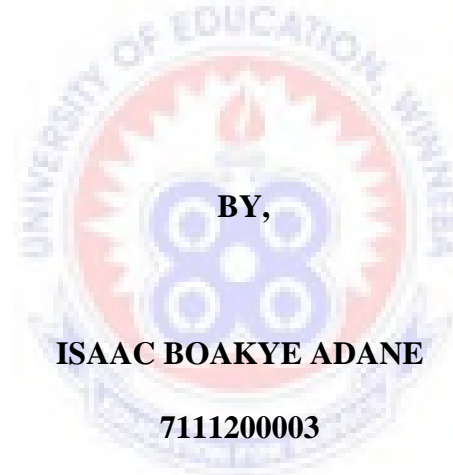**UNIVERSITY OF EDUCATION WINNEBA**

COLLEGE OF TECHNOLOGY EDUCATION; KUMASI

FACULTY OF TECHNICAL AND VOCATIONAL EDUCATION

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DESIGN AND CONSTRUCTION OF AN FM TRANSMITTER USING PHASE-LOCKED LOOP FOR PUBLIC ANNOUNCEMENT SYSTEM

BY,

ISAAC BOAKYE ADANE

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A DISSERTATION SUBMITTED TO THE DEPARTMENT OF DESIGN AND TECHNOLOGY EDUCATION IN THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, UNIVERSITY OF EDUCATION WINNEBA, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF TECHNOLOGY (ELECTRICAL AND ELECTRONICS ENGINEERING) DEGREE.

OCTOBER, 2015

DECLARATION

STUDENT'S DECLARATION

I Isaac Boakye Adane declares that this project with exception of quotation and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for any other degree elsewhere.

ISAAC BOAKYE ADANE

Candidate…………………………   Date: ……………..………

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this project work was supervised in accordance with the guidelines on supervision of project laid down by the University of Education, Winneba.

PROFESSOR WILLIE OFOSU

Supervisor……………………… Date…....................................

ACKNOWLEDGEMENTS

DEDICATION

This dissertation is dedicated to:

- all mother who have worked hard to put smiles on the faces of children. Especially my dear late mother Agnes Adjowa Akomagyan Peters may God richly bless you for your toil.

- all children through no fault of theirs have to go through life without the guidance of a parent. To such, I say do not give up, lean on God, work hard sooner than later you will be exonerated.
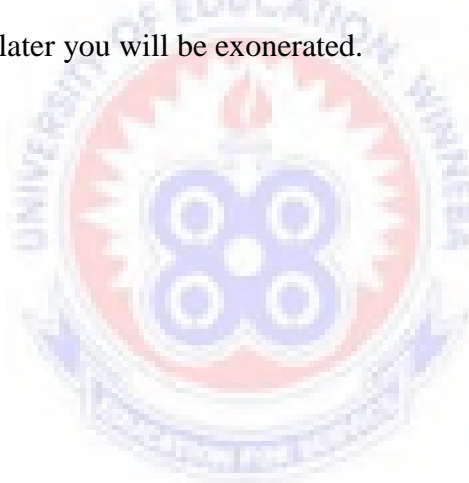
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DEFINITION OF TERMS

- VDC   Direct current voltage
- VAC   Alternating current voltage
- VCXO   Voltage-controlled crystal oscillator
- LOS   Line of sight
- **CIC**   Community information centre
- **CRC**   Community Radio Centres
- VCO   Voltage controlled oscillator
- LCD   Liquid Crystal Display
- PLL   Phase Locked- Loop
- TR   Transmitter
- FLL   frequency locked loop
- RF   Radio Frequency
- IF   Intermittent Frequency
- UNLK   Unlock frequency
- BPF   Band pass filter
- LED   Light Emitting Diode
- SNR   Signal to Noise Ration
- LPF   Low pass filter
- LNA   Low Noise Amplifier

ABSTRACT

Dissemination of information is the basis of all communication around the globe and a backbone for societal development. In the era of technology, radio frequency (RF) application has become eminent in information transmission. Inevitable there would be Public address system due to inherent limitation in human voice. A public address (PA system) is an electronic amplification system with a mixer, amplifier and loudspeakers, used to reinforce a given sound. This project elucidates simple design and cost-effective digital transmitter-receiver to replace emerging traditional PA system which apparently has shortcomings in long distance transmissions and signal-to-noise ratio (SNR). The project aims at developing a phase-locked loop FM transmitter with a radius of 5 km for public announcement, the design output is simulated using multisim and PIC simulator. The project serves as information medium for a community of 1000 people instead of town carrier (gongon beating). The announcement passes through a microphone attached to the transmitter, which converts the sound energy to electrical energy; the electrical signal transmitted was received through the antenna of the FM receiver placed within in a range of 2 km-4 km away from the transmitter. A loudspeaker mounted on pole broadcast information. The result of the project demonstrate that the prototype designed consumes 800 mW with a 70 dB output and signal radius of 5 km. The input used was 12-18 V DC with 76.0-76.8MHz frequency range. This accomplished the intended objectives for the community information center. Finally, depending on the availability of further advance technologies, this type of FM Transmitter/Receiver could be further improved with incorporation of sound sensitive circuit in the design for utmost efficiency and reliability in information delivery.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Over the past decade, the use of technology in information delivery has dramatically changed our lives and living styles. Users of information use it for different reasons. Some use it for health, others for advancement in knowledge, for politics and for many other applications. To all these people, seeking information is a fundamental human process closely related to learning and problem solving (Goldfarb, 2006). According to Okogbe (2002), information and its dissemination appropriately are seen as critical resource for people and communities in both rural and urban areas. Information is now accepted as an important factor in sustaining development of any society because it reduces uncertainty, and enhances awareness of possible actions to be taken to solve problems.Apata and Ogunrewo argued thatlack of information is to act as a barrier to development because of the importance of information provision in "capacity building" and "empowering communities" (as cited in Wakelin & Simelane, 1995and Adimorah, 1995). Information itself is not mobile but needs a vehicle of dissemination from one man to another and from where one distance to another. Issa (1997) affirmed that information has to be widely disseminated regardless of where the person is either an urban or rural inhabitant. The medium of dissemination could be called a channel. Channels of information communication are interpersonal from one person to another through signals, signs, beckoning, language, eye contact, town criers (most especially in the primitive days and in villages).Advancement in technology has made it possible for human being to communicate easily

irrespective of geographical location through the aid of telephones, telegram, fax, radiophone, television, e-mail, telex, internet, intranet, computer etc.

Traditional ways of conveying information to the populace in local communities have received tremendous changes. Gone are the days when in Ghana, information from authorities like Chiefs and other people in authorities were transmitted to their subjects through the use of town criers or drum beating by the informants (Karl Haas, 2008, vol.13). In Ghanaian Communities, due to numerous benefits as compared to "gongon"/drum beating and "town-criers" the technology of public address systems (PA system) has been replicated by some urban/rural folks for information dissemination in Community.This is called "Community Information Centre" (CIC) that is mounting of megaphones on a particular area to convey information to the peoples within that area. For these reasons, in designing successful PA system, the sound (speech/music) should be loud enough and to sufficiently distributed for all audience to hear it comfortably with less-distortion (Midwinter Convention report 1923). The acoustic of the space in which the sounds originate and reproduce the characteristic of the speaking system itself needs consideration (James 2001).

The above studies have called for the limitations in CIC usage. These include lack of sound audibility for people living far away from the megaphone; clearness of sound (signal to noise ratio) associated with increase in volume for audibility; high cost of installation (mounting of megaphone and cable running); high pitch as a result of feedback of the sound since the megaphone is close to the amplification unites and Inability of the sounds wave to travel to a far distance.

A number of interviews conducted by the researcher within Western and Central region indicates that Communities are willing to adopt CIC as "Community Radio Centres" (CRC) for information (announcement) delivery because it is cheap,

effective , simple and reliable (Abraham 2009) than the authorized commercial radio announcement.

However, in spite of the numerous challenges of CIC outlined above, no concerted effort has been made to date by researchers to address these challenges. It is against this background that the researcher seeks to design and construct FM transmitter and Receiver with a phase- locked loop (PLL) for CIC for a particular Community of 5km with a population target of about 1000 people.

The FM transmitter with a phase-locked loop (PLL) designed will take a voice signal (announcement) in the audio range (20-Hz – 20-kHz) from the microphone and transmit it with a predetermined frequency into the air through a loop antenna mounted as shown in Figure 1.1.Thereceiver antenna picks up a noisy attenuate dsignal from transmitter and, selectively filter and amplifies the signal in the spectral regions around 24.3-MHz and 300-kHz, and ultimately demodulates the transmitted signal back to a recognizable audio signal and finally into the receiver speaker mounted about 5km away from the transmitter. The receiving antenna acts as the detector of the electromagnetic waves and the speaker is a transducer converting electric impulses into sound.
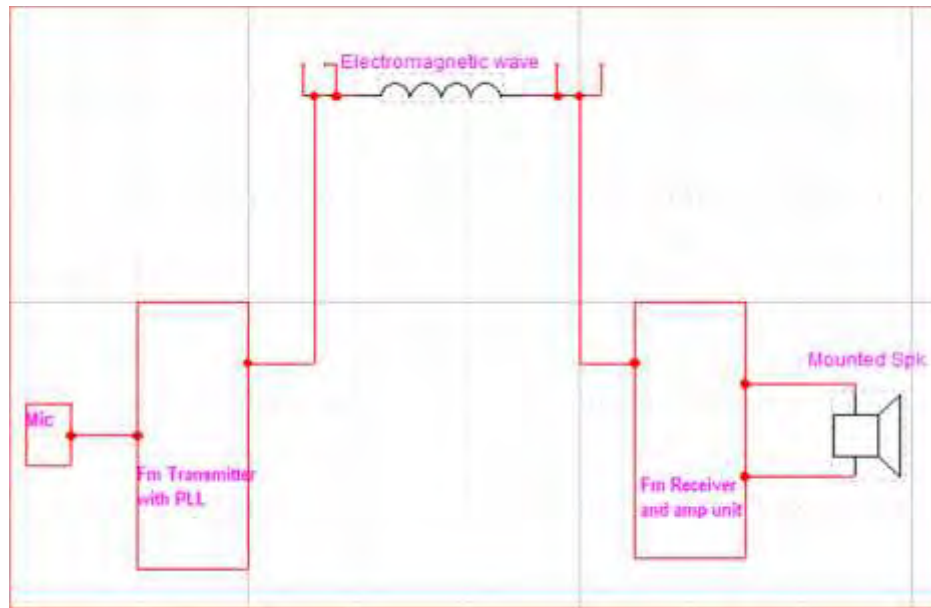
Fig 1.1 Graphical representation the project

1.2 Statement of Problem

Following the increase in access to information (announcement) in rural/urban Communities in Ghana, most Communities are using Public Address (PA) systems as a modern technology to convey local announcement rather than resorting to commercial radio announcement and other traditional method. However, it is found that the PA system is facing some challenges. These include:

1. Fading of sound audibility for people living far away from the megaphone.

2. High pitch as a result of feedback of the sound since the megaphone is close to the amplification unit (Signal to noise ratio).

3. Inability of the sound waves to travel to a far distance (transmitting radius).

4. Running cost as a result of power wastage and power losses on cable.

5. Speech intelligibility (reverberation time, ratio of direct and diffused sound (determined by total absorption and distance source of receiver) and late and early reflection).

In this project, FM Transmitter and Receiver technology will be used to mitigate the problems associated with the use of PA system for local announcement.

