DESIGN AND CONSTRUCTION OF AN FM TRANSMITTER AND RECEIVER FOR PUBLIC ADDRESS SYSTEM

BY

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A PROJECT REPORT SUBMITTED TO THE

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, MODIBBO ADAMA UNIVERSITY OF TECHNOLOGY, YOLA, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF ENGINEERING

JANUARY, 2020

Declaration

I **Ujah, Obiabo Kenneth**, hereby declare that this report was written by me and it is a true record of my own research work. It has not been presented before in any previous application for bachelor's degree. Reference made to published literature have been duly acknowledged.

Sign…………………………… Date…………………………….

Ujah, Obiabo Kenneth

(Student)

The above declaration is confirmed by

Sign…………………………… Date…………………………….

Engr. Mrs. Oriolowo Niyi Zara

(Supervisor)

Certification

This project entitled "**DESIGN AND CONSTRUCTION OF AN FM TRANSMITTER AND RECEIVER FOR PUBLIC ADDRESS SYSTEM**" by **Ujah, Obiabo Kenneth (EE/14/0378)** meets the regulations governing the award of the bachelor's degree of the Modibbo Adama University of Technology, Yola and is approved for its contribution to knowledge and literary presentation.

Sign…………………………… **Date…………………………….**

Engr. Mrs. Oriolowo Niyi Zara

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Sign…………………………… **Date…………………………….**

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(HOD)

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Engr. Dr. Jonathan A. Enokela

(External Examiner)

Dedication

I dedicate this project to the maker and creator of everything and to those who love humanity.

Let's make the world a better place!!!

Acknowledgements

I sincerely want to appreciate the maker and owner of the universe for first bring me into this world, keeping me, and providing for me with men and strength to complete this project- glory to his name!!!

I want to also acknowledge the current and past Head of the department for the Quality leadership they have been providing for the department. To my Project supervisor Engr. Mrs. Oriolowo N. Zara. I want to appreciate her for the guidance she gave to me during the research- indeed she is a great mother and Lecturer. Also, my gratitude goes to all the lecturers in the department for the knowledge they have impacted to me since I came into the school in 2014

To my parents, Mr. and Mrs. Ujah stephen, my siblings and my friends: Naason Nehemiah, Daniel Eli, Peter Ujah and others. Love you all!!!

Abstract

In Nigeria, most especially tertiary institution where the problem of overcrowding cannot be overemphasized, the need for public address system becomes a paramount necessity in order to address a large gathering without the stress of shouting and not been heard. It is of this importance that a transmitter and receiver find it's role since these are the major component of the Public address system. The FM transmitter is designed to pick audio signals with the help of the microphone whereas the FM Receiver is designed to pick the transmitted audio signal by the transmitter using it antenna giving output through the speaker. This system save physical energy put into shouting and enhances proper dissemination of information no matter the size of the audience. The system has been constructed tested working but not satisfactorily.

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List of Abbreviations and Symbols

AC/DC	Alternating current/Direct Current
ADC	Analogue to Digital converter
ADM	Adaptive delta modulation
AGC	Automatic gain control
AM	Amplitude Modulation
ASK	Amplitude shift key
DM	Delta modulation
DSB	Double side band
FSK	Frequency shift key
GSM	Global system for Mobile Communication
ISB	Independent side band
IF	Intermediate frequency
PA	Public Address
PM	phase modulation
PAM	Pulse amplitude modulation
PCM	Pulse code modulation
PDM	Pulse duration modulation
PPM	Pulse position modulation
PSK	Phase shift key
FM	Frequency Modulation
R§D	Research and Development
RF	Radio frequency
SC	Suppressed carrier
SSB	Single side band
TRF	Tuned radio frequency
TV	Television
VHF	Very higher frequency
VSB	Vestigial side band
UHF	Ultra high frequency

CHAPTER ONE: INTRODUCTION

1.0 Background

A public address system is a system that enable the broadcasting of information to a large group of people, whether when giving a speech or playing live or recorded music.

PA stands for 'public address', which reflects the most common applications of a PA system – whether it be train stations, sports stadiums, shops, hospitals, airports or hotels. The three core components of a PA system are – the microphone, which captures sound vibrations and converts them into an electrical signal; the amplifier, which increases and controls electrical signals, and the loudspeaker, which converts an electrical audio signal into vibrations and broadcasts them as a sound [1].

Up until the late 19th century, all forms of public address were done using architectural acoustics – there was no viable alternative to improve speech comprehension. However, the first step towards completely changing how people perceived sound came in 1875, when British-American inventor and music professor David Edward Hughes invented the carbon microphone [1].

This was the first device which enabled proper voice transmission and was built by Hughes using toy boxes, sealing wax and wires in the drawing room of his home. The carbon microphone contained two metal plates and worked by sound waves striking its diaphragm, causing the carbon granules contained inside to vibrate. The higher the pressure on these granules, the lower their resistance and the closer they are pushed together, resulting in a sound current being passed between the plates. Hughes coined the term 'microphone' to describe his invention, as he saw it as the audio equivalent of the microscope. Thus, the first component of a modern-day PA system was born [1].

A couple of decades later, the world's first experimental moving coil loudspeaker was invented by British physicist Oliver Lodge. Known as the 'bellowing telephone', this invention contained the same basic features as today's loudspeakers – a diaphragm vibrated by a voice coil, the sound of which was then amplified by a flared horn.

A transmitter is extremely an important equipment and is housed in the broadcasting station. Its purpose is to produce radio waves for transmission into space. The important components of a transmitter are microphone, audio amplifiers, oscillator and modulator.

The transmitter usually sends its signal using a small FM radio transmitter to a nearby receiver connected to the sound system, but it can also use infrared light if the transmitter and receiver are within sign of each other. The transmitters are responsible for taking in the signal from the microphone, modulating it, and transmitting it to the receiver using radio waves.

The receiver captures the radio waves sent out by the transmitter, demodulates the signal, amplifies it to an appropriate level, and sends it out to the audio mixer. A receiver is an electronic circuit that receives its input from an antenna, uses electronic filters to separate a wanted radio signal from all other signals picked up by this antenna, amplifies it to a level suitable for further processing, and finally converts through demodulation and decoding the signal into a form usable for the consumer, such as sound, and digital data, etc.

1.1 Problem Statement

In Public Address system, Designers are face with the problem of choosing which type of transmitter and Receiver to use in order to make sure the desired audio signal(message) is passed across to the final destination without the problem of distortion and delay.

In telecommunications and signal processing, frequency modulation (FM) is the encoding of information in a carrier wave by varying the instantaneous frequency of the wave. This contrasts with amplitude modulation, in which the amplitude of the carrier wave varies, while the frequency remains constant. In analog frequency modulation, such as FM radio broadcasting of an audio signal representing voice or music, the instantaneous frequency deviation, the difference between the frequency of the carrier and its center frequency, is proportional to the modulating signal. In radio transmission, an advantage of frequency modulation is that it has a larger signal-to-noise ratio and therefore rejects radio frequency interference better than an equal power amplitude modulation (AM) signal. For this reason, most music (audio) is broadcast over FM radio, hence the choice of using FM transmitter and receiver for this project

1.2 Aim of the project

The main aim of this project is to design a suitable FM transmitter capable to transmit audio signal that will be converted to usable form by the receiver

1.3 Objective of the project

The objective of this work is;

- To design and construct an FM transmitter and Receiver which transmits a frequency modulated signal to an FM Receiver which will in turn demodulate the signal and convert to a form that will pick by the speaker. The device can broadcast signals on an FM broadcast band and picked up by the receiver.
- To review some modern digital technologies that has been developed for effective FM signal generation and FM signal receiver.
- To show the design and components of a FM transmitter and Receiver
- To show the construction process of an electronically operated system known as FM transmitter capable of transmitting a frequency modulated signal.

1.4 Significance

The project signifies a lot in the electronic communication system which telecommunication is the vital aspect which is usually demonstrated through radio communication system. The project showed the application of frequency modulation transmitter in public address system

1.5 Scope

This project Work covers the design and construction of FM transmitters for quality audio transmission that will be demodulated and converted to usable form by the design and constructed FM receiver to be use in a public address system

CHAPTER TWO: Literature Review

2.0 Introduction

This chapter presents the review of past similar related works as well as review of the necessary major functional components needed for the research work

2.1 Review of Previous Work

In Recent years, Various project have been embarked on to boost effective communication via the FM transmitter and Receiver for better output and performance, cost reduction and more energy efficiency.

