal is thus

$f(t) = f_c + \Delta f \, Cos\omega mt$

Where $\Delta f = K_f Vm/2\pi$

fc = Carrier frequency

Vm = Amplitude of the message signal (which is the audio signal)

fm = Frequency of the message signal

($\Delta f$ is known as the frequency Deviation and is defined as the maximum departure of the instantaneous frequency of the FM wave from the carrier frequency, fc. The modulation depth $\beta = \Delta f/fm$)

The amplified message (audio) signal and a carrier frequency locally generated by the Collpits Oscillator network, are mixed as shown in figure 2.4 The varactor diodes do the mixing by providing the means of altering the resonant frequency of the tank circuit, hence the modulation. The positive feedback provides sustenance of oscillations.

The network with Q7 fixes the FM signal because the FM signal obtained at the stage before it is susceptible to differential changes based on changes in amplitude of the input message signal.

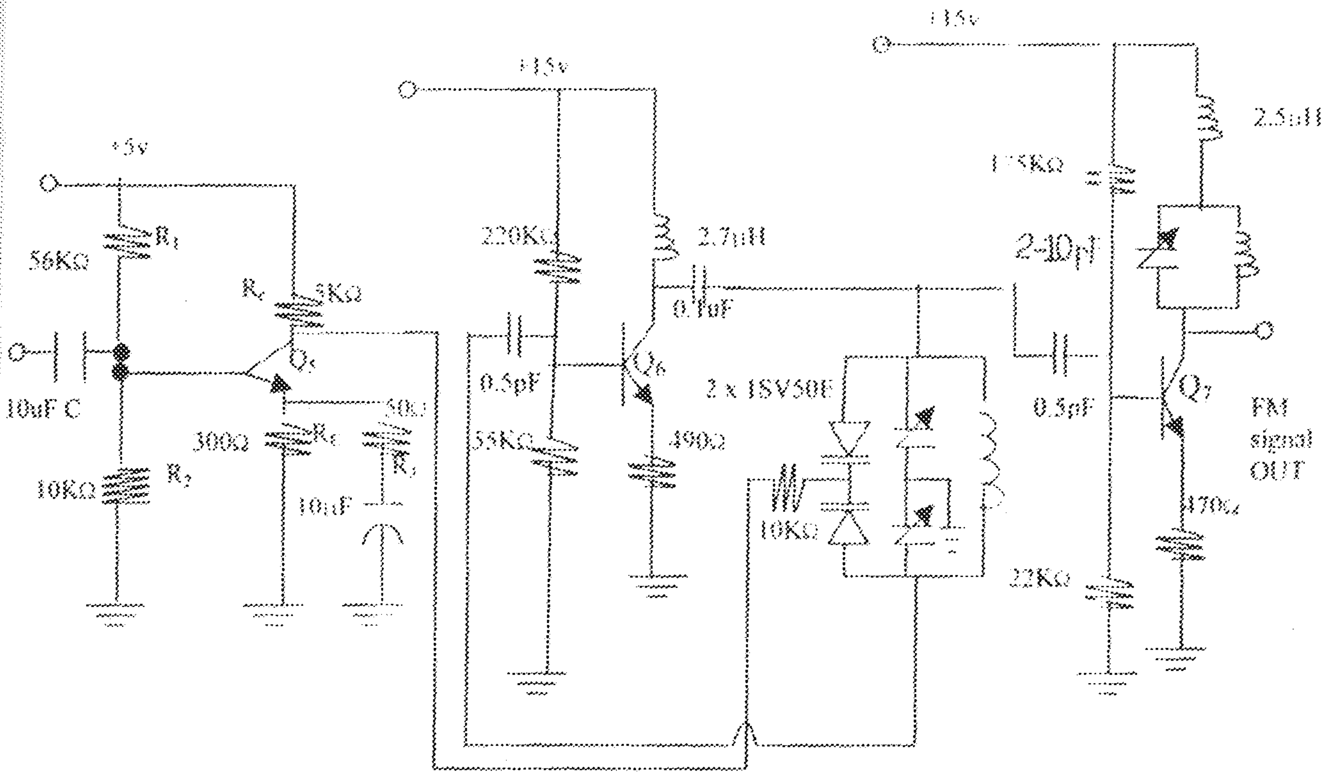



*Figure 2.5: Frequency Modulation Circuit.*

The network Q5 is a common-emitter amplifier circuit, which amplifies the input audio signal,

Ic = 0.5mA is set

To center Vout (Vc) for $I_C$ = 0.5mA.