1.3 Purpose and Objective

Generally, this project seeks to employ the use of FM transmitter with phase- locked loop (PLL)in community announcement instead of ordinary PA system (mounting of Megaphone) for public announcement in Ghana, in effect turns to reduce the cost of operation, equipment and increase access to information for community development. The specific objectives of this project are to:

1. Produce a transmitter using phase-locked loop with a 12-18VDC, 800mW, and 70dB output and signal of a radius of 5km.

2. Design transmitter that uses a programmed microcontroller chip that will lock the oscillator phase frequency and transmits at 76.5MHz frequency (below FM band 88MHz-108MHz)display on HD44780 2x16 LCD.

3. Perform cost evaluation on the proposed designed FM transmitters and compare with commercial PA system.

1.4 Research Question

The purpose of the study has called for formulation of research questions to address the specific problems intended to solve by this project.The overall research question was formulated as follows:

1. Is there a significance difference between ordinary PA system for CIC and FM Transmitter/Receiver using PLL as CIC for public announcement?

2. Will FM Transmitter/Receiver use as CIC provide a long range of transmitting radius with audible voice and less noise signal than ordinary PA system?

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3. What will be the cost benefit of constructing FM transmitter/receiver with SAA1057and PIC16F84microchip for CIC as compare to purchasing of ordinary PA system for public announcement?

1.5 Significance of the Project

The study will assist communication engineers to have an idea of providing efficient and cost effective communication system for CIC in Ghana. In addition, this project seeks to address voice clarity thereby reducing signal to noise ratio (SNR) as a result of high feedback pitch during public announcement with PA system and to be used as information delivery tool for people in authority at the rural areas unlike commercial radio station.

1.6 Scope of the Study

This project is geared towards designing a prototype FM Transmitter/Receiver whichhas all the features of FM system with Phase lock-loop. The centre frequency of the design is 76.5 MHz below normal (88-108) MHz FM frequency making it unique for community announcement i.e. CIC (PA system), announcement and entertainment of customers in a supermarket, airport, lorry station announcement and other public gathering information delivery.

1.7 Limitation

The major limitations during the construction of this project includes: Some of the components are not available and have to be imported to Ghana especially the IC TDA7000, SAA1057and PIC16F84microchip. Changes in environmental condition

also affect the component value thereby giving different value as recorded on the data sheet. These affect tthe design process and the components performance.

1.8 Project Organization

The various stages involved in the development of this project have been properly put into five chapters to enhance comprehensive and concise reading; the project is organized sequentially with chapter one justifying the research. Chapter Two deals with literature review. This includes journals, books on transmitters and receivers and related studies on the topic. Chapter Three describes methodology with various sections of design, development and implementation of the project work. Chapter four concentrate on the results and discussions together with the cost analysis whiles Chapter five concludes the research result with recommendations of the entire project.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This aspect reviews various literatures related to the topic of interest to uncover some critical facts, findings and solutions which have already been identified by previous researchers. Their findings will be helpful in designing the phase-locked loop (PLL) FM transmitter and receiver for transmitting voice audio in rural (CIC) Community Information Centres. Indeed this aspect will also examine the ancient medium of information transmission and the existing modern day medium of information transmission and the PLL technology itself. This chapter will also guide the direction of this project and aids in exploring new technologies used in PA system designs.

Communication has been an age-long process in which information is passed from one generation to another. The idea of public address system was born out of the necessity in human voice to reach out to a large audience in public gathering such as markets, churches and lecture halls. Public speaking is the process of speaking to a group of people in a structured, deliberate manner intended to inform, influence, or entertain the audience. In public speaking, as in any form of communication, there are five basic elements often expressed as "who is saying what to whom using what medium with what effect" (Kleitz.W; 2005pg.134). Montoro and Schneider (2007) stated, "It would have been impossible to transmit and receive audio without the use of radio waves and radio receivers". Nikola Tesla implemented practical applications of the wireless communication and remote control technology (Suzanne. deffree, 2015) and Alexander Stepanovich Popov designed the world's first radio receiver and

was the first to demonstrate the practical application of electromagnetic (radio) waves and exhibit it at All-Russia exhibition in 1896 (Suzanne. deffree, 2015).

2.2 Ancient Medium of Information Transmission

In the traditional African settings where most residents are illiterates the mode of passing information to the people are through "Town-Criers" (City of East Yorkshire, 2007). In Africa, specifically Ghanaian Community before the coming into force of Information Communication and Technology (ICT), the traditional ways of conveying information to the populace in local communities have received tremendous changes. The ancient medium of information dissemination from authorities like chiefs and other people in authorities were carried out through the use of "Town-Criers" in beating of "gongon"/drum by the informants (Apata and Ogunrewo, 2010). According to Nnaemeka, (2013) transmission of information in the ancient days is passed across using drums; wooden gongs to call on people's attention before passing on the information, Ezeorah Chidiebere (2009) cited in Nnaemeka 2013, that a rimmed cattle horn was used to serve as a microphone during traditional announcement. It is clear that these ancient media of information dissemination were effective, cheap, simple and reliable (Abraham 2009) but it is argued by Meyer 2005, that the use of "Town Criers" is still in vogue in some traditional towns and villages in Africa and some parts of the Caribbean. These have necessitated the use of microphone and megaphone as modern approach by some communities in delivering of information (announcement).

2.3 Modern Day Information Medium Approach

Recently, most communities in Ghana have adopted the use of technology in transmitting of announcement in a community. It is called a Community Information Centre (CIC) also known as Community Public Address System (PA system) i.e. mounting of megaphones on a particular area to convey information to the peoples within a certain radius. This means of announcement gives a wider coverage and more reliable means in community announcement that could be seen in a community. On this note PA system is classified as a system which comprises of electrical equipment's to greatly amplify a speaker's voice so it will reach a much larger than he could speak unaided (Green and Maxfied, 1923). This system consists of a microphone as the input medium and an amplifier with the speaker as the output medium.

The public address system described here is most readily considered in three sections: "pick up" apparatus which is place in the neighbourhood of the speaker and converts his words into electric current; amplifier for amplifying this current; and a receiver for reconverting the current into sound waves and distribute the sound over the audience. These early public address systems made good use of transducers and communication cables. The condenser microphone which is a transducer that converts sound or noise into electrical quantity due to the change in resistance which enables the conversion of sound into electrical signal. This electrical signal is then transmitted to the amplifier section through a transmission cable which is parallel or coaxial. A suitable amplifier circuit is built at the loudspeaker section to amplify the signal from the transmission cable and finally the speaker is a transducer that can equally convert this signal (electrical) back to sound energy. The above explanation is the operation of early public address system. This type of system has various forms of problems

during announcement (Travis & Uchizono, 2011). The disadvantages associated with earlier PA systems include:

Risk of open circuit occurrence in the communication cable as a result of the environment; There are complex circuitry due to the absence of integrated circuit chips for higher reliability and easier trouble shooting; High pitch as a result of high frequency; The range of movement is usually restricted by the length of the wire andlow coverage area due to cables and discomfort while handling the microphone due to the cable connecting it to the speaker.

2.4 Community Information Centre (CIC)

This system basically transmits; receives and amplifies voice signal for a large community audience. Public address system is an electronic amplification system used for communication in public areas (Nnaemeka, 2013). On the other side; public address system comprises electrical equipment to greatly amplify a speaker's voice so it will reach a much larger assemblage than he could speak to unaided (Maxfield and Green, 1923).

However, since FM transmitter and receiver systems operate using wireless link, it depends upon certain general principles of radio; there is need for modulation of the transmitted signal and demodulation or reception of the transmitted signal. The systems involved a separate transmitter and receiver systems. In telecommunications, modulation is used to convey a message, or a musician may modulate the tone from a musical instrument by varying its volume, timing and pitch . Often a high-frequency sinusoid waveform is used as carrier signal to convey a lower frequency signal. The three key parameters of a sine wave are its amplitude ("volume"), its phase ("timing") and its frequency ("pitch"), all of which can be modified in

accordance with a low frequency information signal to obtain the modulated signal. Frequency modulation is the modulation type used for this project work.

2.5 Frequency Modulation (FM)

Frequency modulation (FM) is a technique for wireless transmission of information where the frequency of a high frequency carrier is changed in proportion to message signal which contains the information (Mohn, 2007). When the frequency of carrier wave is changed in accordance with the intensity of the signal, it is called frequency modulation. It conveys information over a carrier wave by varying its frequency. In analog applications, the instantaneous frequency of the carrier is directly proportional to the instantaneous value of the input signal. An important concept in the understanding of FM is that of frequency deviation. The amount of frequency deviation a signal experiences is a measure of the change in transmitter output frequency from the rest frequency of the transmitter. The rest frequency of a transmitter is defined as the output frequency with no modulating signal applied. For a transmitter with linear modulation characteristics, the frequency deviation of the carrier is directly proportional to the amplitude of the applied modulating signal. Thus, a transmitter is said to have modulation sensitivity.

2.5.1 Advantages of Using FM as PA system

⟩ There is superior immunity to noise which is made possible by the clipper limiter circuits in the receiver.

⟩ There is effective stripping off of all the noise variations which leaves constant- amplitude.

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⟩ FM signal and electromagnetic wave generated at the oscillator stage is very strong and can penetrate through walls because of the transistor type BF199 VHF/ UHF RF transistor features.

2.6 The FM Transmitter System

The first part of the typical transmitter is the input circuitry. This section makes the proper electrical match between the input source and the rest of the transmitter. It must handle the expected range of input levels and present the correct impedance to the source (Malik N.R.1995). Gain controls and impedance switches allow greater flexibility in some designs. In certain cases, the input circuitry also provides electrical power to the source (for condenser microphone elements). Boylestad, R., & Nashelsky, R. (1996) state that; "The first process is a special equalization called pre-emphasis, which is designed to minimize the apparent level of high frequency noise (hiss) that is unavoidably added during the transmission"

The "emphasis" is a specifically tailored boost of the high frequencies. When this is coupled with an equal (but opposite) "de-emphasis" in the receiver, the effect is to reduce high frequency noise by up to 10dB. The second process is called "compensate for the limited dynamic range of radio transmission" (Ezeorah Chidiebere 2009).

2.7 Phase-Locked Loop (PLL) In FM Transmitter

The first Phase -Lock Loop (PLL) was proposed in 1932 by French engineer de Bellescize, who is considered the inventor of "coherent communication" Gardner, F.M (1967). Phase locked loop (PLL) is one of the most inevitable necessities in modern day electronic systems, it's a feedback system that controlled the output

with an input error as Dash & Gosh, (2010)argue that A phase-locked loop (PLL) is a feedback control system that generates a signal that has a fixed relation to the phase of a reference signal. It responds to both the frequency and the phase of the input signals, automatically raising or lowering the frequency of a controlled oscillator until it is matched to the reference in both frequency and phase. Wikipedia (2012) explained "A phase-locked loop (PLL) is a closed-loop feedback control system that maintains a generated signal in a fixed phase relationship to a reference signal." Generally, the PLL is a circuit synchronizing a self-generated output signal with a reference or input signal in frequency and phase. In the synchronized state (locked state) the phase error between the output signal and the reference signal is zero or constant. If a phase error occurs, a PLL's control mechanism acts on produced output signal in such a way that the phase error is minimized; this is why it is referred to as a phase-locked loop. Figure 2.1 shows a building block circuit diagram of The PLL.
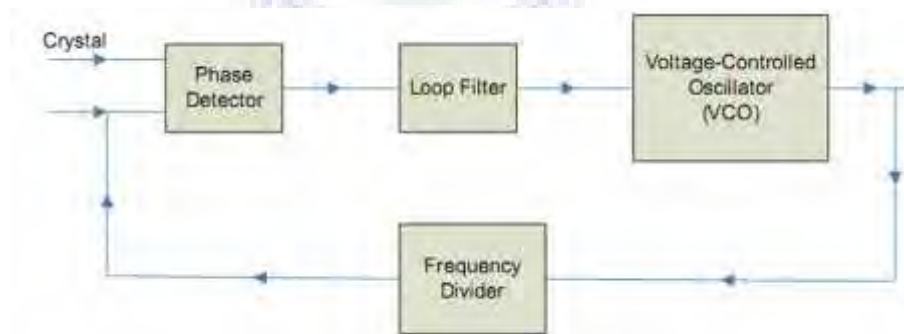
Figure 2.1Block Diagram of Phase Locked Loop (PLL)

⎠ *Phase detector:* As the name implies, this circuit block within the PLL compares the phase of two signals and generates a voltage according to the phase difference between the two signals.

