DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FEDERAL UNIVERSITY OYE EKITI

DESIGN AND CONSTRUCTION OF A MINI RADIO BROADCAST TRANSMITTER USING FREQUENCY MODULATION WITH POWER RATINGS OF 15WATTS

BY

OGUNLANA GBADEBO JOSEPH
(EEE/13/1110)

FEBRUARY, 2019

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A PROJECT REPORT SUBMITED TO THE DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING, FACULTY OF ENGINEERING, FEDERAL UNIVERSITY OYE EKITI.

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FEBRUARY, 2019

DEDICATION

I dedicate this project to Almighty God, my source of inspiration, wisdom, knowledge and understanding and the source of my strength throughout this program. I also dedicate this work to my parents Mr. and Mrs. Ogunlana for their financial and unconditional support, patience and love towards me throughout this program.

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(Head of Department)

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(External Supervisor) Date

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ABSTRACT

In today's world of technological advancement, the use of FM transmitters has become more pivotal and necessary. The FM transmitters are however complex equipment demanding high power supply, high voltage system design, critical maintenance and they are devices that need to be looked into and studied at large to be understood and used to its full potential. These challenges faced by the transmitter constitute major roadblocks to individuals and organizations that may wish to adopt radio broadcast as means of electronic media. The study was therefore carried to design and construct an FM transmitter that is cheap in price, simple in maintenance, efficient in use yet operate on low power supply of 15W. The study was to design and construct an FM transmitter to be received at a range of about 5km in free air. Research and development were put into the study and 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 24v lead acid battery. The successful completion of this study has indicated that a frequency modulated mini broadcast transmitter requiring low power can be designed and constructed.

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LIST OF ABBREVIATIONS

VFO: Variable-Frequency Oscillator

RF: Radio Frequency

FM: Frequency Modulation

PCB: Printed Circuit Board

PDC: Personal Digital Cellular Communications

PWM: Pulse Width modulation

WLAN: Wireless Local Area Network

LED: Light Emitting Diode

BJT: Bipolar Junction Transistor

DMM: Digital Multi-meter

IC: Integrated Circuit

CHAPTER ONE

1.0 INTRODUCTION

A radio transmitter is a device or a combination of equipment used to generate and send messages and signals through electromagnetic waves. It generates radio frequency alternating current that is then applied to the antenna, which in turn radiates this as radio waves to another antenna that receives the signals and passes down into the receiving system. A transmitter sends out radio waves in a specific band of electromagnetic spectrum in order to fulfill a specific communication need, the alternating current generated changes direction at a frequency of up to a billion times depending on the band that transmitter needs to send in. Heating devices such have a similar design but are usually not called transmitters because they use electromagnetic energy domestically rather than transmitting it to another location. Modern radios serve as transceivers; they can send and receive signals through the same antenna.

For a radio transmitter to work it has to reach certain requirements such as the efficient power used, the power level required to meet the systems objectives, the stability and purity of the power of the resulting signal, the frequency of operation and the type of modulation used. Usually a transmitter design includes generation of a carrier signal, a power amplifier, a modulator, one or more frequency multiplication stages and a filter that comes with a matching network to the antenna. More complex transmitters allow better control of the modulation of the emitted signal and improve the stability of the transmitted frequency, although much simpler transmitter might contain only a continuously running oscillator coupled to some antenna system.

The frequency can be fixed; the method involves using a resonant quartz crystal in crystal oscillator to fix the frequency. Whereas it can also be variable, in this case an array of crystals is used on different frequencies. Frequency also varies in Phase-locked loop frequency synthesizers, Variable-frequency oscillator (VFO), direct digital synthesis are also of frequency varying systems.

1.0.1 COMPONENTS OF A TRANSMITTER

i. **Power Supply**: The power supply is the energy source that is used to power the transmitter, it provides the necessary electrical power needed to operate the transmitter

ii. **Electronic Oscillator**: This component creates alternating current at the frequency on which the transmitter will work. It generates a sine wave called carrier wave on which data is imposed and carried.
iii. **Modulator**: This is a part of the transmitter that adds the data into the carrier wave by varying some parts of the carrier wave. There are two ways in which this data can be added; Amplitude Modulation {ADD IN} and Frequency Modulation.
iv. **Amplifier**: This amplifies the carrier wave to increase its power. A more powerful amplifier would mean a more powerful broadcast.
v. **Antenna**: the antenna converts the amplified signal from the amplifier to radio waves before they are transmitted.
vi. **Impedance matching circuit**: The impedance matching circuit is also known as the antenna tuner, its function is to match collective impedances of the transmitter and the antenna so that power can be properly transferred to the antenna. If the impedance of the transmitter and antenna are unequal then it results in standing waves which cause a reflection of the signal back to the transmitter resulting in wastage of power and overheating of the transmitter.