$V_{CE} = V_{CC} - I_C R_C$; $R_C = V_{CC} - V_C / I_C$

$V_C = 0.5 V_{CC} = 0.5 \times 5 = 2.5V$

$R_C = 5 - 2.5 / 0.5 \times 10^{3} = 5k\Omega$

$R_E = 330\Omega$ is chosen

$V_E = I_E R_E$

$= 330 \times 0.5 \times 10^{-3}$

$= 0.165V$

VB = 0.165 + 0.6

$= 0.765V$

for the ratio $R_1 : R_2$ to put $V_B = 0.765V$

$V_{CC} - V_B = 5 - 0.765$

$= 4.235V$

$R_1/R_2 = 4.235/0.765 \Rightarrow R_1/R_2 = 5.53$

$R_1 = 5.53\ R_2$

$R_2 = 10k\Omega$ is chosen: $R_1 = 5.53 \times 10k = 55.3k\Omega$

$r_e = 25/Ic\ (mA)$

$r_e = 25/0.5 = 50\Omega \Rightarrow r_e = 50\Omega$ at $Ic = 0.5mA$

A gain of 50 is chosen (this gain is greater than that chosen for the video signal amplification because generally, for signals from AV ports, the audio signals are far smaller than those of the video)

$Av = R_L/r_e + (R_E // R_3)$

$50 = 5000/(50+R_3)$ (The effect of Re is negligible)

$2500 + 50\ R_3 = 500\ ;\ R_3 = (5000 - 2500)/50 = 2500/50 = 50\Omega$

The amplifier circuit incorporates a high pass filter and has to pass signal from 20Hz – 20KHz (Audio). This implies passing frequencies from 20Hz.

The relevant resistance is $R_3 + re = 50 + 50 = 100\Omega$

$f = 1/2\pi\ R_{in}C\ ;\qquad C = 1/2\pi f\ R_{in}$

$R_{in} = R_{th}\ (bias) // h_{fe}(r_e + R_3)$

$R_{th}\ (bias) \simeq R_2 = 10K\Omega$

$Rin = 10^3 // (100 \times 100)$

$= 10^3 // 10^4$

$= 909.09\Omega$

$C = 1/2\pi \times 20 \times 909.09$

$= 8.75 \times 10^{-6}$

A 10nF capacitor is preferred.

C in combination with $R_2$ therefore forms a high pass filter suitable for passing audio signals.

For the Colpitts Oscillator, operating frequency, we have

$F_0 = 1/2\pi\sqrt{LC_0}$

$C_0 = C_1C_2 \quad /C_1+C_2$ ............................................ (2.9)

Co from the circuit diagrams of figure 2.4 is a ganged capacitor.

$LC_0 = 1/(2\pi f_0)^2$ fo is set at 181MHz instead of 180.75MHz of the carrier since the output will depend on the amplitude of the message signal.

$LC_0 = 1/(2\pi \times 181 \times 10^6)^2$

$= 7.73 \times 10^{-19}$

L is fixed at 0.1μH: $C_0 = 7.73 \times 10^{-19} / 0.1 \times 10^{-6} = 7.73pF$

$C_1C_2/C_1+C_2 = 7.73pF$ ................................ (2.10) Co is chosen to be around this vicinity. A 10pF-ganged capacitor is therefore chosen.

Let RFC (2.7μH) = L, then Reactance at $f_0$ = 181MHz, $X_L = 2\pi f_0 L$

$= 2\pi \times 181 \times 10^6 \times 2.7 \times 10^{-6}$

$= 3.07K\Omega$

Feed back fraction = $\frac{\text{Drop Across } C_2}{\text{Drop Across } C_1} = IX_{C2}/IX_{C1} = C_1/C_2$

From simulations, this was found to be = 0.16 ............................(2.11)

Minimum gain to sustain Oscillations,

$$Av\ (min) = \frac{1}{\text{Feed back fraction}} = \frac{1}{0.16}$$

$Av = R_c / R_E \therefore R_E = R_c$ ; $X_L$ represents $R_c = 3.07K\Omega$

$$R_E = \frac{3.07 \times 10^3}{6.25}$$

$= \quad 0.49 \times 10^3$

$= \quad 490\Omega$

To obtain theoretical values of $C_1$ and $C_2$ at the instance when 181MHz is turned.