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⟩ ***Loop filter:*** This filter is used to filter the output from the phase comparator in the PLL. It is used to remove any components of the signals of which the phase is being compared from the VCO line. It also governs many of the characteristics of the loop and its stability.

⟩ ***Voltage controlled oscillator (VCO):*** The voltage controlled oscillator is the circuit block that generates the output radio frequency signal. Its frequency can be controlled and swung over the operational frequency band for the loop

Today, the PLL is key component of modern communication systems, where it has many different applications such as frequency synthesizers, FM demodulators, carrier synchronization, carrier recovery, frequency division and multiplication etc. Sincethe PLL found broader industrial applications it became available as an integrated circuit incorporated in a single chip. The three main operating states of PLL which essential in this project are ;free running state (no external input frequency or the feedback loop is open), Capture state (the PLL is in the process of acquiring frequency lock with the external input signal by using the feedback loop and the time required to achieve lock is called acquisition time or pull-in time) and Lock state (This is the state where the VCO output frequency is locked onto (equal to) the frequency of the external input signal).

2.8 Antenna

The antenna is the circuit element responsible for converting the output power from the transmitter amplifier into an electromagnetic wave suitable for efficient radiation in free space (Adoga and Kadafur, undated). Another characteristic of antennas is their relative efficiency at converting electrical power into radiated power and vice versa, it is desirable to use an antenna that radiates power uniformly to its listeners.

There are many forms of antenna which are physical constructed based on the frequency of operation and the radiation pattern desired for broadcasting purposes. In fact, the design and implementation of antennas are as important as the devices to which they are attached. In particular, the size of antennas is directly proportional to wavelength and inversely proportional to frequency (Beranek .L; 1954). Lower radio frequencies require larger antennas, while higher frequencies use smaller antennas. An increase of 6dB in radiated power, or increases of 6dB in received signal strength can correspond to a 50% increase in range. Likewise, a loss of 6dB in signal may result in 50% decreased in range (Beranek .L; 1954). The function of the antenna is to act as the interface between the internal circuitry of the transmitter or receiver and the radio space. In the case of the transmitter, it must radiate the desired strength and in the desired direction. These reviews make it appropriate to used helical antenna to achieve the radiated signal of the design presented in this project. A helical antenna is an antenna consisting of a conducting wire wound in the form of a helix. In most cases, helical antennas are mounted over a ground plane. Helical antennas can operate in one of two principal modes: normal (broadside) mode or axial (or end fire) mode.

2.9 Related Studies

There have been various attempts by researchers in the field of FM transmitters and receivers in transmission of information, hence little have been done when it comes to public address system. This aspect of the literature will focus on previous studies conducted by researchers on PA system and FM transmitters and receiver and how their work is related to the one under study. Nnaemeka E.H (2013) design and construction of 20 W wireless public address system, his work acknowledged

reverberation distance in closed spaces and recommended that loudspeakers and microphones should have non-uniform directivity and should stay out of the maximum sensitivity of each other, ideally at a direction of cancellation.

Anquandah and Okae (2013) construct an FM Transmitter Bug for Baby Monitoring as published in European Academic Research, in their research, they failed to acknowledge the use of PLL for frequency stability, however recommended the use of dipole antenna to extend range of the transmitter.

Travis and Uchizono (2011) also implemented wirelessly Operated PA Loudspeaker System for RMAX Search-and-Rescue team, their design accomplished by using two-way radios that operate on either a rechargeable battery pack or three AAA batteries. In the above two designs, the researcher failed to acknowledge the noise generated by some of the components they used in designing their transmitters and also it operate on line-of-sight (Ashley and Palka, 1971).

Yeh, V. et al (2006) worked on the topic *"A 10-mA Current and 1.1-µV Sensitivity Single-Chip FM Radio Receiver"* in their report they concluded that Modern FM radio receiver on portable devices requires low power consumption, small size and good audio performance. They reported a highly integrated FM radio single-chip receiver optimized for low power consumption should integrate all essential RF front-end circuits including LNA and mixer with automatic gain control (AGC), and mixed-signal functional blocks such as channel filter, limiting amplifier, integrated FM demodulator, stereo decoder, and integrated frequency locked loop (FLL).

Kobayashi Kei et al (2001) extensively researched on Analog frequency modulation detector for dynamic force microscopy and presented a new analog frequency modulation (FM) detector (demodulator) for dynamic force microscopy (DFM). The FM detector employs a phase-locked loop (PLL) circuit using a voltage-controlled

crystal oscillator (VCXO) so that the thermal drift of the output signal is negligibly reduced.

Edward Gibbins. (1998) investigated properties of Frequency Modulation (FM) radio signals by using TDA7000 to construct and build a working FM super heterodyne radio receiver.

Green and Maxfield1923 present a document published in IEEE journal on public address system, the report aims at enumerating the problem encountered in development of electrical system for amplifying voice of public speakers and music; and to describe the equipment used on commercial state in USA and other countries. However, Song, B.S.(1987) also presented the paper "A narrow-band CMOS FM receiver based on single-sideband modulation IF filtering" discussed that a narrowband frequency-modulation (FM) receiver with high selectivity is implemented using a switched-capacitor baseband intermediate-frequency (I_F) filter. Measured adjacent channel selectivity was more than 46dB, and input sensitivity with 30dB quieting level was 5mV without considering a front-end radio-frequency amplifier stage. A fully integrated experimental receiver needs no adjustment or trimming, relying instead on a single reference clock.

Furthermore, Rosenkranz, W. (1985) presented a paper titled, "Design and optimization of a digital FM receiver using DPLL techniques" discussed that it is a well-known fact that the performance of the phase - locked loop (PLL) used as an FM demodulator may be superior to that of the conventional FM receiver in some respects. Therefore in his paper a digital approach to FM demodulation based on the digital PLL (DPLL) principle was investigated. The demodulator together with a digital IF filter and an effective method of sampling the FM signal at minimum sampling rate may be applied as a digital FM stereo receiver for broadcasting. For this

application, the design and optimization of the digital receiver was discussed and results of a simulation on an all-purpose computer presented.

To avoid crosstalk there is the need for phase lock loop fixed into the design of FM transmitters and receivers, hence Milki et al (1979), researched on an FM-radio transmitter concept based on an all-digital PLL when they presented a stereo FM-radio transmitter with Radio Data System (RDS) support based on an all-digital PLL designed as a fully integrated single-chip transmitter in a 90nm CMOS technology to be compatible with digital deep-sub micrometre processes with target application of the proposed system as co-integration with baseband processors and transmitters for mobile communication system.

Since noise is a major factor in communication, Ashley and Palka, (1971) analysed reduction of FM Noise in Microwave Diode Oscillators by Cavity and Injection stabilization and concluded that a cavity stabilized silicon avalanche diode oscillator used as a synchronizing signal to injection phase lock a Gunn oscillator has the best combination of low FM and AM noise. Djen and Shah (1994) extensively research and implementation a 900 MHz Transmitter System using highly integrated for Vehicular Technology conference. Their work fails to talk about speech intelligibility, reverberation time, ratio of direct and diffused sound and distance source of the receiver.

In the light of the above reviews on transmitters and receivers use in various front of information delivery approach which shows limitations in community announcement. This project work seeks to design and construct a PA system using FM transmitter and receiver with PLL to solve problems associated with community information system. The use of FM transmitter and receiver as PA system will increase the signal strength of PA system transmission radius as restricted by the length of the wire,

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eliminate noise as a result of inter channel cross talk and ensure frequency stability by the PLL circuit.

CHAPTER THREE

METHODOLOGY

This chapter deals with blueprint for designing and constructingof PLL FM transmitter using microcontroller chip and LCD to enhance public information delivery. Exploratory design method was employed for obtaining necessary desire component values and detailed procedures needed for simulation, designing and construction of the artifact.The design and construction work was divided into two main sections, the hardware component development and software development. The hardware components were obtained from local and foreign market. Checks and test were made and measurement work was carried out using standard digital multi-meter before soldering of components, the development of hardware components started with the design of block diagram and the prototype design. In the development of the hardware, the TDA 7000IC,Microcontroller PIC16F84, PLL frequency IC SAA1057 and HD44780 2*16 LCD was used as the brain of this project. The FM transmitter circuit developed is an RF circuit. These are circuits that generate and transmit as well as receive electromagnetic waves. Virtually, all communication devices contain tuned circuits. A tuned circuit is defined as a circuit made up of inductors and capacitors that resonate at specific frequencies.

3.1. Hardware Components

The main components TDA 7000IC,Microcontroller PIC16F84, PLL frequency IC SAA1057, HD44780 LCD used in the construction of this project were imported. The others were purchase from the electronic shops locally. Table A1 in the appendices shows the major components used in construction of the project.

3.2 The Block Diagram of FM Transmitter with PLL Circuit

Fig 3.1 shows a block diagram of FM transmitter with PLL
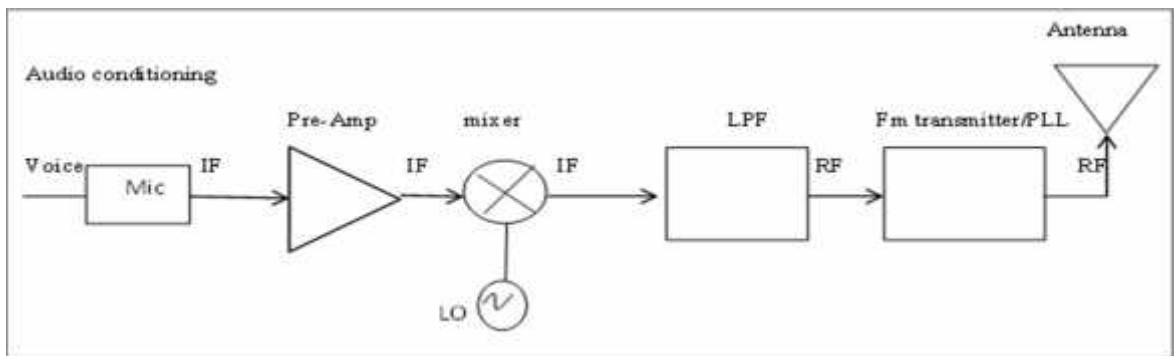
Figure 3.1: A block diagram of an FM transmitter system

The diagram in Figure 3.1 shows the block diagram of FM Transmitter using PLL. The transmitter circuitry is designed to use a 12V (+Vcc) power; the radius of reception is within 5km with a power output of 800mW. The Audio Module is the first stage of the FM transmitter that converts a voice audio signal to usable electrical signal. Microphone is a transducer, which converts sound pressure variations into electrical signals of the same frequency and of amplitudes in the same proportion as a pressure variation.