1.0.2 COMPONENTS OF A RECEIVER

A radio receiver is basically the opposite of a radio transmitter. It captures radio waves using an antenna, processes the waves and selects the waves that vibrate at the desired frequency. It extracts the audio signals that are added to the waves, amplifies these signals and plays them on a speaker.

i. **Antenna**: This is the part that captures the electromagnetic waves. It plays the foremost role in the receiving process. Upon exposure to radio waves, a small alternating current is induced in the antenna by the waves.
ii. **RF Amplifier**: A sensitive **{INPUT}** that amplifies the very weak radio frequency (RF) signal from the antenna so that the signal can be processed by the tuner.
iii. **Tuner**: The tuner is the part of the receiver that extracts the particular frequency required by the receiver. The antenna captures several wave frequencies so the receiver depends on the tuner to select the desired frequency after the RF amplifier has amplified all of them. The tuner employs the combined use of an inductor and a capacitor to form a circuit that resonates at a particular frequency known as the resonant frequency. The

resonant frequency is determined by the values chosen by for the coil, which serves as an inductor and a capacitor.

The tuner blocks any AC signals at an unwanted frequency i.e. any signal above or below the resonant frequency. The resonant frequency can be adjusted by varying the amount of inductance in the coil or capacitance in the capacitor. In simple radio receiver circuits, the tuning can be adjusted by varying the number of turns of the wire in the coil. However, more sophisticated tuners use variable capacitors to vary frequency.

iv. **Detector**: The detector separates the audio information from the carrier wave. For frequency modulation signals the detector is more complex, but for amplitude modulation the detector works by using a diode that rectifies the alternating current signal. After the diode has rectified alternating current signal a direct current signal is left and this can be fed to an audio amplifier circuit.

v. **Audio amplifier**: The audio amplifier amplifies weak signals that come from the detector so that it can be heard. This amplification can be done using a simple transistor amplifier circuit.

Some amount of additional filtering and tuning circuits can be added to better bring about output and to remove unwanted signals, but the above listed parts are the basic elements found in any receiver.

1.1 BACKGROUND OF PROJECT

The first radios were developed in 1879; they were bulky, noisy and had poor reception. But over the years it has been improved and honed to serve multiple communication purposes in broadcasting, navigation and even domestically. Radio transmitters possess growing importance and applications in our daily lives through a range of devices like cell phones, wireless routers and garage door openers to mention a few. Transmitters have provided an efficient way to transmit information and access to information helps in the advancement of technology and development in general. This study is about the Frequency modulation (FM) transmitter which transfers information by the varying the frequency of the carrier wave according to the message signal. The FM transmitter generally uses VHF radio frequencies of 87.5 to 108.0MHz to transmit and receive the signal. The FM transmitter can be regarded as the transmitter with the most range and minimal power, its performance depends on the induction coil and variable capacitor. This study demonstrates the design and construction of a mini radio broadcast FM transmitter with a power rating of 15W. There are two frequencies in the FM signal, the first is a carrier signal and the other is an audio frequency, the audio frequency is used to modulate the carrier frequency and the FM signal is obtained by differing the carrier frequency which can be done by allowing the audio frequency. The construction of this mini broadcast transmitter is the first of its kind on the campus and it serves to tackle inhibited communication on campus grounds. In a university setting, the importance of adequate communication cannot be over emphasized. There are various subsystems in an institution and for them to adequately co-function, they need to depend on each other and this can only be done through proper information dissemination, hence emphasizing the importance of a project of this kind and at this time. This mini broadcast transmitter in its own way contributes to the larger cause of information sharing which is especially important in a learning environment. Through the course of this project I used an approach less commonly used in the construction of PCB boards; this was the use of software implementation. Generally, a software implementation gives a blueprint of the construction at hand and it serves to aid an error free construction process. The software platforms I used ranged from the Proteus 7 software to the MpLab programming software as well as the CCSC code compiler. This project can tackle the challenges of information communication and serve as a platform to inform, entertain and educate students.

1.2 STATEMENT OF THE PROBLEM

Radio transmitting has contributed vastly to global technological advancement and the relatively low cost for FM broadcasting equipment has resulted in its growth over the years. However, on campus grounds the state of communication and radio transmission does not measure up quite well to global standards. Most public information is spread through notice boards and memos or in some cases, social media platforms. These mediums have their respective shortcomings, but in a more general sense they cannot reach all of the targeted audience at the required time. There is also little means of educational and entertainment platforms where students can indulge for benefits outside of the classroom. The mini broadcast transmitters will tackle these roadblocks by quicker sharing of information and covering a wider audience range. This study serves to tackle the challenges in transmitting by exploring and exploiting the FM transmitter especially in relation to challenges posed and how they can be solved.

1.3 MOTIVATION

This study is motivated by the need to contribute to the improvement in transmission. It is also driven by the need to elaborate on FM transmission and its importance in the field of communication and broadcasting.