From equation (2.10)

$C_1C_2 = 7.73\ (C_1 + C_2)$ ........................................................................ (2.12)

From equation (2.11)

$C_1 = 0.16C_2$ ........................................................................................ (2.13)

Substituting (2.13) into (2.12)

$0.16\ C_2 \times C_2 = 7.73\ (0.16C_2 + C_2)$

$0.16C_2^2 = 8.97C_2$

$C_2 = 56.04pF$

Substituting $C_2$ back into (2.12)

$56.04C_1 = 7.73\ (C1 + 56.04)$

$7.25C_1 = C_1 + 56.04$

$6.25C_1 = 56.04$

$C_1 = \frac{56.04}{6.25}$

$= 8.97pF$

$V_C = 0.5V_{CC} = 0.5 \times 5 = 2.5V$

$\therefore I_C = (V_{CC} - V_C)/R_C = 5\text{-}2.5/3.07\text{x}10^3 = 2.5/3.07\text{x}10^3$

$\therefore V_E = I_E R_E\ ;\ I_E = I_C$

$\therefore V_E = 0.8\text{x}10^{-3}\text{x}500$

$= 0.4V$

$VB = 0.4 + 0.6 = 1V$

For the ratio R1:R2

$V_{CC} - V_B = 5\text{-}1 = 4.0V$

$R_1/R_2 = 4/1 \Rightarrow R_1 = 4R_2$

$R_2 = 55K\Omega$ is chosen. $\therefore R_1 = 55 \times 4 = 220K\Omega$

The LC tank of Q7 fixes the desired FM frequency (180.75MHz)

$f_0 = 1/2\pi\sqrt{LC}$ ; $f_0 = 180.75MHz$

$LC = 1/(2\pi f_0)^2 = 1/(2\pi f_0 \times 180.75 \times 10^6)^2$

$= 7.75 \times 10^{-19}$

L is fixed at 0.1μH: $C = (7.75\times10^{-19})/(0.1\times10^{-6}) = 7.75pF$

The capacitor should be around this vicinity. A 10pF variable capacitor is chosen.

The resulting FM signal is considered a narrow band FM. Since long distance transmissions are not required, this is quite sufficient. In this case therefore, Bandwidth of the FM signal

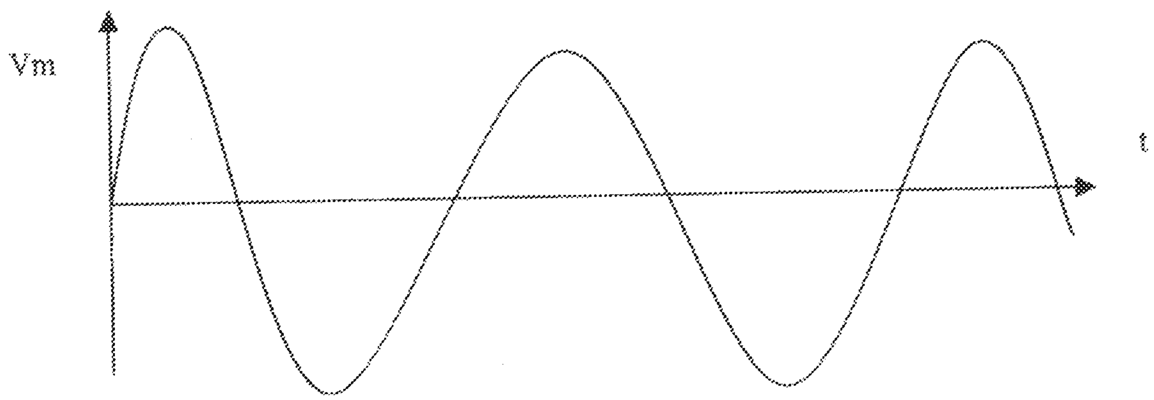
$BW = 2fm$

Audio signal range: 20Hz – 20KHz

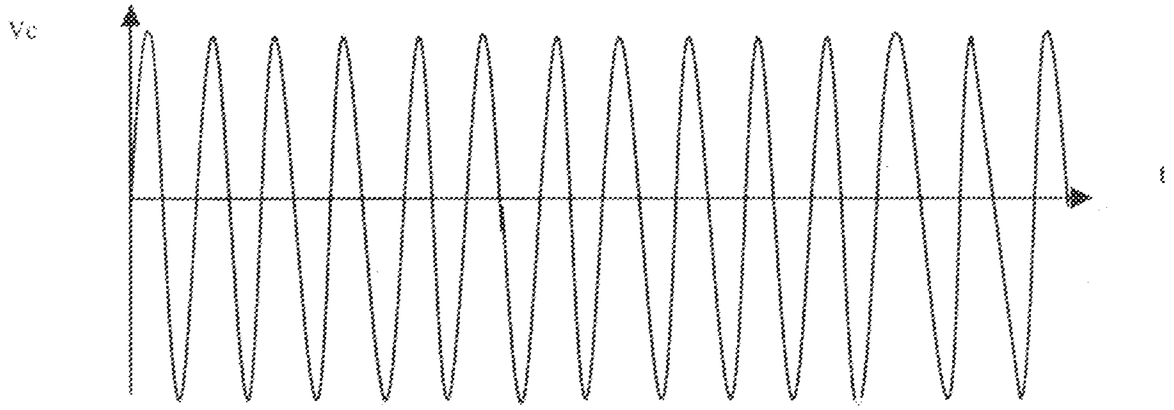
∴ Maximum BW = 2 x 20KHz = 40KHz

Modulation index β for this type of FM is known not to exceed 0.02.