3.3 Design of the Power Supply Unit

Figure 3.2is the complete circuit diagram for the power supply system; it is made up of five sections which includes the 240/12V step down transformer. This project makes use of the bridge rectifier circuit with four IN4001 rectifier diodes as shown below in Fig 3.2. The rectified signal is then passed through a smoothening capacitor to remove the ripples which results to a steadier signal output, a Voltage regulator which controls the DC output constantly at 12V DC. The capacitor used for smoothening has a ripple factor of 0.1

a   b
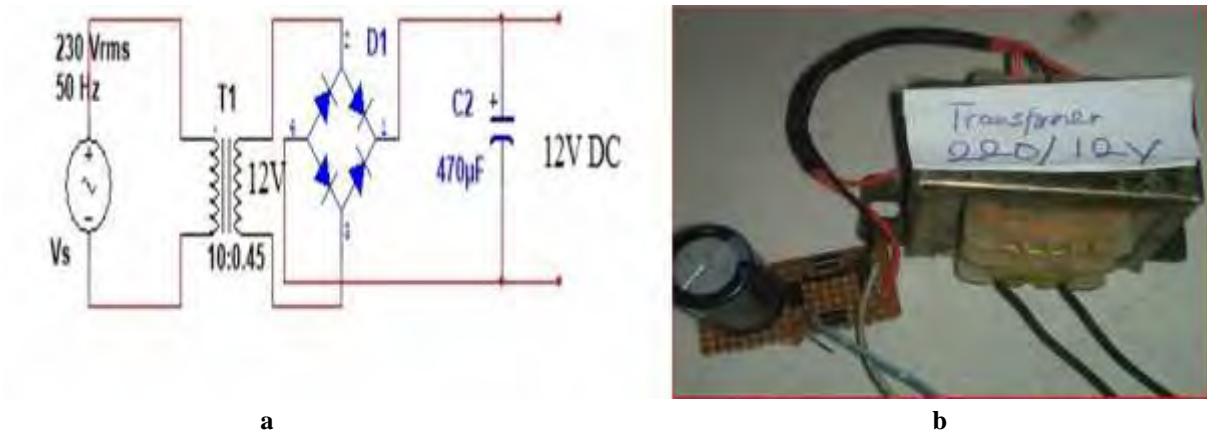
Fig 3.2 Power supply unit for transmitter

3.4 Design of Pre-Emphasis

The circuits at the transmitting side of the frequency modulator is used to increase the gain of the higher frequency component as the input signal frequency increase, the impendence of the collector voltage also increases. If the signal frequency is lesser, then the impendence decreases which increases the collector current and hence decreases the voltage.

$$_1 = 1/r_c \ldots\ldots\ldots\ldots\ldots\ldots (3.1)$$

$$_2 = 1/R_C \ldots\ldots\ldots\ldots\ldots (3.2)$$

$_1$ and $_2$ is break frequency. For FM broadcast purposes, the lower break frequency f_1 is about 2.1 kHz and the higher break frequency f_2 is chosen to be much higher than the highest frequency term in the message band, so that f_2 lies outside the baseband spectral range. For audio rang, f_2 may be taken as 30 KHz. As indicated in appendix1for calculation.

Therefore   R1= 0.000530516k   0.53   .

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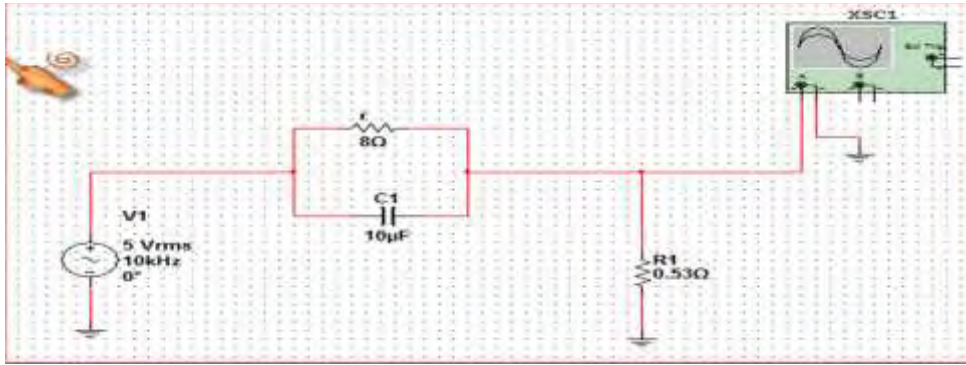
Fig.3.3 Schematic diagram for pre-emphasis

3.5 Design of an Oscillator

Oscillators are necessary in any low power transmitter because they generate a necessary R_F signal. The Colpitt's oscillator is designed for generation of high frequency sinusoidal oscillations. Colpitt's oscillator is same as Hartley oscillator except for one difference. Instead of using a tapped inductance, Colpitt's oscillator uses a tapped capacitance. The circuit diagram of Colpitt's oscillator using BJT is shown in Fig 3.4. It consists of an R-C coupled amplifier using an n-p-n transistor in C_E configuration. R_1 and R_2 are two resistors which form a voltage divider bias to the transistor. A resistor R_E is connected in the circuit which stabilizes the circuit against temperature variations. A capacitor C_E is connected in parallel with RE, acts as a bypass capacitor and provides a low reactive path to the amplified ac signal. The coupling capacitor C_C blocks dc and provides an ac path from the collector to the tank circuit. The feedback network (tank circuit) consists of two capacitors C_1 and C_2 (in series) which is placed across a common inductor L. The centre of the two capacitors is tapped (grounded). The feedback network (C_1, C_2 and L) determines the frequency of oscillation of the oscillator. The two series capacitors C_1 and C_2 form the potential divider led for providing the feedback voltage. The voltage developed across the capacitor C_2 provides regenerative feedback which is essential for sustained

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oscillations. There are different type's oscillator configurations but because of good stability and high resonant frequency for this transmitter operation Colppit oscillator is chosen. When the collector supply voltage Vcc is switched on, the collector current starts rising and charges the capacitors C_1 and C_2. When these capacitors are fully charged, they discharge through coil L setting up damped harmonic oscillations in the tank circuit. The oscillatory current in the tank circuit produces an AC voltage across C_1, C_2. The oscillation across C_2 is applied to base-emitter junction of the transistor and appears in the amplified form in the collector circuit and overcomes the losses occurring in the tank circuit. The feedback voltage (across the capacitor C_2) is 180° out of phase with the output voltage (across the capacitor C_1), as the centre of the two capacitors is grounded.

The frequency of oscillation of the oscillator $f = \frac{1}{2\pi\sqrt{L}}$ (3.3)

Where L is the Self-inductance of the coil (H); C is the Capacitance of the condenser (*f*)

Resultant capacitance of the series combination, $C = \frac{C_1 C_2}{c1+c2}$ (3.4)

Where C_1, C_2 is the capacitances of the two capacitors in the tank circuit
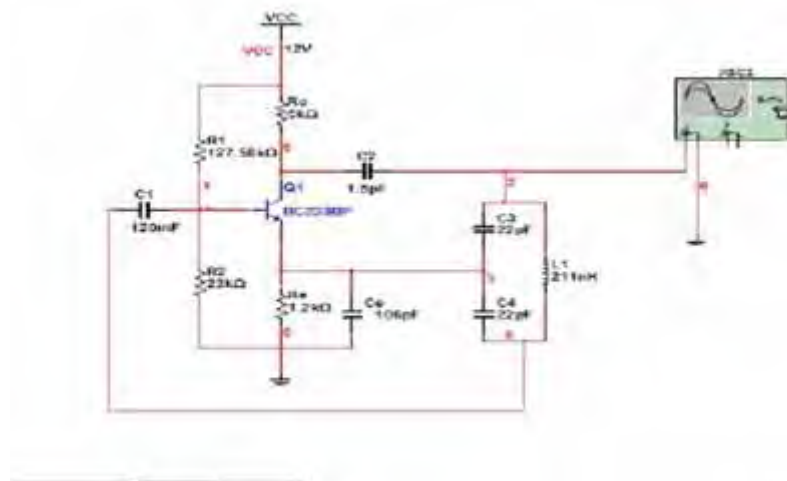
Fig 3.4 Schematic diagram for Colpitt oscillator

3.6 Power Amplifier Design Procedure

The transistor is select according to the frequency of operation, power requirement and *hfe*. For example BC239 has frequency of operation up to 600MHz, *hfe* < 200 and wattage=310mW. Therefore, the transistor must be selected in such way that the minimum *hfe* should be greater than or equal to the Av required.

The supply voltage V_{CC} was selected in such a way that the quotient voltage V_{CEQ} 50%

V_{CC} should give distortion less output and protect from thermal stability. This means, the output voltage swing in either positive or negative direction with half of V_{CC}. See appendixes 3 for the design criteria. The design values use in Fig 3.5 are justified in appendixes 3.
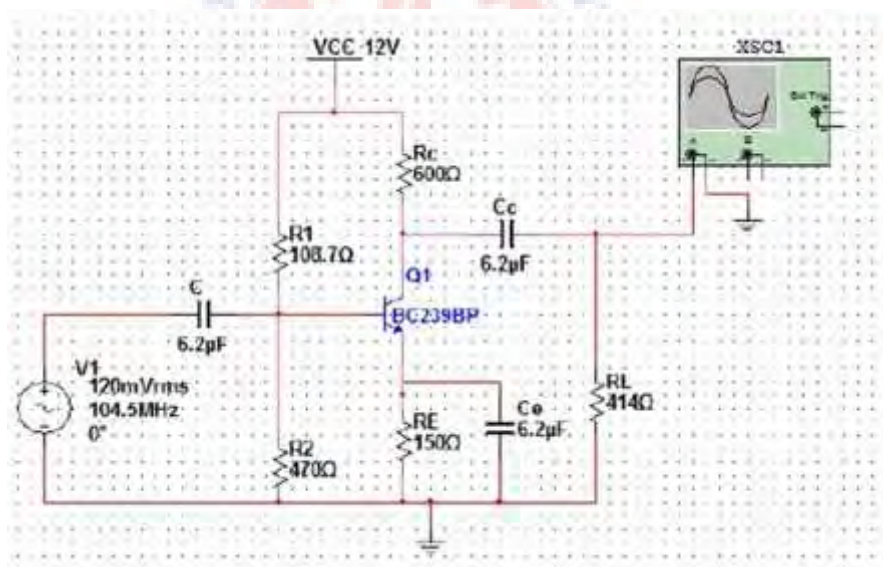
Fig.3.5 Schematic diagram for RF power amplifier

3.7 Antenna

The final stage of any transmitter is the antenna; this is where the electronic FM is converted to electromagnetic waves, which are radiated into the atmosphere.

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A transmitting antenna that is horizontally polarized transmits a better signal to a receiving antenna that is also horizontally polarized; this is also true for vertically polarized antennas.

3.7.1 Design of Antenna Length

The audio frequency carried by the radio frequency carrier of design transmitter is 76.5 MHz, the antenna height required will be $\frac{}{2}$

$$\text{but} \quad = C/f \quad\quad\quad (3.5)$$

$$\text{Where C is } 3*10^8$$

$$\text{Therefore} \quad = \frac{c}{f} \quad\quad\quad (3.6)$$

L=1.96m so practically the antenna height is achieved.