Worked on designing FM transmitter and receiver that are built with discrete analog components and integrated on two circuit boards. The modulation scheme uses a superheterodyne setup, in which the intermediate carrier is at 300-kHz and the transmission carrier is at 24.3-MHz. Using 711-mW of DC power, the transmitter outputs a 5-dBm signal centered at 24.3-MHz with 100-kHz bandwidth. Using about half as much power, around 342-mW, the receiver can detect incoming signals at powers as low as -110 dBm. This receptivity level translates to successful audio reception at distances of almost 2-km from the transmitting antenna atop Packard [2].

Worked on the design and development of a superheterodyne frequency modulation radio receiver using an integrated circuit TDA7000IC for its implementation. The TDA7000IC is used because of the multifaceted function it has such as Radio Frequency, Local Oscillator, Mixer, Detector/Demodulator, Amplitude Modulation amplifier, Limiter, Correlator**.** The tests of reception of signal were carried out in three different areas of Lagos State to determine the level of signal reception and striking results were obtained in Ibeju Lekki and

Ikorodu but fairly results were obtained in Epe area due to the topographic nature of the area. This design finds its usefulness in rural areas where there is no access to television sets in order to disseminate information about the happenings in the country [3].

Worked on the simple and economical technique for building an FM transmitter using basic electronic components like resistor, capacitor, inductor etc. The FM transmitter receives human voice signals though microphone. It further amplifies it, modulate it over carrier and finally transmit it. Assuming favorable conditions, output of transmitter can be received by anyone who tunes it in frequency of our transmitter. The Circuit diagram is described, its working, components required, uses of various components in our circuit, its practical applicability. The design is simulated using NI Multisim and is further implemented on bread-board. This design is capable of transmitting signal for distance of radius 20m, tuned at 97.1 MHz One could clearly hear sound produced at microphone of transmitter [4].

Designed and constructed a 10 watt FM transmitter to be received at a range of about 4km in free air. Research and development (R &D) were used for the study, the necessary tools and materials were acquired. Design procedure involving the modification of an output of a transmitter was adopted. Based on the procedures adopted and the tests carried out, the specific findings include, appreciable range with stable frequency of transmission obtained on power source devised from 12v lead acid battery. Various instructional applications and mass production strategies were outlined. The successful completion of this study has indicated that practical frequency modulated FM transmitter requiring low power can be designed and constructed. Though appreciable range of FM transmitter on low power supply has been achieved in this works, further studies in areas of signal coupling technique need to be carried to improve the range of transmission [5].

2.2 Review of Modulation, demodulation, FM transmitter and receiver

2.2.1 Modulation

Many signals that are transmitter in communication systems have frequency spectra that is not suitable for direct transmission especially when atmosphere is used as the transmission channel. In such a case, the frequency spectra of the signal may be translated by modulating high frequency carrier wave with the signal. Consider, for example, picture signal of a TV camera. It has a frequency spectral of DC to 5.5 MHz. such a wide band of frequencies cannot be propagated through ionosphere. However, if this signal is modulated with a carrier in VHF or UHF range, the percentage bandwidth becomes very small and the signal becomes suitable for transmission through atmosphere [6].

Apart from this primary requirement for modulation of signals, there are additional objectives which are met by modulation

a) Ease of radiation: As the signals are translated to higher frequencies, it becomes relatively easier to design amplifier circuits as well as antenna systems at these increased frequencies.
b) Adjustment of bandwidth: Bandwidth of a modulated signal may be made smaller or Larger than the original signal. Signal to noise ratio in the receiver which is a function of the signal bandwidth can thus be improved by improper control of bandwidth at the modulating stage.
c) Shifting signal frequency to an assigned value: The modulation process permits changing the signal frequency to a preassigned band. This frequency may be changed many times by successive modulations [6].

Modulation may be defined as the process by which some parameter of high frequency signal termed as carrier, is varied in accordance with the signal to be transmitted. Various modulation methods have been developed for transmission of signals as effectively as possible, with minimum possible distortion. The comparison of the effectiveness of these modulation methods may be based upon the signal power to noise power measured at the output of the receiver. According, a wide range of modulation techniques have been developed. These techniques may be broadly grouped into analogue techniques and pulse techniques. The former employ sinusoidal signals as carrier while the latter circuits use trains of pulses as the signal [6].

Analogue modulation may be divided into amplitude modulation and angle modulation. Amplitude modulation (AM) maybe categorized as AM with both sidebands and carrier (AM/DSB), vestigial sideband (VSB), double side-band suppressed carrier (DSB/SC), single side-band suppressed carrier (SSB/SC), and independent side-band suppressed carrier (ISB/SC) [6].

AM/DSB is very popular for radio broadcast and telephony. For TV transmission with large bandwidth, VSB is preferred because of reduced bandwidth of this modulation system. DSB/SC or SSB/SC provide a further reduction in power and bandwidth requirement. SSB/SC find an extensive use in the multiplexed coaxial system and can carry several messages simultaneously. All AM systems are, however, prone to noise which directly affect the signal amplitude [6].

In angle modulation, the instantaneous angle of a sinusoidal is varied per the instantaneous amplitude of the modulating signal. The system leads to phase modulation (PM) and frequency modulation (FM). FM and PM waves requires a larger bandwidth than AM, but are capable of giving a sufficiently improved signal to noise ratio than the latter. It also leads to considerable saving in power [6].

Pulse modulation methods employ a pulse train as the carrier. The simplest type of pulse modulation is pulse amplitude modulation (PAM) which is similar to AM. Other pulse modulation techniques include pulse duration modulation (PDM), pulse position modulation

(PPM) and pulse code modulation (PCM). While PAM may be compared with AM, PDM and PPM with angle modulation, The PCM has no analogue equivalent. In PCM have been developed methods like delta modulation (DM) and adaptive delta modulation (ADM) [6].

A third form of modulation consists of modulating a sinusoidal signal with pulse signals and may be termed as digital modulation. Digital modulation may be divided into amplitude shift keying (ASK), frequency shift keying (FSK) and phase shift keying (PSK). They are especially useful for data transmission systems [6].

2.2.1.1 Frequency modulation (FM) and FM transmitter

Frequency modulation is the process of varying the frequency of a carrier wave in proportion to the instantaneous amplitude of the modulating signal without any variation in the amplitude of the carrier wave. Because the amplitude of the wave remains unchanged, the power associated with an FM wave is constant [7].

A frequency modulated transmitter may consist of modulating system that can directly produce frequency modulated waves by varying the oscillator frequency. Such circuits employ L-C circuits in MO circuits. Alternately, the transmitting equipment may contain a crystal oscillator which is phase modulated by the audio signals. The PM wave is then converted into frequency modulated wave. The basic difference between the two circuits is that while the first circuit employ an L-C circuit in master oscillator and its frequency is likely to change with changes in circuit parameters, the second circuit gives a drift-free frequency. As such, the first circuit always employs some form of automatic frequency control circuit. Another difference worth mentioning is that the first method produces more frequency deviation and require less number of stages of frequency multipliers whereas the phase modulator circuit produces smaller frequency deviation and requires more stages of frequency multiplication [7].

The direct circuit transmitter employs a reactance tube modulator to produce frequency deviation in proportion to the signal amplitude. Alternately, a varactor diode modulator or a ferrite core modulator may also be employed for this purpose. The resulting FM wave is passed through a number of frequency multiplier stages. These stages not only raise the center frequency of the signal but the frequency deviation is multiplied by the same factor as well. The modulated wave is then amplified to the required power level by class C power amplifier stages and transmitted [7].

A part of the output of the frequency multiplier stages is passed to AFC circuit shown in dotted lines. The purpose of this circuit is to make correction in the center frequency of the transmitter should any drift in it take place due to changes in circuit parameters. Signal from the frequency multiplier is mixed with the crystal oscillator (Local oscillator) output in a mixer and the difference frequency is fed to a discriminator which gives DC output according to frequency shift with respect to center frequency [7].