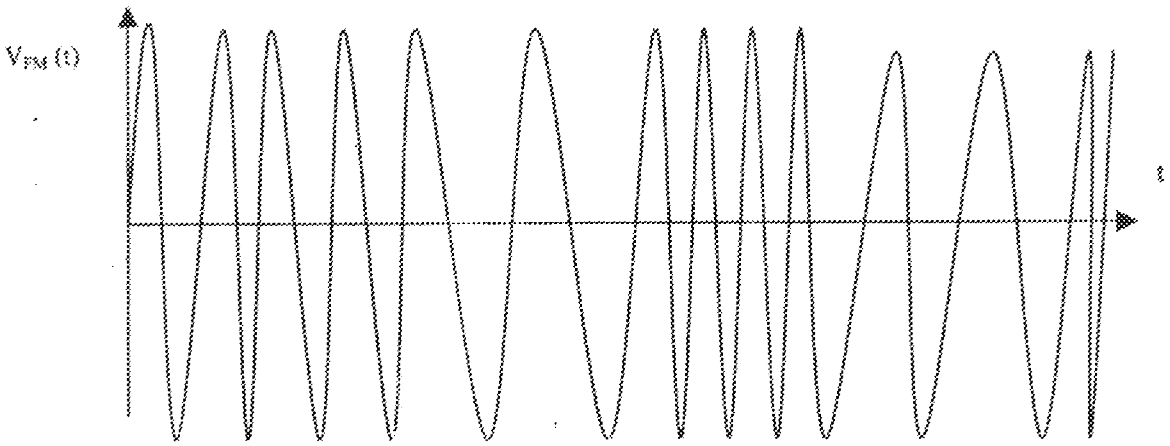
## FM WAVEFORMS




Message (Audio) signal




Carrier signal




FM signal

*Figure 2.6: Waveforms for Frequency Modulation*

## 2.3 THE POWER AMPLIFICATION AND TRANSFER UNIT

This unit constitute mainly of separate amplification of the powers of the AM and FM signals respectively, and their combination so that transmission is done via one antenna. The unit provides sufficient power for transmission to aid good reception.

### 2.3.1 AM Power Amplification

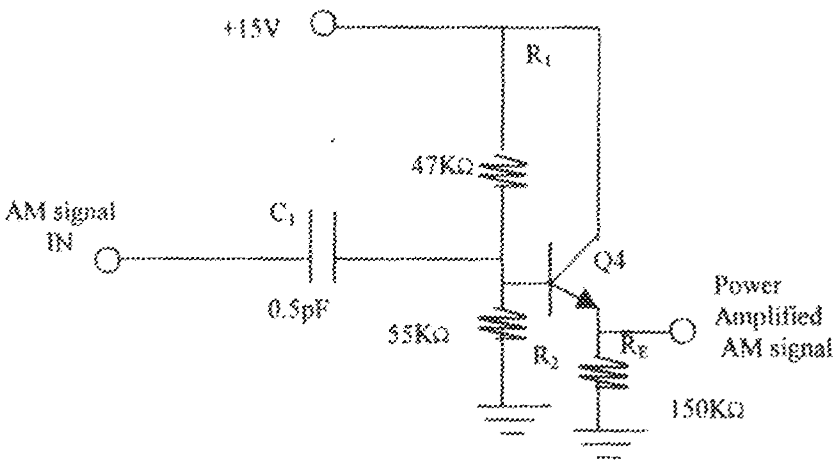



*Figure 2.7: AM Signal Power Amplifier Circuit.*

For power amplification a large change in current is required, therefore an emitter follower amplifier as in figure 2.7 is used.

$R_E = 150\Omega$ is chosen (for purposes of matching with $75\Omega$ antenna)