See appendix 4 for calculation procedures for length (L)

3.7.2 Design of Antenna Cross Sectional Area

The electrical resistance of a wire would be expected to be greater for a longer wire, less for a wire of larger cross sectional area, and would be expected to depend upon the material out of which the wire is made (resistivity). Experimentally, the dependence upon these properties is a straight forward one for a wide range of conditions and the resistance of a wire can be expressed as $R=\frac{\rho}{A}$ …… (3.7)

$$\text{Where R is the electrical resistance of copper ( )}$$

$$\rho \text{ is the resistivity of conductor material (m)}$$

$$\text{L is length of copper (m).}$$

Therefore the radius(r) of the antenna is $6.375*10^{-6}m$

See appendix 4 for calculation of radius.

3.8 Complete Circuit Diagram of the FM Transmitter

After the block diagram, the next step was designing of circuit diagram. Figure 3.2 shows the complete circuit diagram of FM transmitter and Figure 3.3 shows Complete PLL FM circuit design with microchip and LCD respectively.
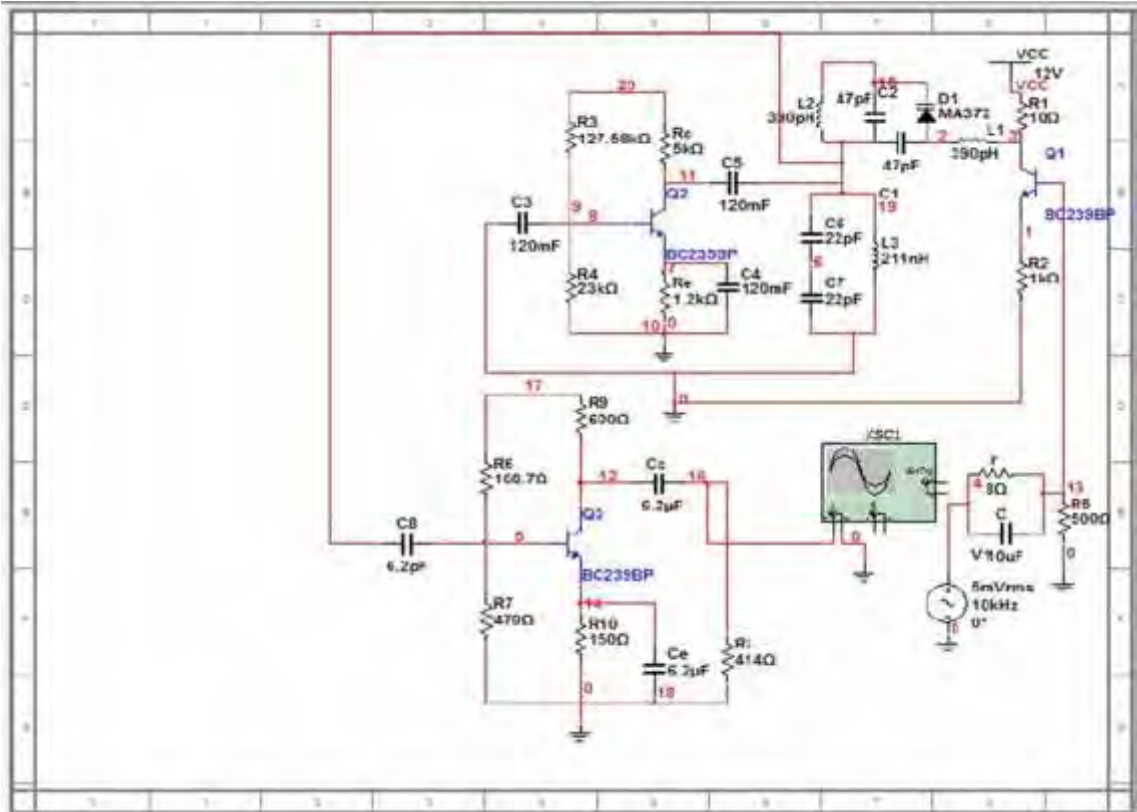
Fig 3.6 Complete circuit diagram of FM transmitter
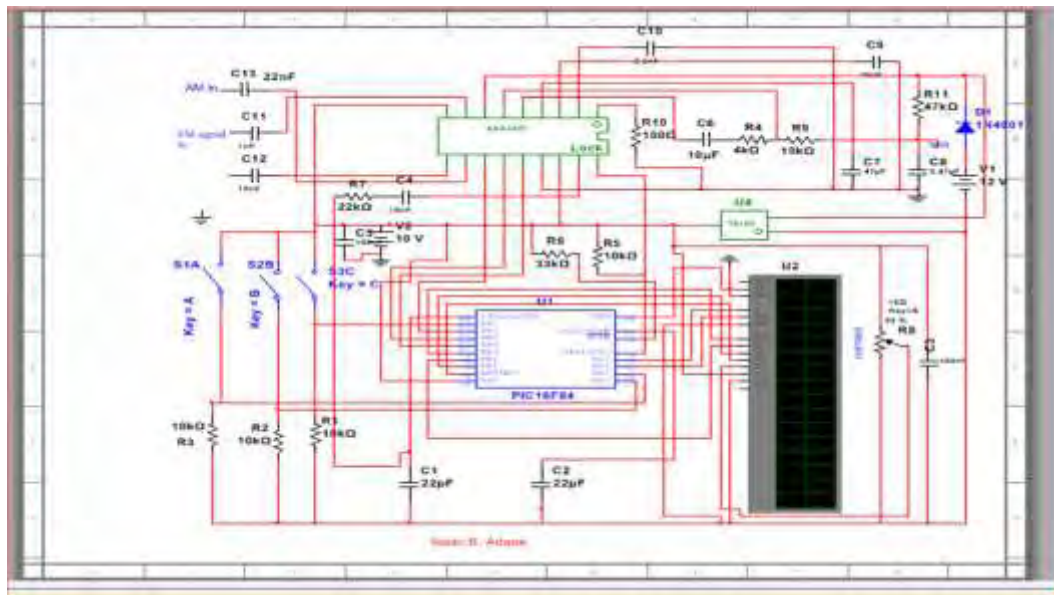
Fig 3.7 Complete PLL FM circuit design with microchip and LCD

3.9 Principles of Operation of the Circuit Diagram of Microcontroller PLL on LCD Screen

Power of 12 Vdc is supplied to pin 7 of SAA1057 IC and then reduces 10 Vdc through 7810 voltage regulator to pin 9, 16 of SAA1057 and pin 2 of HD44780LCD and pin 13, 17, 18 of PIC16f84 respectively. The signal from FM transmitter in Fig 3.6 is fed through 1nf capacitor into pin 8 of SAA1057. The crystal output of transmitter voltage controlled oscillator (VCO)will proceed to oscillate at its natural resonant frequency of 1MHz by simulating negative resistance using RC circuit, however the crystal will determine the resolution of the tuning ability of PLL IC, it is desired to convert it to 200 kHz through the loop filter into VCO of PLL, any difference is fed into comparator (phase detector). After all parameters are fulfilled ,the output frequency is locked through pin 12 and 18 of PLL IC, locked data signal is sent from SAA1057 to PIC16f84 for LCD to display ON AIR.

3.10 Working Principle of FM Receiver System

The receiver works with the transmitter specifically, the receiver picks up a noisy and attenuated transmission, selectively filter and amplify signals in the spectral regions and ultimately demodulate the transmitted signal back to a recognizable audio signal (David Chen, n.d). The receiver consists of an aerial and demodulator with the help of the tuned circuit, this helps in picking up the required signal, this process is illustrated by block diagram in Figure 3.8, since the transmitter sends out electrical energy in form of electromagnetic waves into space; the receiver's antenna intercepts these electromagnetic waves with the aid of a tuning system. These waves are directed into the receiver's circuit to give the audio signal back at the receiving end. The first section of receiver circuitry is the "front end". Its function is to provide a first stage of radio frequency (RF) filtering to prevent unwanted radio signals from causing interference in subsequent stages. A typical tuned circuit consists of a coil and variable capacitor which are connected in parallel. These are connected to the aerial and earth. The coil constitutes an inductor and is called aerial coil; the variable capacitor is commonly referred to as the tuning capacitor. It is able to receive the radio wave through the crystal set which consists of tank circuit which is capacitor and inductor connected in parallel as shown in Figure 3.11.
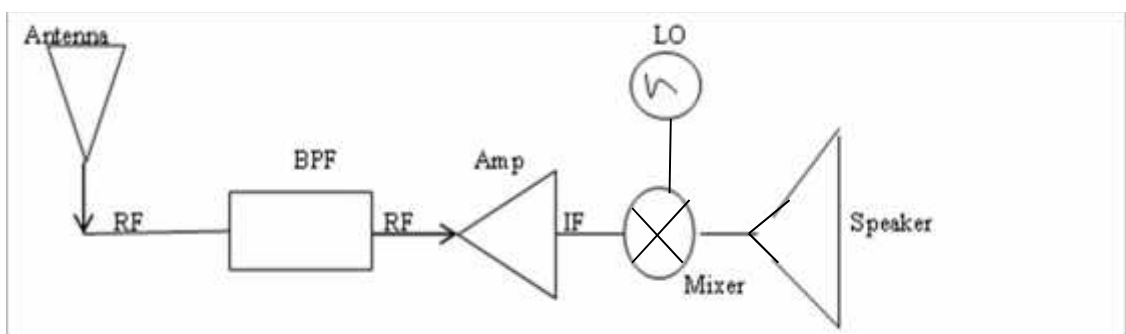
Figure 3.8: Block diagram of the FM receiver system
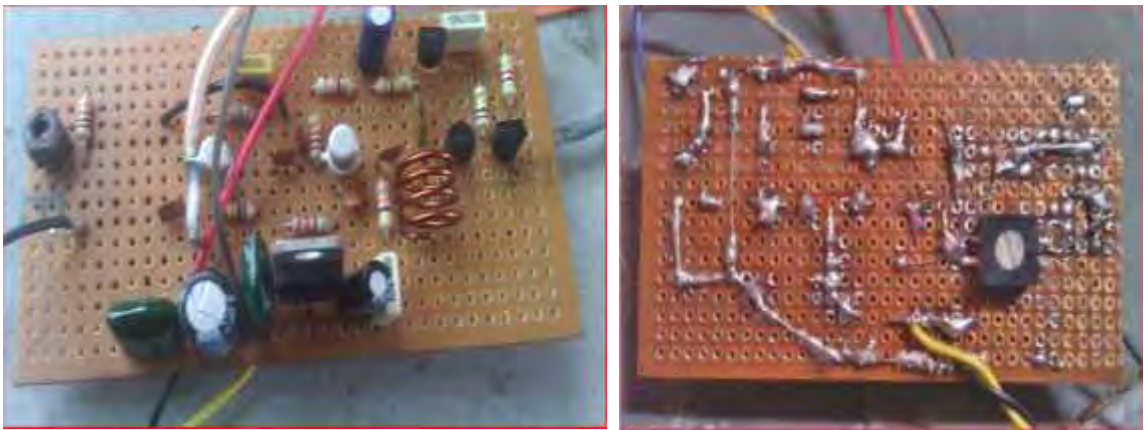
Figure 3.9 Front and back view of prototype FM transmitter.
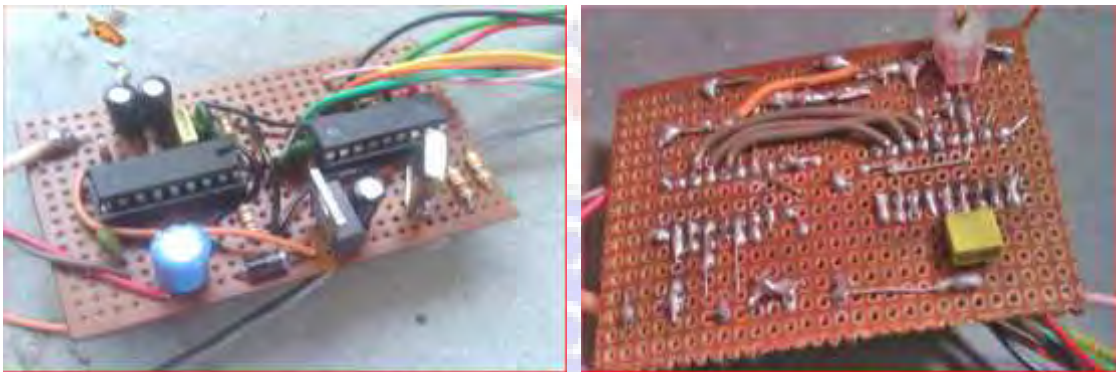
Figure 3.10 Front and back view of prototype PLL microcontroller transmitter.
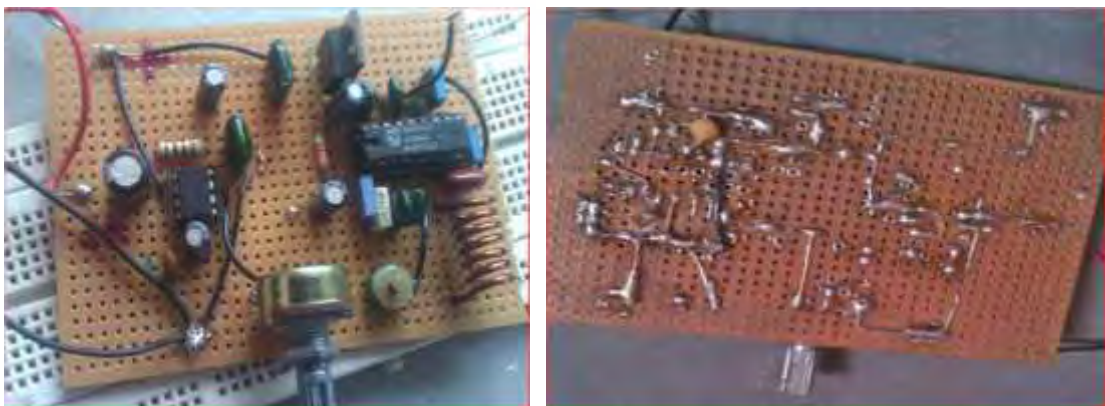
Figure 3.11Front and back view of prototype FM receiver