When the frequency of the transmitter is exactly equal to the center frequency, discriminator output is zero and there is no DC correcting bias. Any positive or negative drift in the frequency produces a corresponding correction bias at the discriminator which when applied to the reactance tube modulator brings the L-C master oscillator frequency back to its center value.

If a modulating signal is present, resulting AF signal produced at the discriminator output is not allowed to reach the reactance tube modulator because of low pass filter which has a cut-off lower than the signal. Frequency deviation resulting from audio signal as well as shifts due to change in circuit parameters causes the discriminator output to contain AF output along with slowly varying DC bias. While the former is usually taken to the AF stages and produces side tone, it is the latter component which reaches the modulator and results in frequency correction.

The indirect circuit for FM transmission comprises of crystal oscillator, the output of which is fed to a phase modulator. The audio signal is integrated and also applied to the phase modulator. The resultant wave at the phase modulator is passed through several stages of frequency multipliers to obtain the desired frequency deviation and increase the central frequency. The signal is amplified by the power amplifier stage to the required power level

2.2.2 Demodulation and Radio receiver

Demodulation or detection is the process of recovering the original modulating signal from a modulated wave. Basically, the demodulation or detection is a process of frequency translation that requires a non-linear device in which the signals lying at a higher frequency in the frequency spectrum are converted to a lower frequency. As such, the frequency converter circuits are also termed detectors [8].

An ideal Demodulator should produce at its output a demodulated signal that resembles the original modulating signal in all respects. Any deviation from the wave shape of the modulating signal is termed distortion. If the Demodulator output contains frequencies that were not present in the modulating signal during transmission, the demodulator is said to contain Amplitude distortion or non-linear distortion. In such a case, the circuit gives a distortion less output for a certain range of input signal amplitudes. Changes in amplitudes of input signals result in distortion. Sometimes, distortion is present at higher frequencies of the modulating signal while normal modulating frequencies, the detector output is distortion free. This type of distortion is referred to as frequency distortion. Lastly, different frequency components of the modulating signal may be reproduced with altered phase relation, this type of distortion is termed as phase distortion [8].

A radio receiver is a device that pick up the desired signal from the numerous signals propagating at the same time through the atmosphere, amplifies the desired signal to the requisite level, recovers from it the original modulating signal and eventually display it in the desired manner. This outline of functions that must be performed shows that the major difference between receivers of various types is in the way in which they demodulate the received signal and this in turn will depend on the type of modulation employed at the transmitter. The second major difference is the method of displaying the received signals [9].

Though various forms of receiver circuits have been developed at one time or the other, only two have any real significance: the tuned radio frequency (TRF) receiver and the superheterodyne receiver. Most of the Present day receivers uses superheterodyne circuits, but the TRF receiver shall be looked at and taken as an introduction to the superheterodyne receiver [9].

(a) **Tuned radio frequency (TRF) receiver**: The TRF receiver is a simple receiver employing straight forward circuit arrangements. It uses two or three stages of RF amplification all tuned simultaneously to the desired signal frequency so that these stages provide selection as well as amplification to the signal. The amplified signal is then demodulated in a detector stage. The demodulated signal is amplified by the AF amplifiers stages and fed to the loudspeaker [9].

As the receiver employs two identical stages as RF amplifier, it is simple to design and align. The circuit works satisfactorily at the medium wave frequencies but at higher frequencies difficulties arise because of the instability associated with high gain achieved at the desired frequency by a multistage amplifier [9].

A second drawback in TRF receiver is the wide variation in the q factor and the bandwidth of the tuned circuits employed in RF amplifiers at different frequencies of the frequency

Because of these drawbacks namely: instability in gain, reception of stations of frequencies adjacent to the desired signal and variation in the bandwidth over the band, the TRF receiver has almost been replaced by superheterodyne receiver [9].

(b) Superhet Receiver: according to the IRF definition, heterodyne reception (beat reception) is the process of operation on modulated radio waves to obtain similarly modulated waves of different frequency; in general, this process includes the use of a locally generated wave, which determines the change of frequency.

The word Superhet stands for SUPER-sonic HET-erodyne which that heterodyning takes with resulting output frequency higher than audio. According to IRE definition superheterodyne reception is a form of heterodyne reception in which one or more frequency changes take place before detection.

A Superhet Receiver may thus be defined as one in which one or more changes of frequency take place before AF signal is extracted from the modulated wave. However, the name Superhet is generally applied to receivers in which only one frequency changes take place before audio is detected. A receiver in which the change of frequency takes place twice before detection is usually called a double superheterodyne receiver. As the process of heterodyning and detection are similar wherein both carry out conversion from a higher frequency input to a lower frequency output, a double superheterodyne receiver is also referred to as a triple detection receiver [9].

Whereas ordinary Superhet receivers used as broadcast receivers operate at comparately low frequencies, there is no practical advantage of using double superheterodyne circuits. The latter circuits are costlier and their use is limited to high frequency receivers where high selectivity is desired. Such circuits are invariably used in communication receivers for the reception of radio telephony and telegraphy signals [9].

In Superhet Receivers, the modulated signal of carrier frequency f_s is fed to a circuit called mixer to which is also fed the voltage at frequency for generated by an oscillator. This oscillator being a part of the receiver is termed as local oscillator. At the output of the mixer is selected a voltage of frequency f_i which is the difference of the signal frequency fs and the local oscillator frequency f_o. This difference frequency is called the intermediate frequency (IF). The signal frequency and local oscillator frequency is varied in unison by using ganged tuning capacitors in these stages. This results in a mixer output (IF) that has a constant frequency irrespective of the frequency to which the receiver may be tuned. Thus, intermediate frequency is fixed for a receiver. It should be noted that the IF signal is exactly similar to the modulated RF signal; the only difference being in their carrier frequencies. [9]

The IF amplifiers, being tuned voltage amplifiers, use transformers in the input and output circuits. Each of these transformers consists of a pair of mutually coupled tuned circuits. With these fixed frequency, tuned circuits as plate load, the IF amplifiers provide most of the gain and selectivity to the receiver. As the gain and selectivity of IF amplifiers remain constant at all incoming signal frequencies, the sensitivity and selectivity of a Superhet Receiver is fairly uniform over the entire frequency range [9].

The Superhet reception has a number of advantages over the TRF reception. A few of them are listed below:

I. Improved selectivity in terms of adjacent channels
II. More uniform selectivity over the complete frequency range
III. Improved receiver stability
IV. Higher gain per stage because IF amplifiers are operated at a low frequency
V. Uniform bandwidth because of fixed intermediate frequency

These advantages of Superhet Receivers make them suitable for most of the radio receiver application such as AM, FM, SSB, communications, television and radar receivers.

Frequency modulated receivers [9].

Frequency modulated receivers are superheterodyne receivers employing double frequency conversion. The RF, mixer and IF stages are similar to that employed in AM receiver except that the device selection and the circuit design are done with view to VHF or UTF operation. Since the receivers are to operate in VHF or UHF ranges with space wave propagation and such signals are not prone to selective or general fading, AGC is not normally employed in these receivers. The resonant circuits employed in various RF and IF stages are designed to have adequate bandwidth to accommodate frequency modulated signals [9].

Amplified frequency modulated IF signals are passed through a limiter stage before being applied to discriminator circuit for conversion into audio signals. A limiter stage is, however, not required if a ratio detector circuit is employed in place of the discriminator [9].

The purpose of a limiter stage is to give to the discriminator stage IF signals of constant amplitude but having frequency deviation as produced by the modulating signal, so that amplitude variations in the FM signal resulting due to external noise during propagation or by internal noises generated within the receiver do not reach the receiver output [9].