1.4 SIGNIFICANCE OF STUDY

This project is important because of the rising need for proper communication measures on campus. It serves to enhance the spreading of important information and enhancing efficiency of operations on the campus. It is the first of its kind given that the university has never operated with a mini broadcast transmitter and it is a breakthrough in the institution's information distribution and overall development.

1.5 AIM AND OBJECTIVES

The aim of this project is to design and construct a mini radio broadcast transmitter that broadcast signals on an FM broadcast band.

The objectives are:

i. To design and construct a mini radio broadcast transmitter that can broadcast signals on an FM broadcast band
ii. To display and explain the working concepts behind the components and circuits of the FM transmitter.
iii. To implement a PCB construction on software platforms through software programming and code compiling.
iv. To test run the transmitter for possible corrections of circuiting and soldering errors.

1.6 SCOPE OF PROJECT

In the course of this project I met some criteria and project goals that needed to be achieved in order for a successful completion of the project. I made use of a few elements for this to complete the project like properly working tools and extensive research on past works regarding radio transmission in general.

Below is a comprehensive step by step list of things that will be covered in this project;

i. **Identification and selection of components/materials**: Acquiring and assembling of materials needed for construction. They included Amplifiers, NPN transistors, resistors and capacitors to mention a few.

ii. **Designing**: Drafting out a schematic diagram of the components and their arrangement as well as routine resistance checks with an ohmmeter before proceeding to construction itself.

iii. **Testing and analysis**: Testing and analyzing of generated radio frequency carrier waves to experiment the functionality of my construction.

iv. **Interface**: Radio frequency interface usage to broadcast the signals right before implementation.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

In today's age, FM radio has found its stronghold across the world as a welcome development in communications and broadcasting. FM radio stations have constantly increased in the world since there is a demand for a variety of broadcasting services. Over the years, scientists and scholars have examined the development, management, content and effects of FM radio. So in this chapter, the major international and national studies conducted by the past researchers on various aspects of FM broadcast transmission have been noted and elaborated upon.

2.1 RELATED WORKS

The author in [1] discussed an experimental coin-sized radio for extremely low-power WPAN (Application at 2.4 GHz). In their paper, an experimental 2.4-GHz CMOS radio composed of RF and digital circuits for the low-power and low-rate preliminary IEEE802.15.4 WPAN is reported, consuming 21mW in receive mode and 30mWin transmit mode. The RF design focus is to maximize linearity for a given power consumption using linearization methods which lead an order of magnitude improvement in LNA/mixer IIP3/power performance. Chip-on-PCB technology allows implementation of a coin-sized radio at very low cost, which also provides 3 dB gain patch antenna and high (50) inductors. Index Terms—2.4-GHz single-chip radio, chip on PCB, digital baseband, low-power RF CMOS transceiver, low-rate WPAN.

In [2], the authors elaborated on a WPAN Mesh Standard-Low Rate Part: Meshing the Wireless Sensor Networks. This paper introduces a new IEEE standard, IEEE 802.15.5, which provides mesh capability for wireless personal area network (WPAN) devices. The standard provides an architectural Frame work enabling WPAN devices to promote interoperable, stable, and scalable wireless mesh topologies. It is composed of two parts: low-rate WPAN mesh and high-rate WPAN mesh. In this paper, we present only low-rate WPAN mesh because it is designed to support wireless sensor networks. IEEE 802.15.5 low-rate part is a light-weight scalable mesh routing protocol that caters well to the requirements of resource-constrained wireless sensor networks. By binding logical addresses to the network topology, IEEE 802.15.5 obviates the need for route discovery. This eliminates the initial route discovery latency, saves storage space and reduces the communication overhead and energy consumption. A distributed link state scheme is further built atop the block addressing scheme to improve the quality of routes, robustness, and load balancing. The routing scheme scales. Well with regard to various performance metrics. The standard also provides enhanced functions such as multicast, reliable broadcast, power saving, time synchronization, route tracing and portability. We also present the performance evaluation of major functions performed with 50-nodes tested deployed over a whole floor (100 x 140 ft2) at CUNY Engineering building. The results testify that the IEEE 802.15.5 will serve well for wireless personal area networks and wireless sensor networks.

The authors in [3] investigated the coexistence Performance Enhancement Techniques for DRP Based WLAN/WPAN and Cellular Radios Collocated in a Mobile Device. The incorporation of Bluetooth and Wireless LAN transceivers in mobile devices poses design Challenges associated with their coexistence with the cellular transceiver, as they often need to operate concurrently and their close proximity is inevitable. We present some recently developed techniques that transform the RF and analog circuit design complexities, typically encountered when targeting enhanced coexistence performances, into the digital domain, and demonstrate how these techniques allow the concurrent operation of two transceivers without each of them adversely impacting the performance of the other. The ideas presented have been implemented in a commercial Bluetooth single chip transceiver offered by Texas Instruments.