Figure 3.12 Prototype FM Transmitter Using Phase-Lock Loop for Public Announcement System

3.11 Software Development and Programming

Multisim, Pic Simulator, MATLAB and Visual Basic were used in designing and simulating the entire design to conduct performance analysis. The software will also talk about performance Parameters of the transmitter/receivers which include; Selectivity, Sensitivity, Fidelity and Image Frequency Rejection.

The programming language employed to run the microcontroller was Visual Basic optimizing C cross compiler. The C programming language is a general-purpose programming language that provides code efficiency, structured elements of programming and a rich set of operators. Its generality combined with its absence of restrictions, make C a convenient and effective programming solution for a wide variety of software tasks, many applications can be solved more easily and effectively with C than with other more specialized languages. The Visual Basic compiler

generates code for the pic16f84. The Basic compiler gives software developers the flexibility of programming in C while matching the code efficiency and speed of assembly language. Using a high-level language like C has many advantages over assembly language programming.

In developing a programme for microcontroller PLL base, a computer is used to develop software for the microcontroller chip. This project focuses on developing software using visual basic language. The visual basic program specifies locations, assigns addresses and symbols to the pins in the microchip, it is also easy to insert or delete instruction in a program. The hex file developed through programming in appendix 8 was loaded into the microcontroller with the help of Microchip PICkit2 as shown in Figure 3.13.

Figure 3.13: The setup interface for loading HEX file from the computer into microcontroller Pic 16f84 using microchip Pic kit2.

The moment power is switched ON; the LCD screen of the transmitter will display M.TECH.PROJECT on the line one while line two displays UEW-K.ADANE.BOAK as shown in Figure 3.14. The microcontroller chip scans the input and check if all input parameters and conditions are fulfilled, this is done within 3000μsec before the transmitter begins to transmit signals. At the stage of scanning, second line of the LCD screen will display UNLK- 76.00 MHz as also shown on the Figure 3.14, after scanning and all parameters fulfilled the SAA1057 IC will lock the phase signal frequency (76.0 MHz) of the transmitter. Lock data is sent from the PLL to the microcontroller for processing at this stage the second line of the LCD will display "ON AIR- 76.00 MHz" indicates that the frequency is locked, for that matter the transmitter has begun to transmit voice signal to the receiver. An appendix 7 shows the assembler language file used in programming microcontroller pic16f84 which the output on the LCD as shown in Figure 3.14.
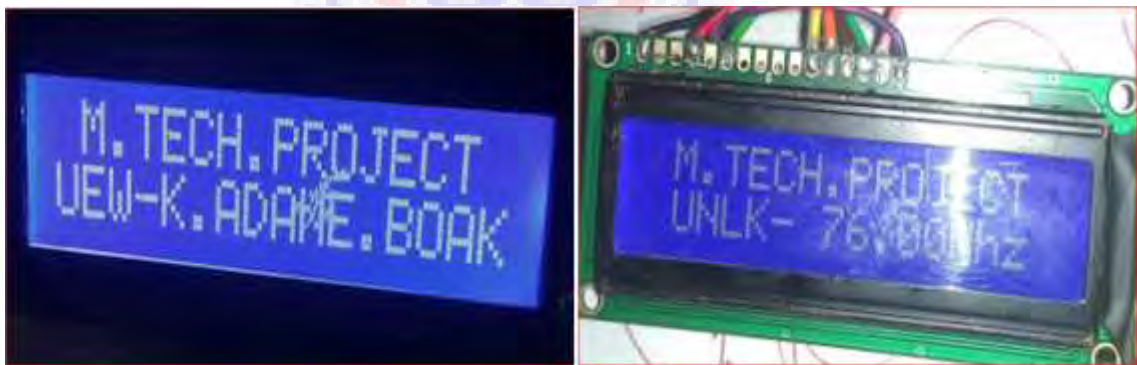
a   b

Figure 3.14 LCD screen displaying at different stages

CHAPTER FOUR

RESULTS AND DISCUSSION

The intension of implementing an FM Transmitter/Receiver with PLL circuit for community information centre was to achieve higher efficiencies in terms of selectivity, power rectification, signal strength and radius and good audio performance with the use of TDA700IC for sound amplification, BF199 and BC239 for frequency generation, SAA1057 for PLL and PIC16f84 for programing instruction. Demonstration was conducted to test the prototype and the results obtained were capture under the following headings:

4.1 Performance Analysis of Transmitter/Receiver with PIC Simulator IDE

The FM Transmitter/Receiver were analysed by simulating the design parameters using PIC simulator as shown in Fig4.2, the resulted output in Figure 4.1 was exactly what was seen on the simulator LCD display. On the other hand, Multisim was used to simulate FM Transmitter/Receiver component values to affirm that inductors, resistors and capacitors values were accurate as possible within the bounds of tolerance.

Figure 4.1 Transmitter output on LCD

Figure4.2 Software interface of Pic simulator analysis

4.2 Transmitter Frequency and Power Test

Figure 4.3 shows the transmitter electromagnetic output waveform when the antenna signal was fed into a spectrum analyser to determine the selectivity ability of the transmitter to select exact frequency, as voice (announcement) was transmitted and received at 76.00 MHz with this frequency the transmitter did not have to compete with more powerful signals from radio stations that will cause inter-channel cross talk on receiver. The was evidence clear that when the distance between transmitter and receiver increases the signal level reduce but when attenuation is zero, and no loses the frequency was exactly 76.00 MHz, as indicated on the oscilloscope when the received signal in decibel (dB) was plotted against frequency. In all the circuit was sensitive to its environment and was not designed to operate as the voltage drops or at extreme temperatures. The measured DC power consumption of the transmitter was 800.5mW with an input power of 12 Vdc as shown in Figure 4.4.

Figure 4.3 Spectrum analyser showing frequency of the transmitter
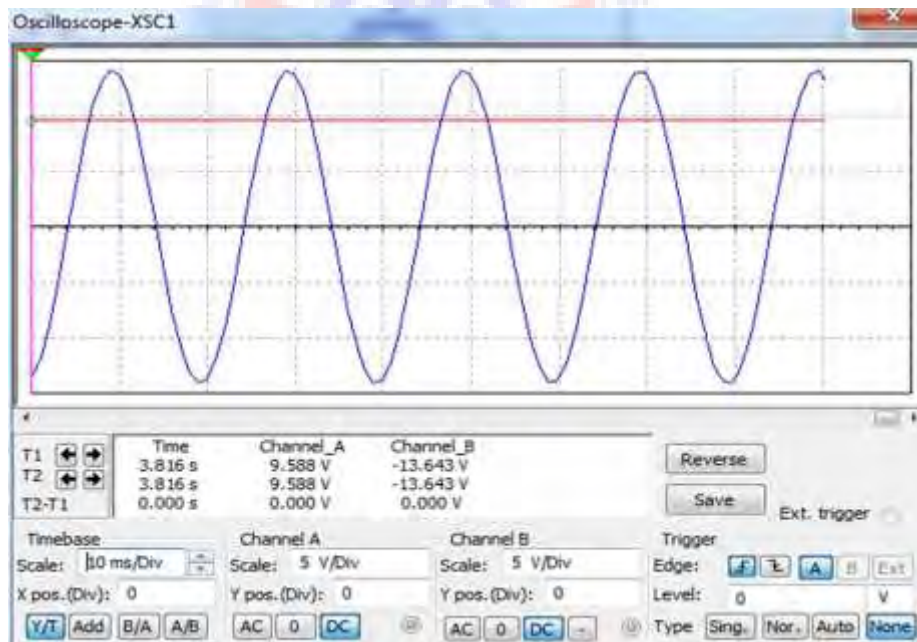
Figure 4.4Simulation Result of 220 VAC/12 VDC

4.3 Testing of Transmission Radius and Signal Strength

Signal to radius strength were tested with the transmitter and receiver. For the transmission testing the antenna as well as the amplifier was tested together to see how successful it transmit information over varying distances and frequencies.Two field tests were conducted.

Firstly, the transmitter was connected to the roof antenna and a voice (announcement) was sent out through a microphone. The receiver attached to the speaker was placed2km away from the transmitter and good signal reception was achieved. As the receiver was move further along the way, it was noticed that dead spots occurred most frequently in the presence of trees. Sometimes, standing in front of tall buildings helped reception, because some signals bounced off the building in the direction of the receiver due to reflection.

On the second field test, the receiver was positioned in different direction towards hilly area. It was notice that as the elevation increased, the reception improved because there was a clearer line of sight (LOS) between the receiver and the transmitter antenna. Trees often disrupted reception, while building helped reception. In fact, one of the best long-range sites was moving the receiver at a higher altitude at a distance of about 4km from transmitter with LOS, decent and clear audio signal was perceived. Transmissions were especially strong near lamp posts and other large metal poles. The receiver was move5.5km away from the transmitter and no LOS. There were dead spots along the way and SNR degraded with distance, like wise as the frequency drift from 76.00 MHz there was attenuation in the receiver.