Another common feature of FM reception is that there is an unbearable noise in the output when a signal is not incoming. To overcome this, squelch circuits are commonly included as part of FM receivers

2.3 Review of functional components

2.3.1 2N3904 transistor

There are two basic types transistor; the bipolar junction transistor (BJT) which 2n3904 belong to and the field effect transistor (FET) .The bipolar junction transistor is used in two broad areas of electronics: (1) as a linear amplifier to boost an electrical signal and (2) as an electronic switch [8]

2N3904 is a NPN transistor hence the collector and emitter will be left open (Reverse biased) when the base pin is held at ground and will be closed (Forward biased) when a signal is provided to base pin. 2N3904 has a gain value of 300; this value determines the amplification capacity of the transistor. The maximum amount of current that could flow through the Collector pin is 200mA, hence we cannot connect loads that consume more than 200mA using this transistor. To bias a transistor we have to supply current to base pin, this current (I_B) should be limited to 5mA.

When this transistor is fully biased then it can allow a maximum of 200mA to flow across the collector and emitter. This stage is called Saturation Region and the typical voltage allowed across the Collector-Emitter (VCE) or Collector-Base (VCB) could be 40V and 60V respectively. When base current is removed the transistor becomes fully off, this stage is called as the Cut-off Region and the Base Emitter voltage could be around 600 mV.

A 2N3904 Transistors acts as an Amplifier when operating in Active Region. It can amplify power, voltage and current at different configurations.

Applications:

Driver Modules like Relay Driver, LED driver etc...

Amplifier modules like Audio amplifiers, signal Amplifier etc...

VCB and VBE is high hence can be used to control voltage loads up to 40V

Commonly used in TV and other home appliances

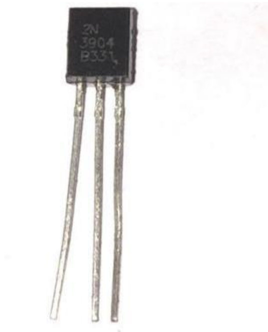

Fig 2.1 2N3904 TRANSISTOR

2.3.2 2N2222 transistor

The 2N2222 is a common NPN bipolar junction transistor (BJT) used for general purpose low-power amplifying or switching applications. It is designed for low to medium current, low power, medium voltage, and can operate at moderately high speeds. It was originally made in the TO-18 metal can as shown in the picture.

The 2N2222 is considered a very common transistor, [10][11][12] and is used as an exemplar of an NPN transistor. It is frequently used as a small-signal transistor, [13][14] and it remains a small general purpose transistor [15] of enduring popularity. [16][17][18]

The 2N2222 was part of a family of devices described by Motorola at a 1962 IRE convention. [19] Since then it has been made by many semiconductor companies, for example, Texas Instruments. [20]

The JEDEC registration of a device number ensures particular rated values will be met by all parts offered under that number. JEDEC registered parameters include outline dimensions, small-signal current gain , transition frequency , maximum values for voltage withstand, current rating, power dissipation and temperature rating, and others, measured under standard test conditions. Other part numbers will have different parameters. The exact specifications depend on the manufacturer, case type, and variation. Therefore, it is important to refer to the datasheet for the exact part number and manufacturer.

Manufacturer V ce Ic P D f T

ST Microelectronics [21]

2N2222 40 V 800 mA 500 mW/1.8 W 300 MHz

All variations have a beta or current gain (h fe) of at least 100 in optimal conditions. It is used in a variety of analog amplification and switching applications.

2.3.3 TDA2003 audio amplifier

Fig 2.2 TDA2003 audio amplifier

The TDA2003 is an Audio Amplifier IC from ST Microelectronics with a maximum output power of 10W commonly used in stereo amplification in car Radio. The IC can output a maximum current of 3.5A and features very low harmonic and crossover distortion [22].

Pin Description

Pin number	Pin name	Description
1	Non inverting input	Non inverting end (+) of amplifier
2	Inverting input	Inverting end (-) of the amplifier
3	Ground	Connect to the ground of the circuit
4	Output	This pin output the amplified signal
5	Supply voltage	Supply voltage, Minimum 6V and Maximum 36V

Features of TDA2003

- Low-frequency class AB amplifier most suited for audio amplification
- Can provide up to 20 Watts as output power
- Operating Voltage: 8V to 18V
- Maximum output power 12V (at 1.6Ω RL)
- Voltage Gain: 80dB
- Supply Voltage rejection: 36dB

- Short circuit and thermal protection is available
- Breadboard friendly
- Available in 5-pin TO220 package

TDA2003 is a general-purpose 10W amplifier IC that can be used in stereo or mono audio design circuits. The amplifier can output upto 3.5A current to drive speakers and can also handle high current upto 5A for shorter duration without any damage. It can also handle short circuits in both

AC and DC rail without killing itself. It has an operating voltage of 18V but can handle high voltage up to 28V. This makes it robust to be used in automotive audio designs.

The TDA2030 is breadboard friendly and hence can be easily tested using a breadboard. A sample application circuit for TDA2003 is given below.

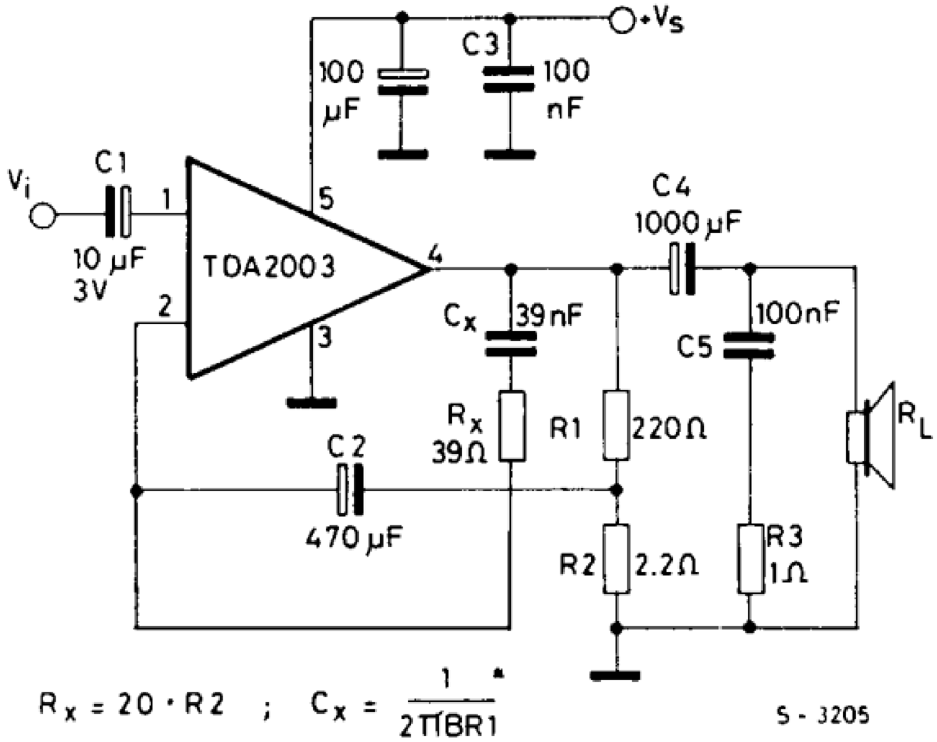

Fig 2.3 sample application circuit of TDA2003

TDA2003 is a 5-pin Amplifier IC. The pin 5 and 3 are used to power the Amplifier IC, and the audio signal to be amplified is given in through pin 1 which is the non-inverting input. The amplified audio output can be obtained through pin 4. The values of the components given above are the values recommended by manufactures. The two important components are the Cx and Rx which sets the bandwidth for the amplifier using the formulae shown above. Also the Resistors R1 and R2 are used to setting the gain of the amplifier [22].

Applications

- Used for Audio signal Amplification
- Suitable for high power amplification
- Capable of operating on dual/split power supply*
- Can be used to cascade audio speakers

CHAPTER THREE: DESIGN AND CONSTRUCTION PROCEDURES

3.0 Introduction

This chapter contains detailed explanation of design and construction procedures of FM transmitter and receiver system, it entails the description of the component used in achieving the transmission and receiving of FM signal. The design has two sections, the transmitter design and the receiver design

3.1 Transmitter design

Design is the systematic putting together or an assemblage of components in order to achieve a purpose [23]. The transmitter design gives insight in the calculations used in selecting each component. The block diagram of the transmitter is given in the figure and each sub-unit of the block is discussed individually.