The authors in [4] proposed, designed and fabricated a WLAN/WMAN Dual Mode Transceiver System for Indoor/Outdoor Application. The transceiver RF IC chip with packaged size of 6mm*6mm was fabricated using 0.25 um Si-Ge Bi-CMOS process. A power amplifier and PLL/VCO chip were fabricated using the same process. Ceramic front-end filter were also fabricated for WLAN / WMAN frequencies. To make compact transceiver system, these chips were mounted on 2 cm*2cm double side PCB. The full system has been tested with external ADC/DAC and baseband modem. The measured results show that fabricated transceiver system meets the requirements for WLAN/WMAN standards.

In [5], the authors conducted research and documented a paper on a 3-5 GHz UWB Impulse Radio Transmitter and Receiver MMIC Optimized for Long Range Precision Wireless Sensor Networks. In this paper, an ultra-wideband impulse radio (UWB-IR) transmitter and receiver monolithic microwave integrate circuit (MMIC) for precision localization sensor network was presented. Longer range was achieved with low power consumption at the transmitter by fully exploiting FCC's peak power constraint efficiently. The transmitter and receiver MMIC were fabricated on a commercial low cost 2 m GaAs HBT process. The transmitter MMIC peak power output is 20dBm with power consumption of 0.8mW at 1 MHz pulse repetitive rate. The receiver MMIC uses non-coherent detection and has a 44 dB front-end conversion gain. The receiver MMIC is cascaded with a 500 MHz baseband amplifier to achieve input tangential signal sensitivity (TSS) of -71dBm. Equivalent time sampling using analogue to digital converters running at around a few MHz is utilized for precise time of arrival ranging with low cost components. Two dimensional wireless localization network utilizing time difference of arrival (TDOA) is constructed and test results covering an 80 x 90 meter square area shows position error variance of less than 10 cm. ranging at 200 m demonstrated with range error variance of better than15 cm.

In [6] the authors lined out the operation of a 5-GHz Wireless LAN Transmitter with Integrated Tunable High-Q RF Filter suitable for wireless transmitters. It was implemented in a standard digital 0.18- m CMOS technology. The scholars used active circuits are used to enhance the of two independent LC resonators, which are cascaded to form a wide bandwidth filter that can be tuned in both center frequency and bandwidth. A 5.145-GHz stagger-tuned filter with a 200-MHz bandwidth and 0.8 dB of ripple was demonstrated in an 802.11a sliding-IF transmitter. The transmitter provided a spectral mask and EVM-compliant output power of 8.26 dBm for a 64-QAM OFDM signal. At lower output power, an EVM of 32.3 dB is achieved.

In [7], the authors extensively researched CMOS RFIC architectures for IEEE 802.15.4 networks. As the wireless industry focuses on increasing high data throughput, the emerging IEEE 802.15.4 (ZigBee) protocol targets a set of applications that require simple wireless connectivity, relaxed throughput, very low power consumption, and lower module cost. Their study summarized the 2.4 GHz radio physical layer (PHY) technical specifications, examined alternative modem implementations and compared possible architectures for the receiver and the transmitter in terms of performance, estimated chip area, and production cost.

The authors in [8] evaluated the accurate power efficiency estimation of GHz Wireless Delta-Sigma Transmitters for different Classes of switching mode power amplifiers in their journal. The paper proposed a new closed-form expression for computing the power efficiency of delta sigma (DS) radio frequency (RF) transmitters. Due to the large bandwidth of the pulse width modulated (PWM) signal at the output of the DS modulator, the peak efficiency of the power amplifier (PA) when driven by a PWM signal is considerably different than its peak efficiency when the input signal is a continuous sine wave. A weight averaging of the efficiency over the frequency bandwidth of the PWM signal is considered for accurate estimation and prediction of the power efficiency of DS RF transmitters. It is shown that, for a low-pass DS transmitter, the overall average power efficiency of the DS transmitter can be accurately estimated by the product of the modulated peak efficiency of the PA and the coding efficiency of the modulator. For band pass DS transmitters, an additional parameter that accounts for the duty cycle effect on the efficiency of switching-mode PAs has to be considered. To validate the new proposed expression, a DS transmitter for WiMAX, CDMA and EDGE standards is designed, prototyped and tested. The comparison of the simulated and measured efficiencies of the DS transmitter proves the validity and accuracy of the proposed expression.