4.4 General Discussion

The project was built on a perforated board with pre-made traces. The board layout could be improved by placing the variable capacitor anywhere perpendicular to the magnetic field passing through the inductor. When a metallic screwdriver is brought in proximity to the inductor, it changes the oscillation frequency because the inductance value is changed.

Furthermore, the variable capacitor was very sensitive and difficult to tune. Touching the tuning capacitor with a screwdriver changes the oscillation frequency as well. The 10pF fixed capacitor CFIX was added in parallel to the tenable capacitor to desensitize the oscillation frequency from the absolute value of the variable capacitor. An improvement would be to use a controllable voltage to set the capacitance of a reverse-biased PN junction which in turn sets the oscillator frequency. To enhance the flow of the electromagnetic wave that is constantly being generated, FM transmitter and Receiver must be packaged in dielectric (insulator) material such as plastic or ceramic.

The result from the field test gives a clear indication that the FM Transmitter/Receiver use as CIC will provide a long range of transmitting radius, audible voice and less noise signal as compare to ordinary PA system. Table 4.1 in Chapter Four shows a clear result that having locally designed and construct PA system using FM Transmitter/Receiver with SAA1057and PIC16F84microchip, the costis cheaper than purchasing of ordinary PA system from market.

4.5 Financial Requirements

This section includes financial costs associated with this project. Beside the material cost, the cost due to labour is also calculated. The information on Table 4.1 lists the closest possible value based on market research.

Component	Quantity	Unit price (Gh¢)	Total (Gh¢)
TDA7000	1	27.00	27.00p
LM 386	1	7.00	7.00p
Power supply	2	15.00	30.00p
IN4001	5	0.40p	2.00p
SWITCH	1	2.00	2.00p
VERO-BROAD	2	4.00	8.00p
BC 239	3	9.00	27.00p
PIC 16f84	1	65.00	65.00p
Speakers (2W)	1	12.00	12.00p
SAA1057	1	20.00	20.00p
HD44780 2*16 LCD	1	50.00	50.00p
Variable Capacitor (Tuning gang)	1	2.00	2.00p
50k Variable Resistor (VOLUME)	1	1.50p	1.50p
FM Tuning Capacitor (15-30Pf)	3	2.50p	7.50p
0.22µF	1	.05p	.50p
22nF	1	1.00p	1.00p
10nF	1	.70p	.70p
27pF	1	1.20p	1.20p
22pF	1	1.20p	1.20p
3.3nF	1	2.00p	2.00p
180pF	1	3.50p	3.50p
150pF	1	2.00p	2.00p
82pF	1	1.60p	1.60p
68pF	2	1.20p	2.40p
220pF	1	2.20p	2.20p
100nF	2	2.20p	4.40p
330pF	1	3.00p	3.00p
100nF	1	2.00p	2.00p
10K	4	1.50p	6.00p
22K	3	2.40p	7.20p
78nH	1	4.00p	4.00p
70nH	1	3.50p	3.50p
LM7809(voltage regulator)	1	8.50p	8.50p
LM78105(voltage regulator)	1	6.00p	6.00p
Miscellaneous (Cable, soldering lead etc.)	lot	40.50p	40.50p
		Total	**371.40p**

Table 4.1 List of components and cost

Labour cost= Gh¢ 100

Total cost = material cost + labour cost

=371.40 + 85.00

Gh¢ = 456.40

Overall cost = material cost + labour cost + 10 %*(total cost)

= 371.40 +85.00 + 10/100*456.40

= 456.40+ 45.64

Gh¢ = 502.04

The current cost of a 20 W public address system which has a radius of 1km in the market is around Gh¢900.00. Also the cost of 5km FM transmitter without Receiver in market is also around Gh¢1300.00.As shown in table 4.1, the cost involved in constructing a 5km radius FM transmitter and receiver using PLL circuit is Gh¢ = 502.04p which is cheaper also the materials needed for replacement are also available in the local market except PIC16f84 and SAA1057.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main achievement of this project is the successful construction of two systems of communication, PA system using FM Transmitter/Receiver was designed, built and tested; favourable wireless communication was achieved when human voice send by the microphone attached to the transmitter was clearly heard on 76.6MHz on FM radio receiver. The transmitter was able to transmit output signal at 70-dB, while the receiver is able to detect signals as weak as -110-dBm and as far away as 5km.In summary, the transmitter was able to transmit from 76.00MHz to 76.90MHz; the device was powered from either a 12-18VDC or through an adapter connected to a 60Hz 220VAC standard outlet. Displayed output was on a backlit LCD screen. Inter-channel crosstalk was minimized if not eliminated due to perfect selectivity design of PLL technology which makes the transmitter to transmit on the exact resting frequency. Also having locally designed and constructed, the cost and inconvenience of importing the whole FM Transmitter, Receiver and PA system would be reduced.

Finally, this FM transmitter for public address system can be used for commercial purpose as Community Information Centre to broadcast announcement over a distance of 5 km to a population of about 1000 people.

5.2 Recommendation

This project is recommended for communities in a situation where there is need to communicate with a large number of people.

Further improvements in this project is also recommended such as; An infrared switching circuit can equally be built in the receiver to enable it to be tuned on with a remote control as the case may be, also sounds sensitive circuit (sensor) must be integrate into the design of the receiver so that the receiver becomes active from standby mode at the sensing of electromagnetic wave from the transmitter antenna.

Finally The Government of Ghana, Ministry of information in conjunction with National Youth Employment should embrace this technology and train Ghanaians on how to build transmitter/receiver for community information centre to reduce unemployment in the country as community information centre springs up around the county and beyond.

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APPENDICES

Appendixes1

Calculation for R1 value for pre-emphasis

$$_1 = 1/r_c$$

Let C=10μF & f_1=2.1 kHz

$$2\ f_1 = 1/r_c = 1/r*10μF$$

$$r = 1/2\ f_1\ (10μF)$$

$$r = 1/2*3.14*2.1k*10μF$$

$$r = 1/2*3.14*2.1*10^{-3}$$

$$r = 1/131.95*10^{-3}$$

$$r = 0.007578628k \qquad 7.58 \quad or\ 8$$

$$_2 = 1/R_C\ let\ c=10μF\ \&\ f_2=30\ kHz$$

$$2\ f_2 = 1/RC$$

$$2*\ *30\ kHz = 1/R*10μF$$

$$R = 1/2\ *30\ kHz*10μF$$

$$R = 1/2\ *30*10mF$$

$$R = 1/1884.95m$$

$$R = 0.000530516k \qquad 0.53$$

Appendixes 2

Data sheet parameters of transistor BC 239

Maximum rating: V_{CB}=30V, V_{CE}=12v, V_{EB}=4v, IC=50mA

Normal rating: V_{CE}=10v, IC=8mA, hfe=20 to 200. Collector current Ic is the biased

current at which hfe is obtained from the data sheet; in this design Ic selected is 8mA.

Appendixes 3

Calculation values for RF power amplifier design

$$V_{CEQ} \frac{V}{2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{3.5}$$

Let $V_{CC} = 12v$

Design of voltage divider R_1 and R_2.

Refer to appendix 2 for data sheet value for I_c and *hfe*

Therefore

$$I_B = \frac{I_l}{hf\,(m\ \ )} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \tag{3.6}$$

$$= \frac{8m}{20} = 0.4m$$

The current flowing through R_1 should be $10I_B$ for better design, with this assumption $9I_B$ flow through R_2 therefore the voltage across R_2.

$$R_2: V_2 = 9I_B * R_2 = V_B + V_E = 0.7 + 1 = 1.7$$

$$R_2 = \frac{1.7}{9*0.4*1\ ^{-3}} = 0.47k$$

Voltage across $R_1 = V_{cc} - V_2 = 10I_B * R_1$

$$R_1 = \frac{8.7}{1\ *8*1\ ^{-3}} = 108.7$$

Design of R_C

$$R_C \geq \frac{0.4V}{I_l} \geq \frac{4.8}{8*1\ ^{-3}} \leq 600$$

Design of R_E

$$R_E = \frac{VE}{IE} \ldots\ldots\ldots\ldots\ldots\ldots \tag{3.7}$$

$$R_E = \frac{VE}{IE} \leq \frac{1.2}{8*1\ ^{-3}} \qquad 0.15k$$

Where $V_E \leq \frac{V}{1} \leq 0.1*12 = 1.2$

Dc biasing, normally 40% Vcc is allocated for the collector resistor R_C, 50% Vcc is allocated for the quotient drop V_{CEQ} and 10% V_{cc} is allocated for the emitter resistor R_E.

<div align="center">

Therefore: $V_c \geq 40\%$

$V_{cc} = 0.4*12 = 4.8v$

V_{CEQ} 50% $V_{cc} = 0.5*12 = 6v$

V_E 10% $V_{cc} = 0.1*12 = 1.2v$

</div>

Design of R_L: the voltage gain of the C_E amplifier can be obtained by using the relation

<div align="center">

$A_V = \dfrac{r}{r} = -\dfrac{R/R}{r \approx \hbar i/\hbar f}$ .... (3.8)

But re $= 25mv/I_E = 25mv/8mA = 3.125$

Let the required gain be 100 (i.e. Av=100)

Therefore: $A_v = rc/re = 100 = -\dfrac{R}{\frac{R+R}{1.5}}$ cross multiplying

$\dfrac{5\ R}{5\ +R} = -1250$ $R_l = 414$

</div>

Design of coupling capacitor C_1 and C_2: the purpose of the coupling capacitor is to couple the A.c signal to the input of the amplifier and block D.c; it also isolates the input signal source and the voltage divider network. The value of the coupling capacitor C_C is set in such a way that the reactance X_C at the lowest frequency (say 76.5MHz), should be equal to one tenth or less of the series impedance that is being driven by the signal passing through the capacitor.

Design of coupling capacitor C_1

<div align="center">

$X_c \leq \dfrac{R}{1}$ (3.9)

But, $R_{in} = R_1 \| R_2 \| hfe = 108.7 \| 470 \| 20 = 1.7k\Omega$

Therefore, $\dfrac{1}{2\pi\ 1} = \dfrac{1}{2\pi*7.5M\ *c1} \leq \dfrac{1.7k\Omega}{1}$

</div>

$$= C_1 \geq 8.9 * 10^{-1} \; F \approx 8.9p$$

Design of coupling capacitor C_2:

$$X_{C2} \leq \frac{R}{1} \quad \dots\dots\dots\dots\dots\dots\dots \quad (3.10)$$

But, $R_{out} = R_c = 600$

Therefore, $\dfrac{1}{2\pi \; 2} = \dfrac{1}{2\pi * 7 \; .5M \quad *c2} \leq \dfrac{6\Omega}{1}$

$$C_2 \geq 2.54 \mu F$$

Design of the emitter by-pass capacitor C_E

The purpose of the by- pass capacitor is to bypass the signal currents to the ground.