$I_C = (V_{CC}-V_C)/R_E$ ; $V_C = 0.5 \times 15 = 7.5V$

$I_C = (15-7.5)/150 = 0.05A$

$I_C \simeq I_E \therefore I_E = 0.05A$

$V_B = 7.5 + 0.6 = 8.1V$

For ratio $R_1:R_2$, $15 - 8.1 = 6.9V$

$R_1/R_2 = 6.9/8.1 \Rightarrow R_1/R_2 = 0.85$

$R_1 = 0.85R_2$

$R_2 = 55K\Omega$ is chosen $\therefore R_1 = 0.85 \times 55K = 47K\Omega$

### 2.3.2 FM Power Amplification

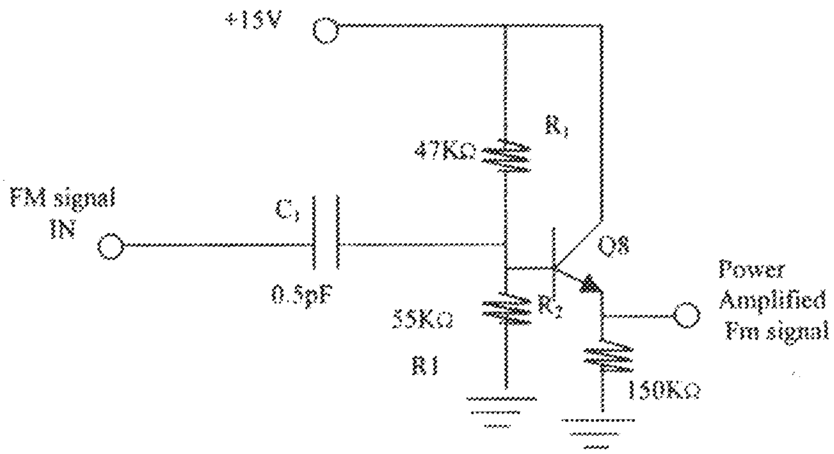



*Figure 2.8: FM Signal Power Amplifier Circuit.*

RE = 150Ω is chosen

$I_C = (V_{CC}-V_C)/R_E$ ; $V_C = 0.5 \times 15 = 7.5V$

$I_C = (15-7.5)/150 = 0.05A$

$I_C \simeq I_E \therefore I_E = 0.05A$

$V_B = 7.5 + 0.6 = 8.1V$

For ratio $R_1$:$R_2$, 15 - 8.1 = 6.9V

$R_1/R_2 = 6.9/8.1 \Rightarrow R_1/R_2 = 0.85$

$R_1 = 0.85R_2$

$R_2 = 55K\Omega$ is chosen $\therefore R_1 = 0.85 \times 55K = 47K\Omega$

### 2.3.3 Combined Power Transfer to Antenna and Impedance Matching

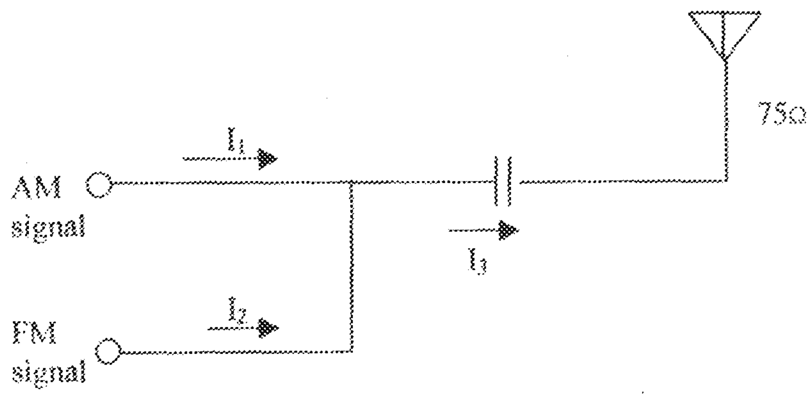



*Figure 2.9: Representation of Combined Power Transfer to Antenna.*

From 2.3.2, $I_1 = I_2 = 0.05A$

From figure 3.9, KCL: $I_3 = I_1 + I_2$

$$\therefore I_3 = 0.05 + 0.05$$

$$= 0.1A$$

$V = f\lambda;\ \lambda = V/f$

V = Speed of Light = $3.0 \times 10^8$m/s

f = Operating Frequency = 175.25MHz

λ = Wavelength of the Signal

$$\therefore \lambda = \frac{3.0 \times 10^8}{175.25\times10^6} = 1.71\text{m}$$

The height of the antenna is at least $l = \lambda/4$.

The antenna is considered therefore, a Hertzian (Dipole) type.

$$\therefore L = 1.71/4 = 0.43\text{m}$$

Radiated power

$P = 80\pi^2\ (l/\lambda)^2\ I^2$ ( $I = I_3$ in this case)

$= 80\pi^2 (0.43/1.71)^2 \text{ X } (0.1)^2$

$= 0.5 = 500$mW

Power dissipated

$P_r = I^2R$; R= Antenna Impedance = 75ω

$= (0.1)^2 \times 75$

= 0.75 = 750mω

For impedance matching, from figures 3.7 and 3.8,

$R_{E1} = R_{E2} = 150\Omega$

In combination, $R_{E1} // R_{E2} = 150 // 150 = 75\Omega$.

This matches the antenna impedance.

# CHAPTER THREE

## 3.0 CONSTRUCTIONS, TEST AND RESULT

The design specification of each component of this project was followed strictly except in cases of non-availability of components.