In [9], the author presented a 1-GHz RF-transmitter IC for Personal Digital Cellular Communications (PDC) application in Japan. This IC was mounted in a standard TQFP 32-pin package and it represented the first reported SOI-Bi-CMOS implementation for cellular usage. The IC utilized a linear, fully complex mixing of a UHF signal (650MHz -750MHz) and a fixed VHF signal (175 MHz or 250MHz) to generate spurious-free, I-Q LO (850 MHz - 1 GHz).The generated LO carrier was mixed with the 7d4 DQPSK modulated baseband PDC signal in an I/Q up converter/ modulator. The I/Q up conversion signal path included an up conversion I/Q modulator, a 2-stage linear 40dBAGC control circuit, an on-chip and a +1 dBm output driver with on-chip double termination to 50 ohms. The transmitter has better than 50 dB LO-leakage suppression, sideband-rejection of 40dB, and less than - 65 dB of spurious leakage at the output. The output noise floor is better than -139 dB /Hz at 10 MHz offset from the carrier in full power mode. The IC dissipates 32 mA of maximum current from a 2.7 V supply

In [10], the authors discussed a Single-Chip Dual-Band Direct-Conversion WLAN Transceiver in 0.18-_m CMOS. This paper presents a single-chip dual-band CMOS direct-conversion transceiver fully compliant with the IEEE 802.11a/b/g standards. Operating in the frequency ranges of 2.412–2.484 GHz and 4.92–5.805 GHz (including the Japanese band), the fractional-PLL based frequency synthesizer achieves an integrated (10 kHz–10 MHz) phase noise of 0.54 /1.1 for 2/5-GHz band. The transmitter error vector magnitude (EVM) is 36/ 33 dB with an output power level higher than 3/5 dBm and the receiver sensitivity is 75/ 74 dBm for 2/5-GHz band for 64QAM at 54 Mb/s.

In [11], the authors evaluated a Kautz-Volterra Behavioral Model for RF Power Amplifiers.

A new type of behavioral power amplifier (PA) model, a discrete-time Kautz-Volterra (KV) model was presented. In the model a priori knowledge of the system properties in terms of different poles for different nonlinear orders is used, which is needed for modeling nonlinear and linear memory effects in PAs. An accurate model can thus be achieved with a small number of parameters. Simulated results of parallel Hammerstein and Wiener structures and from modeling the behavior of a PA are presented.

In [12], the authors highlighted the focus on increasing high data throughput, the emerging IEEE 802.15.4 (Zig-Bee) protocol targets a set of applications that require simple wireless connectivity, relaxed throughput, very low power consumption, and lower module cost. This article summarized the 2.4 GHz radio physical layer (PHY) technical specifications, examined Alternative modem implementations, and compared possible architectures for the receiver and the transmitter in terms of performance, estimated chip area, and production cost.

In [13], the authors studied the RF Transmitter System Design for Wireless Local Area Network Bridge at 5725 to 5825MHz. In data communication system, the outdoor of Wireless Local Area Network (WLAN) technology can be implemented in bridge connection. It allows LANs in separated buildings to be connected over the distance ranging in several hundred meters. In RF system design level, the performance of the WLAN Bridge also relies on the RF transmitter system where it must be well designed to minimize the nonlinear distortions in the system. This paper presents a RF transmitter system design for a WLAN bridge at 5725 – 5825 MHz based on IEEE 802.11a standard. Based on the calculation and simulation results, the RF transmitter can transmit maximum output power of 24 dBm with –25 dB constellation error at 54 Mbps data rate which is, comply with the standard. The prototype of the RF transmitter without filters has been measured to verify with the simulation results in term of gain compression.

The authors in [14] investigated Low Power Receiver Architecture and algorithms for wireless personal area networks. Low-power receiver architecture and algorithms for IEEE 802.15.4 WPAN is a popular commercial standard for wireless personal area networks and sensor network interfaces. The write up focused on low power receiver designs using energy/bit as the design metric. Low power Timing Acquisition and Tracking Algorithms: Synchronizers (Timing, Frequency, and Phase) are the most power and area-hungry blocks inside a digital receiver, since the algorithms are correlation based and require on-chip multipliers. We present an interesting very low-area and low-power technique that does not use any multiplier, but is still non-coherent.

This technique can be used across many standards based QAM signaling. Modeling and Simulation: Receiver architecture and noise sources are modeled and simulated to optimize the design for low-power, while meeting the design constraints. Unlike traditional Monte Carlo BER simulations with baseband equivalent models, we use BER simulations with continuous band pass signals. Such simulations give the exact requirements of the receiver and avoid over-design, resulting in energy savings. Bandpass BER simulations are time consuming and need a powerful CPU with large RAM. We have developed simulation techniques, which consume lesser resources. The behavioral simulation in MATLAB is written in such a way that it is very close to RTL simulation 18. A Direct-Conversion CMOS Transceiver for the 802.11a/b/g WLAN Standard Utilizing a Cartesian Feedback Transmitter a fully integrated dual-band transceiver is implemented in 0.18- m CMOS and is compliant with the IEEE 802.11a/b/g standards. The direct-conversion transceiver occupies 12mm2 in a QFN-40 package. Fractional- synthesizer operates at twice the channel frequency, covering continuously bands from 4.9 to 5.9 GHz, as well as the 2.4-GHz band. The 5- and 2.4-GHz receivers achieve a sensitivity level below 73 dBm in the 54-Mb/s Mode and below 93dBmin the 6-Mb/s mode, while consuming 230 mW. A fast RSSI-channel power-detection system allows to power down signal processing in the listen mode. The 5- and 2.4-GHz transmitters implement a wideband Cartesian feedback loop for enhanced EVM performances and improved spectrum masks compliance. The transmitters deliver 2-dBm average power with an EVM of 3% in the 54-Mb/s mode while consuming 300mW.