To bypass lowest frequency component the reactance X_E at the lowest frequency (say 76.5MHz), should be equal to one tenth or less of the emitter resistance.

$$X_{C2} \leq \frac{R}{1} = 0.1R_E = 0.1*1500 \;\; = 150$$

Therefore, $\dfrac{1}{2\pi} = \dfrac{1}{2\pi * 7 \; .5M \quad *C} \leq 150\Omega$

$$C_E \geq 0.14pF$$

Calculating the signal resistance in the base leg (r_b).

$$r_b = R_{b1} \parallel R_{b2} = 108.7 \; \Omega \parallel 0.47k \; \Omega = 88 \; \Omega$$

Given that beta equal 20 multiply the emitter leg signal resistance by the beta.

$$\times re = 200 \times 3.125 = 625 \; \Omega$$

Calculating the circuit input impedance by finding the parallel equivalent of the signal base resistance and the signal emitter path resistance.

$$z_{in} = r_b \parallel re = 88 \parallel 625 = 77.14 \; \Omega$$

Calculate the output impedance. $z_{out} = Rc = 600 \; \Omega$

The voltage gain of the common emitter amplifier is

$$Av = rc/re \quad \dots\dots\dots\dots \quad (3.11)$$

$$Av = \frac{6}{3.1} = 192$$

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Appendixes 4

Calculation of antenna length

$$=C/f \qquad\qquad (3.5)$$

where C is $3*10^8$

Therefor $\quad =\dfrac{C}{f} = \dfrac{3*1(}{7 .5} = \dfrac{3}{7 .5}m = 3.92m$

$L=\dfrac{3.9}{2}m = 1.96m.$

Cross sectional area calculation of antenna

From equation (3.7) $\qquad R=\dfrac{\rho}{A}$

Where R is the electrical resistance of copper ( )

ρ is the resistivity of conductor material (m)

L is length of copper (m)

$R=\dfrac{\rho}{A} = \dfrac{1.4 \; m*1.6 *1^{-8}}{6} = 40.04 * 10^{-6}m$

$D=\dfrac{4 .0 *1^{-0}}{3.1} = 12.75 * 10^{-6}m$

Radius (r) $=6.375*10^{-6}m$

Appendixes 5

Component Name	Quantity
TDA7000	1
Lm 386	1
12 volt transformer	1
IN4001	4
SWITCH	3
VERO-BROAD	1
BC 239	3
Pic 16f84	1
Speakers (2W)	1
SAA1057	1
HD44780 2*16 LCD	1
Variable Capacitor (Tuning gang)	1
50k Variable Resistor (VOLUME)	1
C1	0.22μF
C2	22nF
C3	10nF
C4	27pF
C5	22pF
C6	3.3nF
C7	180pF
C8	30pF
C9	3.3nF
C10	150pF
C11	82pF
C12	68pF
C13	220pF
C14	100nF
C15	330pF
C16	220pF

C18	470nF
C19	100nF
VC1	FM Tuning Capacitor (15-30Pf)
R1	10K
R2	22K
R3	10K
L1	78nH
L2	70nH
ANT	Telescopic antenna or 1m wire

TABLE A1:Parts list of design components

Appendixes 6

Figure A2: The setup used in transferring of programme from PC into Pic16f84 IC

Appendixes 7

The Assembler files programme language for pic16f84

'------------------------pll Microcontroller PIC16F84-----------------------------

Define LCD_BITS = 4

Define LCD_DREG = PORTB

Define LCD_DBIT = 0

Define LCD_RSREG = PORTA

Define LCD_RSBIT = 2

Define LCD_EREG = PORTA

Define LCD_EBIT = 3

Define LCD_RWREG = 0

Define LCD_RWBIT = 0

Define LCD_COMMANDUS = 5000 'delay after LCDCMDOUT, default value is 5000

Define LCD_DATAUS = 50 'delay after LCDOUT, default value is 50

Define LCD_INITMS = 100 'delay used by LCDINIT, default value is 100

Symbol ck = PORTB.5

Symbol ce = PORTB.6

Symbol da = PORTB.7

Symbol dn = PORTA.0

Symbol up = PORTA.1

Symbol lock = PORTA.4

Dim freq As Word

Dim f5 As Word

Dim fshow As Word

Dim fmod As Byte

Dim fhbyte As Byte

Dim flbyte As Byte

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Dim change As Bit

Dim tm As Byte

Dim t2 As Byte

AllDigital

TRISB = %00000000

TRISA = %11111111

'--

ce = 0 'CE=0

ck = 0 'CK=0

da = 0 'DA=0

Lcdinit

LcdcmdoutLcdClear

Lcdout " M.TECH.PROJECT   "

Lcdcmdout LcdLine2Home

Lcdout "UEW-K.ADANE.BOAK "

WaitMs 3000

Lcdcmdout LcdLine2Clear

change = 1'------------------------

Read 10, freq.LB

Read 11, freq.HB

If freq> 1600 Then

        freq = 1520

        Write 10, freq.LB

        Write 11, freq.HB

Endif

If freq< 1520 Then

        freq = 1600

        Write 10, freq.LB
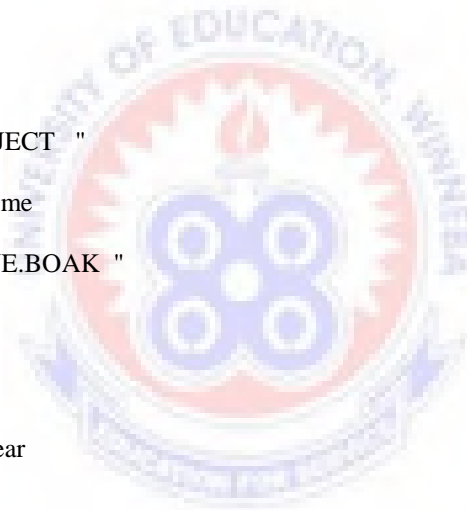
Write 11, freq.HB

Endif'---

loop1:'--

Read 10, freq.LB

Read 11, freq.HB

'----------------------------------

fshow = freq / 20

fmod = freq Mod 20

fmod = fmod * 5

'---

Lcdcmdout LcdLine2Pos(8)

If fmod< 10 Then

Lcdout "", #fshow, ".0", #fmod, "Mhz "

Else

Lcdout "", #fshow, ".", #fmod, "Mhz "

Endif

'---

tm = 0

If up Then

freq = freq + 1

tm = tm + 4

If tm = 64 Then freq = freq + 1

If tm = 128 Then freq = freq + 1

If tm = 192 Then freq = freq + 1

If tm = 0 Then freq = freq + 1

If freq> 1600 Then freq = 1520

fshow = freq / 20

fmod = freq Mod 20

fmod = fmod * 5

```
                        Lcdcmdout LcdLine2Pos(8)

                        If fmod< 10 Then

                                Lcdout "", #fshow, ".0", #fmod, "Mhz "

                        Else

                                Lcdout "", #fshow, ".", #fmod, "Mhz "

                        Endif


        Endif

        If dn Then

                freq = freq - 1


                        tm = tm + 4

                        If tm = 64 Then freq = freq - 1

                        If tm = 128 Then freq = freq - 1

                        If tm = 192 Then freq = freq - 1

                        If tm = 0 Then freq = freq - 1

                        If freq< 1520 Then freq = 1600

                        fshow = freq / 20

                        fmod = freq Mod 20

                        fmod = fmod * 5

                        Lcdcmdout LcdLine2Pos(8)

                        If fmod< 10 Then

                                Lcdout "", #fshow, ".0", #fmod, "Mhz "

                        Else

                                Lcdout "", #fshow, ".", #fmod, "Mhz "

                        Endif

        Endif


        Write 10, freq.LB

        Write 11, freq.HB
```

```
                    change = 1

                    WaitMs 100


TRISB = %00000000

'----------------------------------------------------------------


WaitMs 10

If change Then

'---------------------

Read 10, freq.LB

Read 11, freq.HB

'-------------------------------------------------------------

            fshow = freq / 20

            fmod = freq Mod 20

            fmod = fmod * 5


            Lcdcmdout LcdLine2Pos(8)

            If fmod< 10 Then

                    Lcdout "", #fshow, ".0", #fmod, "Mhz "

            Else

                    Lcdout "", #fshow, ".", #fmod, "Mhz "

            Endif

'----------------------------------------------------------------------------

            f5 = freq * 5

            fhbyte = f5.HB

            flbyte = f5.LB

'----------------------------------------·--------------------

            For t2 = 1 To 2

                    da = 0

                    ck = 0
```

```
                ce = 0

                WaitUs 5

                ce = 1

                ck = 1

                WaitUs 5

                ck = 0

'--------------------------------------------------------------------------

                For tm = 1 To 8

                        da = fhbyte.7

                        WaitUs 5

                        ck = 1

                        WaitUs 5

                        ck = 0

                        fhbyte = ShiftLeft(fhbyte, 1)

                Next tm

'----------------------------------------------------------------

        For tm = 1 To 8

                        da = flbyte.7

                        WaitUs 5

                        ck = 1

                        WaitUs 5

                        ck = 0

                        flbyte = ShiftLeft(flbyte, 1)

                Next tm

'------------------------------------------------------------------------------------------------------------

                da = 0

                ce = 0

                WaitUs 5

                ck = 1

                WaitUs 5
```

```
                    ck = 0
'--------------------------------------------------------------------------------------------------
          Next t2
          'send 1101_1101_1001_0101-Word b->> saa1057
          flbyte = %10010101
          fhbyte = %11011101
'--------------------------------------------------------------------------------
          da = 0
          ck = 0
          ce = 0
          WaitUs 5
          ce = 1
          ck = 1
          WaitUs 5
          ck = 0
'----------------------------------------------------------------------------------
          For tm = 1 To 8
                    da = fhbyte.7
                    WaitUs 5
                    ck = 1
                    WaitUs 5
                    ck = 0
                    fhbyte = ShiftLeft(fhbyte, 1)
          Next tm
'----------------------------------------------------------------------------
          For tm = 1 To 8
                    da = flbyte.7
                    WaitUs 5
                    ck = 1
                    WaitUs 5
```

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```
                ck = 0

                flbyte = ShiftLeft(flbyte, 1)

        Next tm

'--------------------------------------------------------------------------------

        da = 0

        ce = 0

        WaitUs 5

        ck = 1

        WaitUs 5

        ck = 0

WaitMs 10

change = 0

'--------------------------------------------------------------------------------

If Not lock Then

WaitMs 300

Lcdcmdout LcdLine2Home

                Lcdout"UNLK- "

Goto loop1

Endif

        If lock Then

                Lcdcmdout LcdLine2Home

                Lcdout "ON AIR-"

                change = 1

                WaitMs 500

                Goto loop1

        Endif

Endif

'----------------------------------------------------------------------change = 0

WaitMs 10'-------------------------------------

Goto loop1
```

Appendixes 8

Sample of Hex files for pic1684

:10094000031C08009A2C1030A800A101A001A70CDC

:10095000A60C031CB12C2208A00723080318230FA0

:10096000A107A10CA00CA50CA40CA80BA72C080097

:100970001030A600A501A401210DA40DA50D22088B

:10098000A4022308031C230FA5020318CE2C22085F

:10099000A40723080318230FA5070310A00DA10D1A

:1009A000A60BBC2C08000310A00DA10DFF3E0318E0

:1009B000D32C08000530E52C0230E52C0630E52C60

:1009C0000330E52C0430E52C0130A8002308210277

:1009D000031DEC2C220820020430031801300319F7

:1009E00002302805031DFF300800A8000515A80ED9

:1009F000F030860528080F3986040925A80EF03046

:100A0000860528080F39860409253230A800872476

:100A1000080085150000851100000800A8000511D8

:100A2000A80EF030860528080F3986040925A80E7F

:100A3000F030860528080F39860409258830A8007B

:100A40001330A900912408002C30840000080319F9

:100A50000800840AF524262D2C3084003410320836

:100A6000A4003308A5001030A2002730A3004925B8

:100A7000E830A2000330A30049256430A200A3019E

:100A800049250A30A200A3014925240854258001E4

:100A900008002408A0002508A100B8242008031994

:100AA000522D3414341C572D303E8000840A080027

:02400E00412F40

:1042000000000000000000000000000000000000AE

:08421000000000000410006005F

:00000001FF