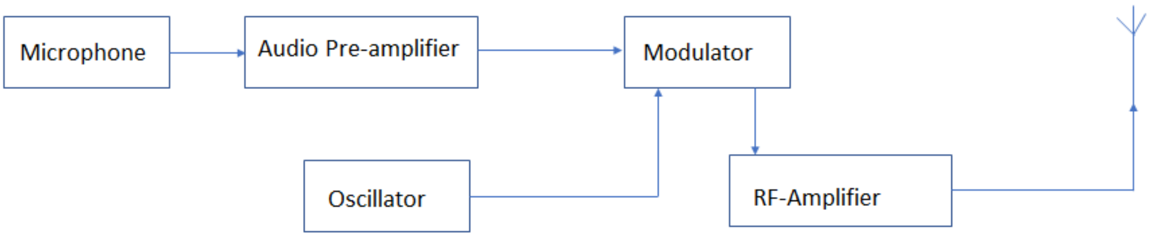

Fig. 3.1 FM transmitter block diagram

3.1.1 ELECTRET MICROPHONE

This is a capacitive type of microphone comprising of two dielectric plates. One is a permanently charged dielectric plate made of a ceramic material that has been heated and allowed to cool in a magnetic field. The other plate is formed by the diaphragm on the front of the microphone case.

Sound pressure moves the front plate and this vibration of the plate changes the capacitance resulting in a changing voltage that is fed to a Field Effect Transistor amplifier built inside the microphone case.

Electret microphones have excellent sensitivity, a wide frequency response, are low in cost and small in size.

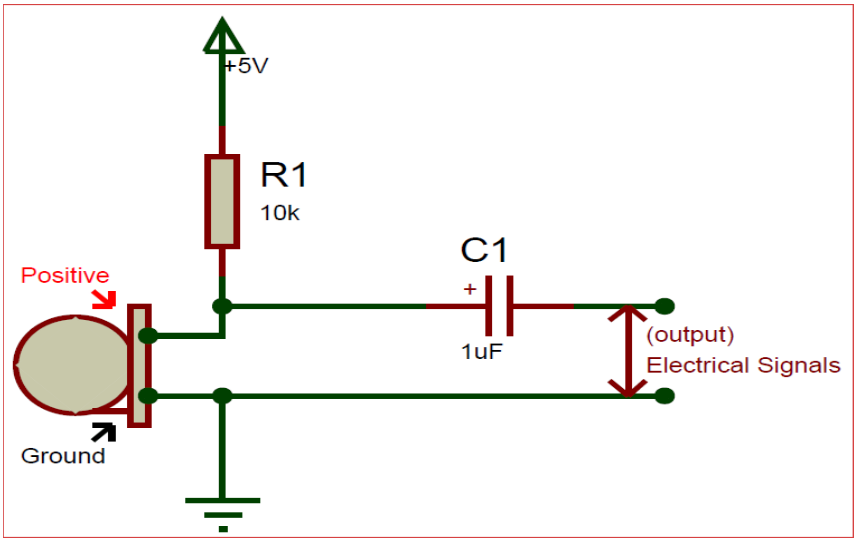

Fig 3.2 Electret microphone

The R1(10K) is used to limit the current flowing through the microphone and the capacitor C1 is used to filter the DC noise that might be coupled along with the analog electrical signals(output)

3.1.2 AUDIO AMPLIFICATION STAGE

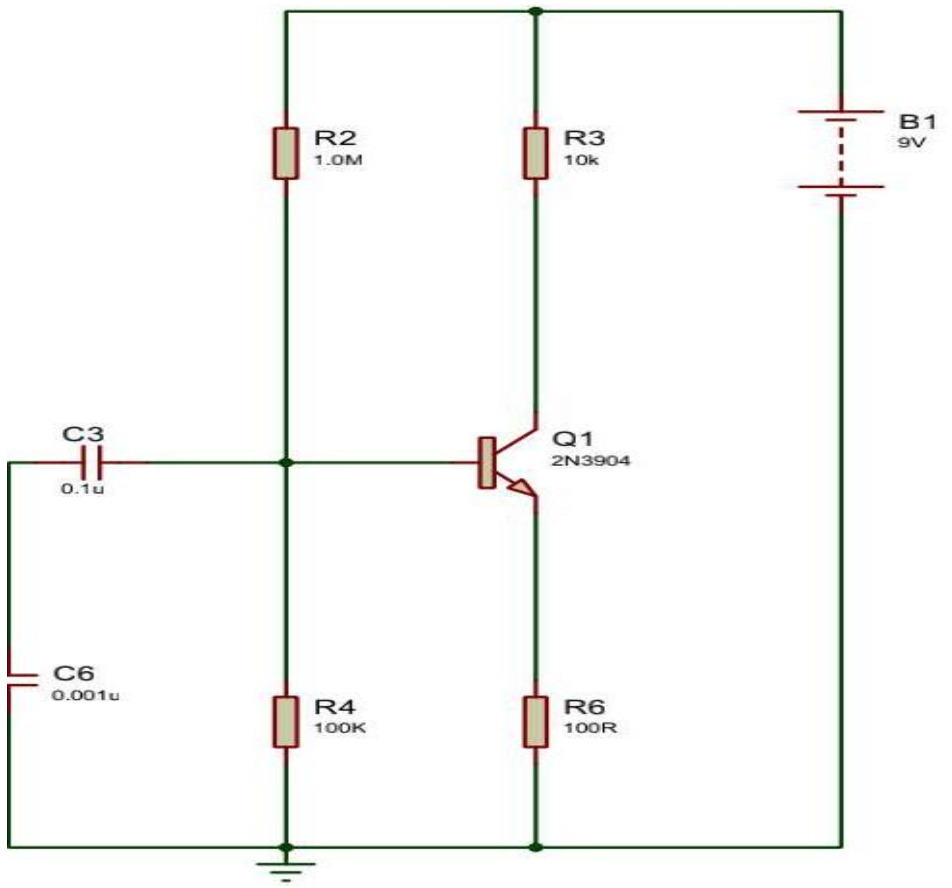

Fig 3.3 Pre amplifier stage

Capacitor C3 isolates the the DC base voltage of the transistor Q1 but allows the alternating audio signal from the microphone pass to be amplified by Q1 which is operating in a self-biasing common emitter mode. The output signal then comes from the collector of Q1 and feeds the oscillator stage.

The pre-amplifier stage use the common emitter for biasing.

From the data sheet of Q1 (2N3904)

VCEO = 40v

Iq = 1mA

β=40

Vbe=0.7v

Icsat=0.1mA [10].

For the project a Vcc of 9v is used . To calculate the value of load resistor R3. The quiscient voltage Vq is always half the value of Vcc, i.e

$$Vq = \frac{Vcc}{2} = \frac{9v}{2} = 4.5v$$

And,

$$R3 = \frac{Vq}{I_q} = \frac{4.5v}{1\times10^{-3}A} 4.5K$$

10K was selected for better operation.

For the voltage divider resistor R2 and R4,the bias currents and the voltage across the resistor need to be calculated. The bias current is approximately 10 times the base current. Now:

$$I_b = \frac{I_C}{\beta} = \frac{0.1\times10^{-3}}{40} = 0.004mA$$

$I_{bias} = 10I_b = 0.04mA$

The voltage across the base Vb is 0.7v more than the emitter voltage Ve. Assuming Ve to be 20% of Vcc

$$\text{I.e } Ve = \frac{Vcc \times 20}{100} = \frac{9v \times 20}{100} = 1.8v \text{ .}$$

but Vb = Ve+Vbe =1.8+0.7 = 2.5v

Thus,

$$R4 = \frac{V_b}{I_{bias}} \frac{2.5}{0.04\times10^{-3}} = 100K\Omega$$

R2=$\frac{V_{cc}-V_b}{I_{bias}}=\frac{9-2.5}{0.04\times10^{-3}}=162.5K\Omega$

1MΩ was used proper operation

3.1.3 Oscillator stage

The oscillator stage is where the RF carrier is produced and modulated by the audio signal from Q1. The resonant circuit (L1, C1) transistor Q2 and the feedback capacitor C2 are the oscillator circuit here. An oscillating current flows around the resonant circuit. The circuit oscillates because of feedback occurring though C2. The feedback signal makes the voltage across R6 vary and hence the base-emitter current of the transistor Q2 vary at a resonant frequency thus causing the emitter-collector current to vary at the same frequency. This current helps maintain oscillation in the resonant circuit. Resonant circuits are sometimes called LC or 'tank' circuits. This comes from the ability of the LC circuit to store energy for oscillations. In a pure resonant LC circuit (one with no resistance) energy is not lost. However in a real AC network the resistive elements will dissipate electrical energy, such as wire and joint resistance and dielectric losses. The purely reactive elements, the C and the L, just store energy to be returned to the system later. Note that the tank circuit does not oscillate just by having a DC potential put across it. Positive feedback must be provided in this case by C2.