In [15], the authors conducted research into a Dual-Mode 2.4-GHz 0.18-/spl mu/m CMOS Transceiver for Bluetooth Systems. This paper reports on our development of a dual-mode transceiver for a CMOS high-rate Bluetooth system-on chip solution. The transceiver includes most of the radio building blocks such as an active complex filter, a Gaussian frequency shift keying (GFSK) demodulator, a variable gain amplifier (VGA), a dc offset cancellation circuit, a quadrature local oscillator (LO) generator, and an RF front-end. It is designed for both the normal-rate Bluetooth with an instantaneous bit rate of 1 Mb/s and the high-rate Bluetooth of up to 12 Mb/s. The receiver employs a dual conversion combined with baseband dual-path architecture for resolving many problems such as flicker noise, dc offset, and power consumption of the dual-mode system. The transceiver requires none of the external image-rejection and intermediate frequency (IF) channel filters by using an LO of 1.6 GHz and the fifth order on chip filters. The chip is fabricated on a 6.5-mm2 die using a standard 0.25-µm CMOS technology. Experimental results show an in-band image-rejection ratio of 40 dB, an IIP3 of -5 dBm, and a sensitivity of -77 dBm for the Bluetooth mode when the losses from the external components are compensated. It consumes 42 mA in receive π/4-diffrential quadrature phase-shift keying (π/4-DQPSK) mode of 8 Mb/s, 35 mA in receive GFSK mode of 1 Mb/s, and 32 mA in transmit mode from a 2.5-V supply. These results indicate that the architecture and circuits are adaptable to the implementation of a low-cost, multi-mode, high-speed wireless personal area network.

In [16], the authors designed an 8-GHz Beam forming Transmitter IC in 130-nm CMOS. The 8-GHz beam forming transmitter IC was designed in a 130-nm CMOS process. Two power amplifiers with independently controllable phase enable the beam forming. The phases are digitally controllable over the full 360° range, which is accomplished by binary weighting of quadrature phase signals in the power amplifiers. The quadrature phase signals are generated by a quadrature voltage controlled oscillator followed by a buffer, which serves as an isolation between the power amplifiers and the oscillator. The chip contains seven on-chip differential inductors, and consumes a total of 47 mA from a 1.0 V supply. The measured output power is -3 dBm for each power amplifier.

In [17], the authors researched transceiver design technology for fully digital DS-UWB systems. The transceiver includes all of the radio building blocks, such as a T/R switch, a low noise amplifier and I/Q demodulator, a low pass filter, a variable gain amplifier as a receiver, the same receiver blocks as a transmitter including a phase locked loop (PLL), and a voltage controlled oscillator (VCO). A single-ended-to-differential converter is implemented in the down conversion mixer and a differential-to-single-ended converter is implemented in the driver amplifier stage. The chip is fabricated on a 9.0 mm2 die using standard 0.18 µm CMOS technology and a 64-pin Micro Lead Frame package. Experimental results show the total current consumption is 143mA including the PLL and VCO. The chip has a 3.5 dB receiver gain Flatness at the 660 MHz bandwidth. These results indicate that the architecture and circuits are adaptable to the implementation of a wideband, low-power, and high-speed wireless personal area network. 2A 5-GHz Direct-Conversion CMOS Transceiver Utilizing Automatic Frequency Control for the IEEE 802.11a Wireless LAN Standard2. A fully integrated CMOS direct conversion 5-GHz transceiver with automatic frequency control is implemented in a 0.18- m digital CMOS process and housed in an LPCC-48 package. This chip, along with a companion baseband chip, provides a complete 802.11a solution the transceiver consumes 150mWin receive mode and 380mW in transmit mode while transmitting +15-dBm output power. The receiver achieves a sensitivity of better than 93.7 dBm and 73.9 dBm for 6 Mb/s and 54 Mb/s, respectively (even using hard-decision decoding). The transceiver achieves a 4-dB receive noise figure and a +23-dBm transmitter saturated output power. The transmitter also achieves a transmit error vector magnitude of 33 dB. The IC occupies a total die area of 11.7 mm2 and is packaged in a 48-pin LPCC package. The chip passes well than 2.5-kV ESD performance.