A prototype on the temporary location of breadboard and the proper construction at the completed design on the Vero board. Testing was carried out at both stages and results taken and analysed to ensure that they were within design error.

## 3.1 HARDWARE CONSTRUCTION, TESTING AND RESULT

The different components were connected according to design on breadboard and then tested ok on breadboard for each module before it is transferred the to Vero board. The details of the process are given below.

### 3.1.1 THE POWER SUPPLY UNIT

This unit consists of a 240V/25V transformer, a bridge rectifier, resistor (current limiting), LED and an ON-FF switch.

The output measured was 25V when the primary winding of the transformer was connected to the ac mains supply and the 25V (secondary) terminals were connected to the ac input terminals of the bridge rectifier. The bridge rectifier was soldered unto the Vero board having given the required output and the terminals of the 4700µF capacitor were connected (on board) to those of the rectifier output. .

A 1KΩ current limiting resistor was connected to the power indicator LED before it was taken to ground. The terminals were connected to the 15V and 5V dc voltage regulators respectively and measurement with a multimeter showed they gave the required outputs.

### 3.1.2 THE AMPLITUDE MODULATION UNIT

This consists of a video signal amplifier, a 175.25MHz crystal oscillator circuit and a mixer circuit. The mixer circuit consists of a VHF power amplifier, which allows the modulation of the carrier signal by the amplified video signal; both of which are fed to it. The 47KΩ and 10KΩ used in biasing the resistors were soldered very closely and the 5KΩ collector and 500Ω emitter resistors were connected with respect to the corresponding terminals of the BC548 transistor, which serves as the amplifier. The 450Ω resistor and 12μF capacitor serve as a blocking capacitor for dc, and their emitter terminals are and grounded for stability. Output from the collector of the amplifier was measured and the voltage was found to be about 10 times that of the input signal used during the test. The 175.25MHz crystal oscillator was soldered between the base (on the bias) and collector of the 2N5109 transistor. The 0.5pF was soldered to one terminal of the crystal oscillator before it was taken to the emitter.

The 10pF Variable capacitor and the fixed inductor of the collector-tuned tank were connected in parallel and connected in series with the 2.5μH RFC. The filtering 0.5pF capacitor was soldered directly to the base of the C1970 power transistor. One input terminal of the IF transformer was connected to the output of the video amplifier with the filtering 0.1μF capacitor soldered in-between; and the other terminal was soldered to ground. One output terminal of the IF transformer was connected to the 15V supply and the other to the 4μH RFC. The LC tank having same configuration as that of the crystal oscillator circuit was soldered and tuned exactly to the frequency of the crystal oscillator circuit. The tuning was done with the aid of an oscilloscope. The filtering 0.1μF and the 0.5pF capacitors were connected before and after the LC tank.

### 3.1.3 The Frequency Modulation Unit

This unit consists of an audio signal amplifier, a collpits oscillator network and frequency-fixing network.

For the audio signal amplifier, the 56KΩ and 10KΩ resistors were soldered closely. The 5KΩ collector and 330Ω emitter resistors were connected and soldered to their respective terminals on the BC548 transistor. The 9μF capacitor was connected and soldered unto the BC548 base (in-between the bias) forming a high pass filter with the 10KΩ resistor.

The 50Ω resistor and 10μF capacitor were connected together and the negative pole of the capacitor was connected and soldered to ground. At this stage, the output from the collector of the BC548 was measured and the voltage was found to be about 50 times that of the input signal used during the test.

The bias resistors were fixed closely and the 2.7μH RFC was connected and soldered to the collector of the 2N5109 transistor. This is for the collpits oscillator. The 0.1μF filtering capacitor was connected and soldered to the collector output and then connected to the tuned LC tank. The ganged capacitor (10pF) was connected and soldered in parallel with the fixed inductor; and the tank with the aid of an oscilloscope, was tuned to about 181MHz.

The varactor diode, which alters the resonant frequency of the tank to produce modulation, were connected and soldered back to back, and fed in between with the output of the audio amplifier.

The 10KΩ resistor was connected and soldered, which acts as a current limiting resistor to prevent excess current from the varactor diode.

For the frequency-fixing network, the LC tank was tuned to 180.75MHz to fix the generated FM signal at the desired frequency. Extra care was taken in doing this. The LC tank was connected and soldered in series with the 2.7μH RFC. Connection was made between the collector and the emitter of capacitor soldered in between. This was done for the positive feedback to the 2N5109 transistor with the 3.3pF be achieved. The 0.5pF filtering capacitor was connected and soldered to the 2N5109 collector output.