$$F_C=\frac{1}{2\pi\sqrt{LC}}\text{.......................................} (3.1)$$

A frequency between 88 Mhz and to 108 Mhz is the frequency range of FM ,a variable capacitor is used within the range of 10-35pf, the maximum inductor is at C=35pf and 108 Mhz

$$L = \frac{1}{2\pi * F_C^2 * C} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

R5 and R7 is calculated the way R2 and R4 in pre-amplifier stage

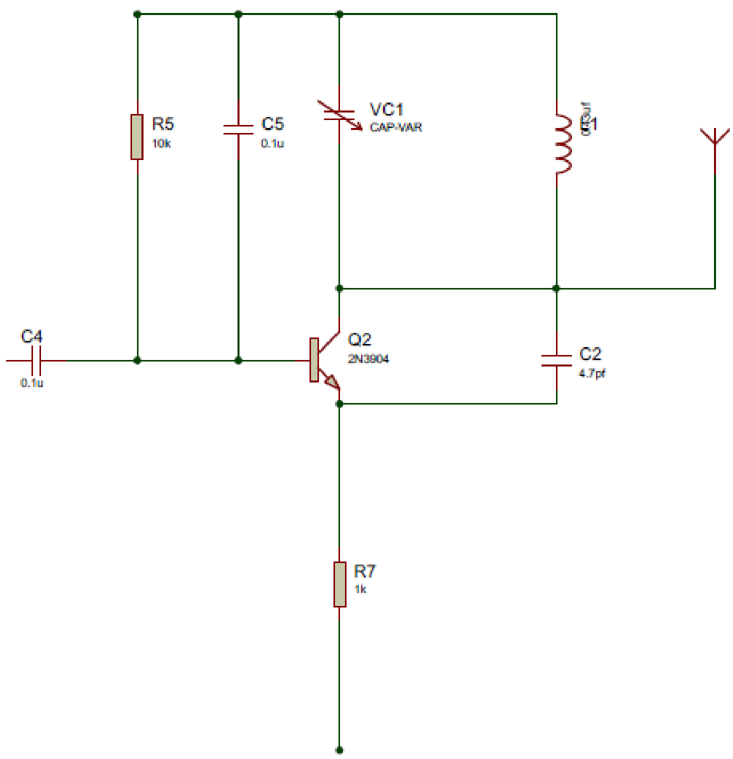

Fig 3.4 Oscillator stage

Theory behind FM Transmitter Circuit

Audio signal from the microphone is very low level signal, of the order of mill volts. This extremely small voltage needs to be first amplified. A common emitter configuration of a bipolar transistor, biased to operate in class A region, produces an amplified inverted signal.

Another important aspect of this circuit is the colpitt oscillator circuit. This is a LC oscillator where energy moves back and forth between the inductor and capacitor forming oscillations. It is mainly used for RF application.

When this oscillator is given a voltage input, the output signal is a mixture of the input signal and the oscillating output signal, producing a modulated signal. In other words, the frequency of the oscillator generated circuit varies with the application of an input signal, producing a frequency modulated signal.

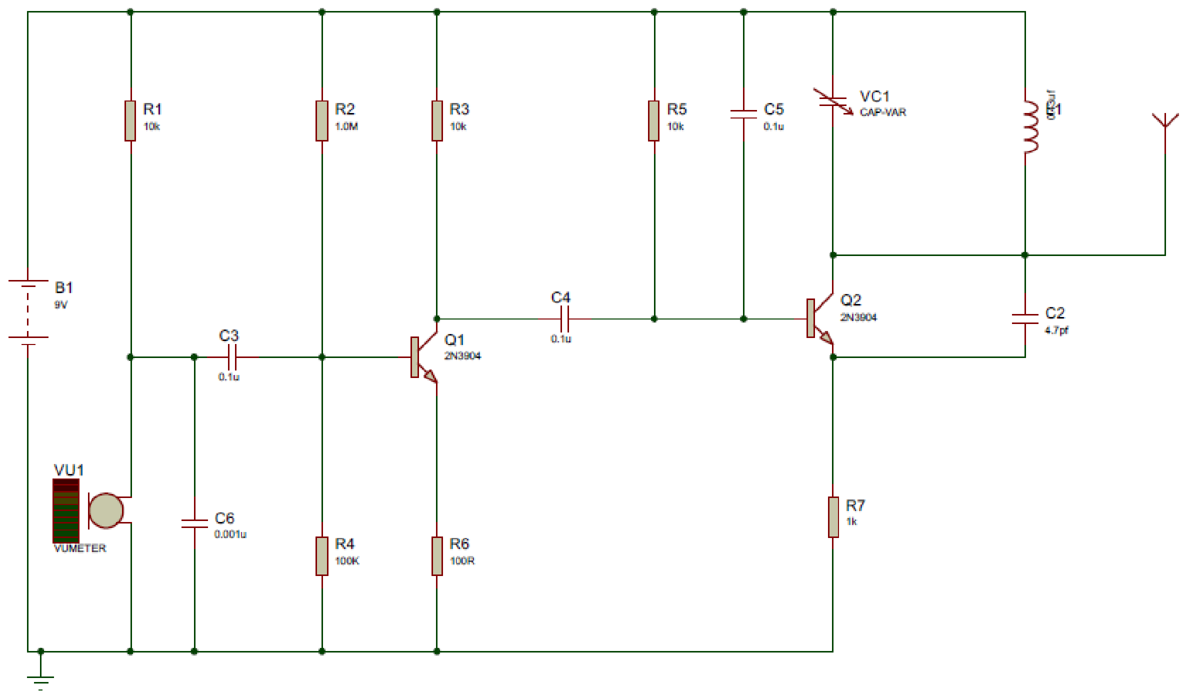

Fig 3.5 FM transmitter circuit

3.2 FM receiver design

This section talks of the receiver circuit and it individual sub unit of the block diagram

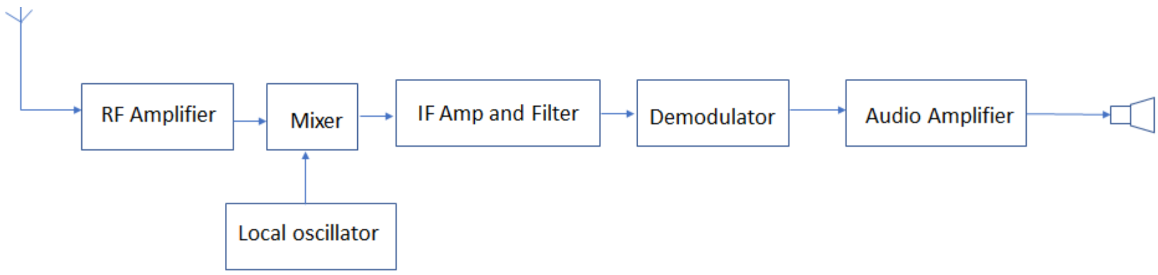

Fig 3.6 Receiver block diagram

3.2.1 Antenna: Captures the radio waves. Typically, the antenna is simply a length of wire. When this wire is exposed to radio waves, the waves induce a very small alternating current in the antenna

3.2.2 RF amplifier: A sensitive amplifier that amplifies the very weak radio frequency (RF) signal from the antenna so that the signal can be processed by the tuner.

Tuner: A circuit that can extract signals of a particular frequency from a mix of signals of different frequencies. On its own, the antenna captures radio waves of all frequencies and sends them to the RF amplifier, which dutifully amplifies them all.

Unless you want to listen to every radio channel at the same time, you need a circuit that can pick out just the signals for the channel you want to hear. That's the role of the tuner.