Various integrated self-contained or system-level calibration capabilities allow for high performance and high yield. 23. Accurate Power Efficiency Estimation of GHz Wireless Delta-Sigma Transmitters for Different Classes of Switching Mode Power Amplifiers This paper proposes a new closed-form expression for computing the power efficiency of delta-sigma (DS) radio frequency (RF) transmitters. Due to the large bandwidth of the pulse width modulated (PWM) signal at the output of the DS modulator, the peak efficiency of the power amplifier (PA) when driven by a PWM signal is considerably different than its peak efficiency when the input signal is a continuous sine wave. A weight averaging of the efficiency over the frequency bandwidth of the PWM signal is considered for accurate estimation and prediction of the power efficiency of DS RF transmitters. It is shown that, for a low-pass DS transmitter, the overall average power efficiency of the DS transmitter can be accurately estimated by the product of the modulated peak efficiency of the PA and the coding efficiency of the modulator. For bandpass DS transmitters, an additional parameter that accounts for the duty cycle effect on the efficiency of switching-mode PAs has to be considered. To validate the new proposed expression, a DS transmitter for WiMAX, CDMA and EDGE standards is designed, prototyped and tested. The comparison of the simulated and measured efficiencies of the DS transmitter proves the validity and accuracy of the proposed expression.

In [18], the authors conducted a study on Class-AB 1.65GHz-2GHz Broadband CMOS Medium Power Amplifier. In this paper a single stage broadband CMOS RF power amplifier is presented. The power amplifier is fabricated in a 0:25¹m CMOS process. Measurements with a 2:5V supply voltage show an output power of 18:5dBm with an associated PAE of 16% at the 1-dB compression point. The measured gain is 5.1 § 0:5 dB from 1.65 to 2 GHz. Simulated and measured results agree reasonably well.

The authors in [19] provided an elaborated method for routing an Internet Protocol version 6 over Low power Wireless Personal Area Network (6LoWPAN). According to the authors, the IP does not calculate routes to moderate the effects of network mobility. It is left to a routing protocol which maintains routing tables in the routers. 6LowPAN uses an adaptation layer between the network (IPv6) and data link layer (IEEE802.15.4 MAC) to fragment and reassemble IPv6 packets. The routing in 6LowPAN is primarily divided on the basis of routing decision taken on adaptation or network layer. The mobile router detects movement into a wireless network through the reception of a beacon message, and sends a Router Solicitation (RS) message requesting registration in the wireless network to a gateway. The gateway acquires an address of the mobile router from the RS message, stores the acquired address, assigns a new address to be used in the wireless network to the mobile router, and sends a Router Advertisement (RA) message with assigned address information and gateway address information, to the mobile router. The mobile router acquires the assigned address information and the gateway address information from the RA message.

The authors in [20] presented an auto configuration system for 4M group management using wireless sensor network for reconfigurable manufacturing system. The present invention enables connection between a wireless sensor node and a service server while reducing load on the wireless sensor node. The wireless sensor node transmits a router solicitation message to a gateway apparatus; the gateway apparatus analyzes the message to extract the discrete information of a device or service, searches for a service server based on such information and acquires the configuration information necessary for execution of a service application of the wireless sensor node; the gateway apparatus multicasts the received router solicitation message into a link; a router within the link receives the router solicitation message, and multicast a router advertisement message which contains the prefix information of an address, etc. into a link; the gateway apparatus sets the acquired configuration information in the router advertisement message and transfers the resultant message to the wireless sensor node; and the wireless sensor node analyzes the message.

The authors in [21] implemented and measured a Single-Chip 2.4GHz Low-Power CMOS Receiver and Transmitter for WPAN Applications. In this paper A single chip 2.4GHz low power CMOS receiver and transmitter for WPAN applications are implemented and measured. The receiver uses a low-IF architecture with a polyphone filter and transistor linearization technique to improve linearity per power, and the transmitter adopts a ROM based direct-conversion architecture for low power consumption and high integrated density. Experimental results show –79dBm of sensitivity, 13dB of receiver NF, - 4.5dBm of receiver IIP3, and - 4dBm of transmitter output power. The power consumption is 9mW in receiver and 17mW in transmitter at 1.8V, respectively.

The authors in [22] examined the theoretical and experimental basis of noise and distortion in the reception of FM signals and noted that media convergence had a decisive impact on FM radio broadcasting. The study revealed that the expansion of FM radio into several new cities would necessitate the implementation of robust IT systems such as sales pipeline and traffic systems, programming, attendance, billing, collections, and royalty management accounting for streamline operations across locations.

In [23], the authors constructed an integrated two-wire transmitter that converts signals temperature sensors, thermocouples and resistance temperature detectors into a 4-20 mA output. The device was programmed to perform various functions of signal conditioning. The silicon temperature sensor with a standard output allows for the compensation of cold junction thermocouples. In this publication, light was shed on the problems that can be caused in distributed process control systems while transmitting data over long distances, transmitting data properly has caused the startup of many communication schemes, some of which employ smart electronics in the I/O sensors and control elements. Measured samples of an experimental chip configured an RTD-signal conditioner that showed accuracy of 0.1% and a non-linearity of 0.02%.