### 3.1.4 The AM Power Amplifier

The 47KΩ and 55KΩ bias resistor were connected and soldered closely forming a bias with the output of the modulator circuit connected to the base

Of the C1970 VHF power transistor. The 150 resistors was connected and soldered to the emitter of the transistor.

### 3.1.5 The FM Power Amplifier

The 47KΩ and 55KΩ bias resistors were soldered closely unto the base of the C1970 transistor. The output of the FM frequency network was then soldered unto the base (in-between the resistors). The 150Ω emitter resistor was connected and soldered. At the time of test the output of the power amplifier measured around the desired value.

### 3.1.6 Combined Power Transfer to the Antenna

The AM and FM signal operating frequencies were checked with an oscilloscope to ensure synchronization between the received picture and sound.

The amplified output signal of FM signal was the connected to that of the amplified AM signal and a large capacitor (1µF) was connected and soldered to the combined output and was then connected to the antenna.

The circuit was checked for any open or short circuit, and then was tested by connecting it to a VCD player, which had been connected via cables to a TV set. About Two other TV sets in that areas were then toned and the signals were picked from the circuit. The TVs were placed at about 12m away from the device. The picture and sound were clear. The sensitivity of the system can therefore be deduced from this point.

## 3.2 SOLDERING, CASING AND FINISHING

Care was taken in soldering of the various components and the workshop norms were strictly adhered to obtain good results. Steps that were taken to this respect are stated as follows:

The Vero board was first cleaned of dust and any particles to ensure lasting joints. The thin type of lead (0.5) was used for proper contact.

Easier and faster soldering was ensured by thinning the lead. of the components. A 40ω soldering iron was used to prevent damage to components due to overheating.

Connections and soldering were made as close as possible, and also connecting wires, they were made as short as possible to minimize inductive and capacitive strays: and interference which must be guarded against as the project is communications inclined.

A suitable size casing was used for the device; the casing size is about 8 ½ by 5 ½ by 4 ½ inches, and a good finished work was produced.

## CHAPTER FOUR

### 4.0 CONCLUSION AND RECOMMENDATION

In the design and construction of the Indoor Wireless AV distributor, the most disturbing problems encountered had to do with the availability of components: some of them were just not readily available where ordinary they should. Special arrangement had to be made in this respect and in some cases equivalent of components were utilized.

In any case, the engineering sense of minimum input with maximum output was maintained.

The project also, being one of communications, was quite tasking because of the extra care that had to be taken in working with frequencies. With respect to the objectives spelt out in carrying out this project, the required results have been obtained.

The Indoor Wireless Audio Video Distributor, having been designed and constructed, has from tests, shown to be capable of transmitting Video to TVs within a workable radius of coverage.