The tuner usually employs the combination of an inductor (for example, a coil) and a capacitor to form a circuit that resonates at a particular frequency. This frequency, called the resonant frequency, is determined by the values chosen for the coil and the capacitor. This type of circuit tends to block any AC signals at a frequency above or below the resonant frequency.

You can adjust the resonant frequency by varying the amount of inductance in the coil or the capacitance of the capacitor. In simple radio receiver circuits, the tuning is adjusted by varying the number of turns of wire in the coil. More sophisticated tuners use a variable capacitor (also called a tuning capacitor) to vary the frequency.

3.2.3Detector: Responsible for separating the audio information from the carrier wave. For AM signals, this can be done with a diode that just rectifies the alternating current signal. What's left after the diode has its way with the alternating current signal is a direct current signal that can be fed to an audio amplifier circuit. For FM signals, the detector circuit is a little more complicated.

3.2.4 Audio amplifier: This component's job is to amplify the weak signal that comes from the detector so that it can be heard. This can be done using a simple transistor amplifier circuit.

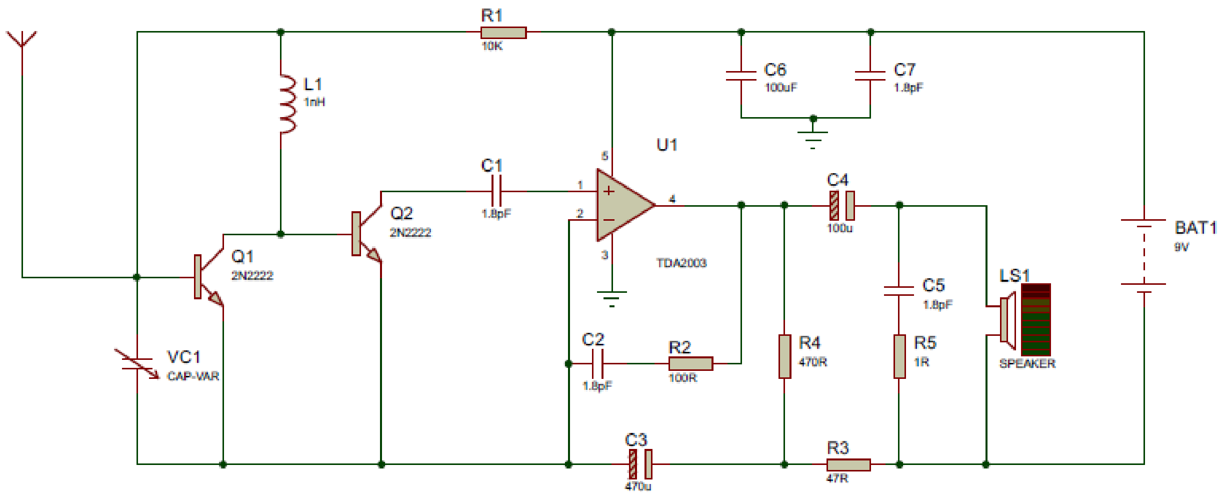

Fig 3.7 FM receiver circuit diagram

3.3 Complete circuit diagram

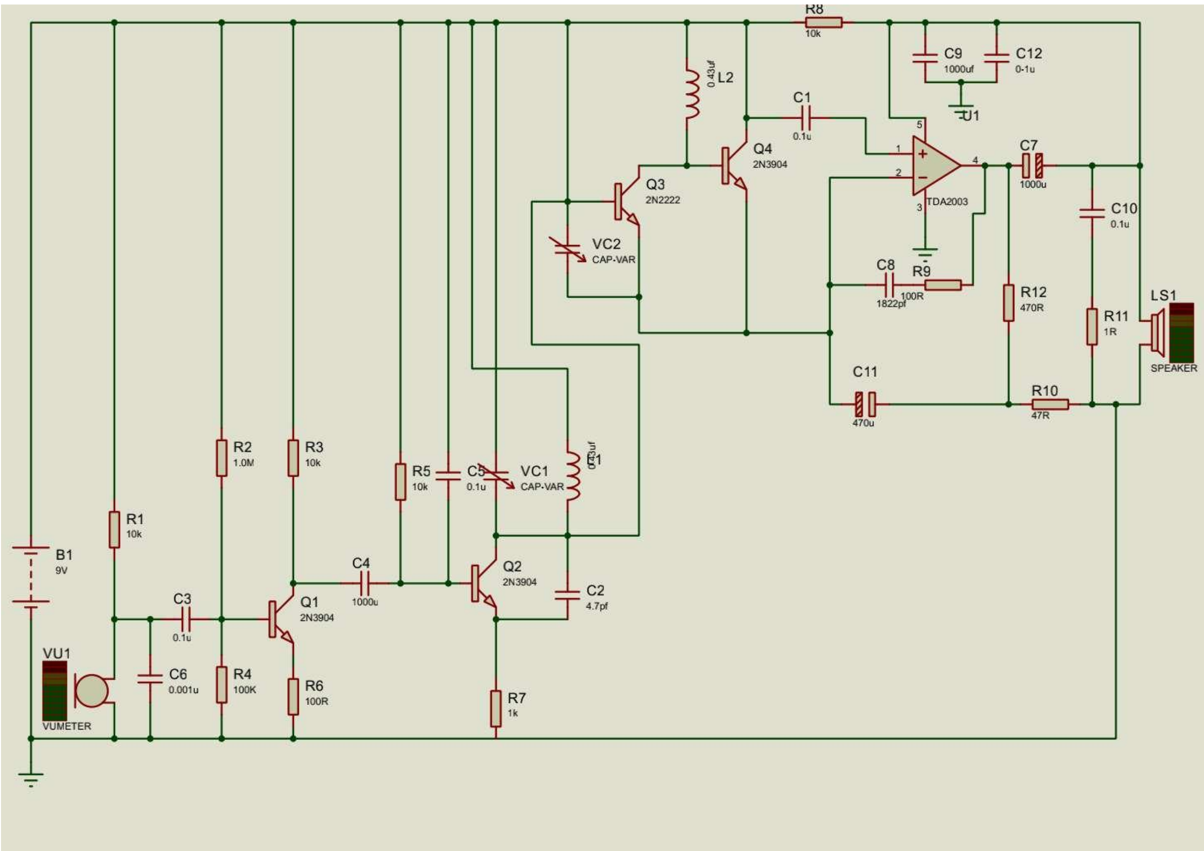

Fig 3.8 circuit diagram of FM transmitter and receiver

3.4 Construction procedure

This procedure shows how the whole system was put together: soldering of components and packaging.

- **Component soldering**

Vero board was used as the based or plane where every component soldered upon. Every component was placed carefully and soldered as seen in the figure below:

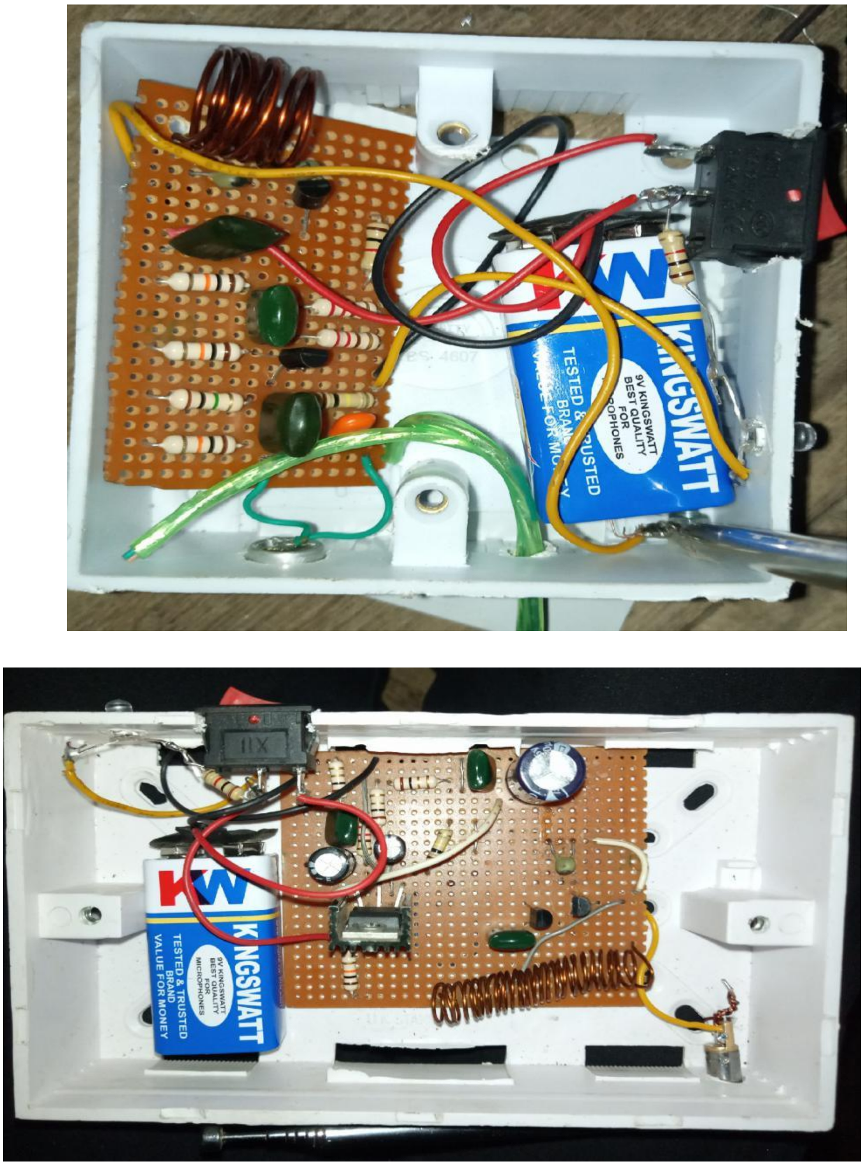

Fig 3.9 soldered circuit

- **PACKAGING**

The entire circuitry was put enclosed in two plastic boxes. One for the FM transmitter and the other for the FM receiver

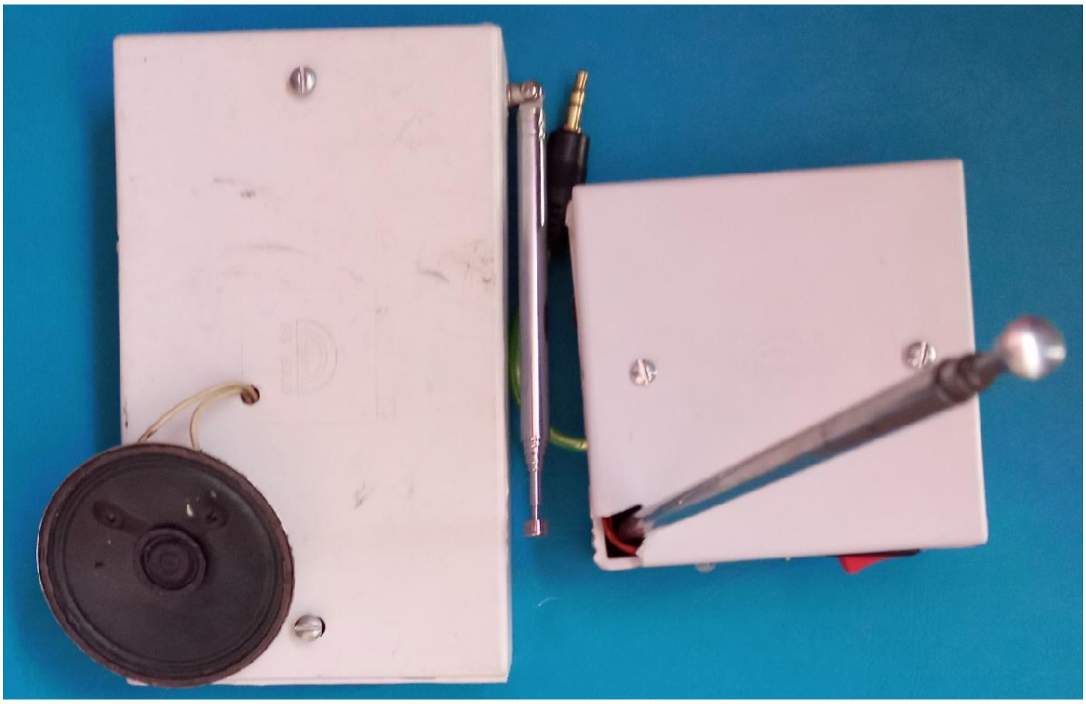

Plate 1 constructed circuit

CHAPTER FOUR: Performance and Cost Evaluation

4.0 Introduction

This chapter discusses the principle of the operation of the system, testing of the system and the result of the operation and test carried out. It also evaluates the cost of components used to construct the entire project.

4.1 principle of operation

The principle of operation and control of the the FM transmitter and Receiver system is based on two mode; the ON and OFF mode. The sequence of operation starts when the switches on the transmitter and receiver are turned ON. The transmitter picks up sound from the environment using the microphone and transmist it which is capture by the receiver. The sequence ends when the switch on either the transmitter is turned OFF or when both are switch off

4.2 Testing

The circuit was designed and simulated on proteus before it was replicated on a breadboard. The component were transferred on the board and soldered together with great care and technique, checking for open circuit or short circuit using Multi-meter to ensure that the voltage at every level is as expected. In the course of the project from the design to the simulation, the soldering on the Vero board, the system was tested for the functionability and each worked as expected.

4.3 Result

After the construction, the system was tested and the following result was obtained with an inductor coil with value 527.818nH

Table 4.1: Results

S/N	CAPACITOR VALUE(pf)	Transmitting frequency(Mhz)	Max distance from Receiver(cm)
1	5.43	94.0	10.00
2	5.05	97.5	15.10
3	6.05	89.0	17.2

4.4 cost Evaluation

The value of all components used in this project are described by table 1

Table 4.2: costing and evaluation of project components

S/N	Description of items	Quantity	Cost/unit	Total price
1	2N2222 transistor	2	50	100
2	TDA2003 amplifier	1	200	200
3	470Ω resistor	1	20	20
4	100Ω resistor	1	20	20
5	1822PT	1	30	20
6	1000F 32V capacitor	2	100	200
7	47Ω resistor	1	20	20
8	47 25V capacitor	1	50	50
9	O.1UF 50V capacitor	6	20	120
10	10VΩ	3	20	60

11	1MΩ	1	50	50
12	100VΩ	1	20	20
13	0.01UF50V	1	20	20
14	2N3904 transistor	2	50	100
15	4.7pF capacitor	1	20	20
16	1KΩ resistor	3	20	60
17	10-35pF variable	2	150	300
18	9V transistor battery	2	200	400
19	Construction board dot type	1	200	200
20	Condense mic	1	150	150
21	1W8Ω speaker	1	200	200
22	Soldering lead	5Yard	500	500
23	Radio antenna	1	150	150
24	TDA2003 heat sink	1	50	50
25	S.P.S.T. switch	2	50	100
26	Packaging for transmitter	1	350	350
27	Packaging for receiver	1	600	600
28	527.818nH inductor	1	150	150
29	528.807nH inductor	1	150	150
30	Led light	2	20	40
31	Transportation	1	500	500
32	Transistor battery connector	2	100	200
33	Connection wires	2Yard	100	200
	TOTAL			5,350

CHAPTER FIVE: CONCLUSIONS

5.0 Summary

The FM transmitter and receiver used for this project is a prototype design, and the objective of the project was achieved, which was to design an FM transmitter and receiver for use in a public address system. The system use the microphone in the transmitter to pick audio input and transmit it through the antenna ,the transmitted signal is capture by the antenna of the receiver and gives out the out the process audio through the speaker

5.1 Conclusions

After the design and construction of the system, it was demonstrated that the system had the capability to be used to broadcast and send audio messages to a large gathering of people

5.2 Recommendations

Based on the challenges I encountered in the process of putting this project together, I recommend the following for further research work to be done more perfectly;

i. Since some of the circuits components like the variable capacitor are difficult to find, purchasing or ordering should be made

ii. Powerful amplifier and RF amplifier should be used to boost the sound

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