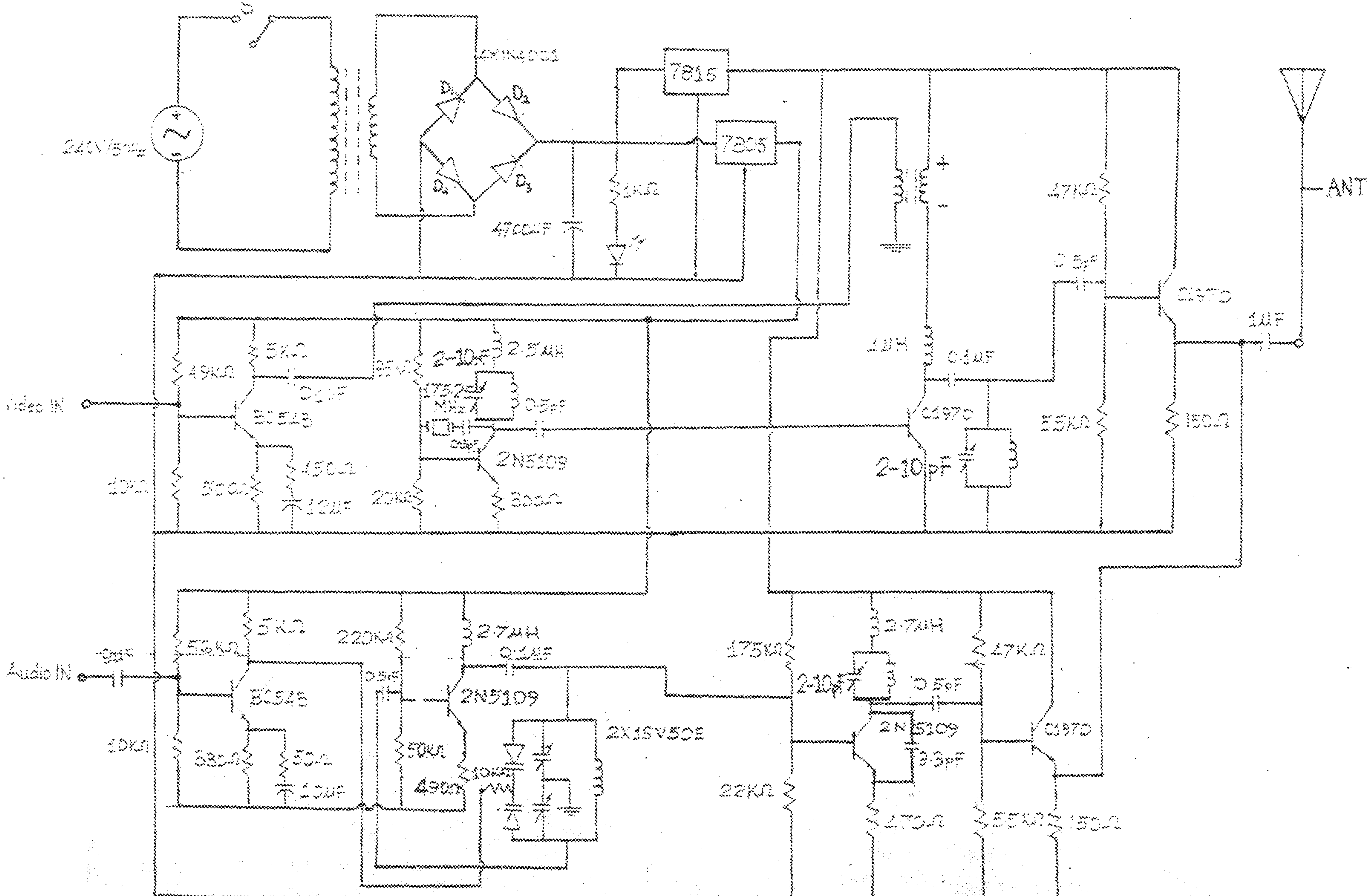
It is recommended that for further work, some control means should be included in the design so that issues of unwanted reception could be taken care of. A calibration could do this job. The size of the building where the distributor is to work will determine the radius of coverage to be selected. Computer Aided Design (CAD) should be made an integral part of some of the computer technology courses of the department.

This would go a long way in helping students carry out excellent designs and construction with the advantage of ease and flexibility.

# REFERENCES


| | | |
|---|---|---|
| 1. B.L. Theraja<br>A.K. Theraja | A TEXT BOOK OF ELECTRICAL TECHNOLOGY<br>Chand & Company Ltd, New Delhi, 1999<br>ISBN 81-219-1473-6 Pg 1795-1823; 1825; 1947; 1961. |
| 2. D.C. Green | TRANSMISSION SYSTEMS<br>Pitman Publishers Ltd, London, 1984<br>ISBN 0273018264 |
| 3. Jack Smith | MODERN COMMUNICATION CIRCUITS<br>Long and Sons Ltd, 1986<br>ISBN 0-07-058730-2 |
| 4. John Watson | MASTERING ELECTRONICS 4$^{TH}$ EDITION<br>Palgrave, New York, 1996<br>ISBN 0-333-66970-3 |
| 5. Paul Horowitz<br>Winfield Hill | THE ART OF ELECTRONICS, 2$^{ND}$ EDITION<br>Cambridge University Press, UK, 1989<br>ISBN 0-521-49846-5 |
| 6. Thomas C. Hayes | STUDENT MANUAL FOR THE ART OF ELECTRONICS<br>Cambridge University Press, UK, 1995<br>ISBN 0-521-49847-3 Pg 84 -100; 115 -117 |

| | |
|---|---|
| 7. V. Dzhakonin (Edition) V. Kuznetsov (Translation from the Russian to English) | TELEVISION<br>Mir Publishers, Moscow, 1986<br>ISBN 5-03-000236-7 |
| 8. Yinusa A. Adediran | TELECOMMUNICATIONS: PRINCIPLES AND SYSTEMS<br>Finom Associates, Minna 1997.<br>ISBN 978-33101-3-5 Pg 14 – 18, 36; 48 – 54; 92, 136 – 144 |



S
240V/50Hz
4X1N4001
D1
D2
D3
D4
7815
7805
4700uF
+
-
ANT
47KΩ
0.5pF
C1970
1uF
1uH
0.1uF
150Ω
2-10pF
Video IN
49KΩ
5KΩ
BC548
2-10pF
2.5MH
17.734
MHz
0.5pF
2N5109
20KΩ
Audio IN
BC548
5KΩ
56KΩ
220KΩ
2.7MH
0.1uF
2N5109
2X15V50E
50KΩ
490Ω
10KΩ
175KΩ
2.7uH
47KΩ
0.5pF
2N5109
3.3pF
22KΩ
470Ω
150Ω