In [24], examined the FM radio for indoor localization with spontaneous recalibration and noted that modern FM radio stations primarily catered to the needs of local residents in large cities and townships. Their discussions revealed that FM radio stations had become prominent sources of entertainment and advertisement services in modern times. They also opined that Wi-Fi signal strength finger printing techniques are widely used in office buildings with existing Wi-Fi infrastructure. This study was a sequel to their previous works which proposed the exploitation of FM signals, this research was of great use given that in that it posed to solve the problem of Wi-Fi not covering all the desired areas. The only problem with their study was that it pertained to signal degradation due to environmental factors affecting signal propagation. therefore in order to improve on their previous work by maintaining a desirable level localization accuracy, they performed periodic calibration of the system. The authors addressed the problem of recalibration by introducing a concept of spontaneous recalibration and demonstrate it using the FM localization system.

In [25], the authors shed light on the use of slow scan television (SST) used in transmission. They used the Robot36 transmission because of its ability to transmit colour images and because of its wide use. The transmitter in their study possesses similar characteristics to the transmitter in this project; it runs on 433.8MHz, an output power 1.5W and a narrow band FM modulation. They thoroughly investigated heat dissipation due to its small size relative to dissipate power and used a miniature with available parts for signal modulation transmission.

In [26], the authors examined the computing location from ambient FM radio signals and noted that the DRM equally supported all terrestrial radio broadcasting bands, including AM bands (LW, MW, SW) and VHF bands (with the FM band II). They also reported that AM radio stations made serious efforts to improve the quality of MW transmissions. The scholars suggested that traditional AM radio stations should replace their MW transmitters by DRM digital transmitters in the competitive broadcasting environment. DRM is the universal, openly standardized digital broadcasting system for all broadcasting frequencies, including the AM bands (MW, SW, LW), as well as VHF bands I, II, and III. The suggestions from the scholars for the MW transmitters to be replaced was a substantial one because DRM possesses a host of advantages over MW like saving up to 80% energy and having less cost of maintenance. DRM is also of better quality, cost efficient and clearer. Their technique is based on a model for computing the likelihood of locations using both received signal strengths and information from a simulated signal map strength map.

In [27], the authors discussed over modulation protection in FM transmitters. They opined that there should be a use of a pre-emphasis filter prior to frequency modulation in order to enhance robustness against noise coloration inherent to reception. Their method also placed a restriction on the maximum frequency deviation that can be imparted by a message signal modulating the FM carrier, to limit the occupied band of the broadcast signal. Their study addresses the need for a gain control mechanism specifically tailored to take care of pre-emphasized audio in a broadcast system, to prevent over modulation, this is achieved through an adaptive filter based algorithm for over modulation protection in FM radio.

In [28], the authors examined the indoor positioning system based on FM radio and noted that the system was built on commercially available short-range FM transmitters. The scholars also reported that despite the low cost and off-the-shelf components, the FM positioning system reached a high performance, comparable to other positioning technologies such as Wi-Fi. The scholars suggested that these applications could be enabled by a low-cost, sub room location solution.

In [29], the authors investigated indoor localization using audio features of FM radio signals and reported that typical localization systems used various features of the signal to estimate the distance, including received signal strength indicator (RSSI), timing information or angle of arrival (AoA). They suggested that there are a number of signal features of FM radio which could be used for localization, namely stereo channel separation (SCS) and signal to noise ratio (SNR). The results of their investigation showed the possibility of audio-based localization when signal strength readings are not available. The paper generally investigated the feasibility of indoor localization using methods such as the finger printing of audio features of FM radio signals emitted by low-power FM transmitters using SNR and SCS values.

The author in [30] documented on the construction of portable audio transmitters. The circuit used BC547 transistor to amplify the signal before frequency modulating it. Due to its small size and its 9V power source, the signal range was limited to just 15m. The components used were a BC547, a microphone, a variable capacitor 47 pf, 9V battery, 330 ohms resistor, 10p capacitor, 1n capacitor, 4.7k resistor and LED. The experimentation began with cutting up a PCB to the required size i.e. a size suitable for a 9V battery clip. For the inductor, 0.5mm wire and 8 turns ere used which each turn having a diameter of 6mm. as for the antenna he used a 5cm long wire and center tap the coil and solder the antenna to the center tap. LED was used in the circuit show if it was functional and then a wiring tape was used to cover the whole circuit except the variable capacitor and the microphone. This is especially important because while tuning to the required bandwidth, contact with the circuit would lead to severe noise. Once the signal was found, the first step is recommended, all you have to do is power the circuit and turn on auto find bands on your mobile. Your mobile would scan for channels and all you have to do is look for your transmitter on that list. The second method is time consuming, in this method you have to turn on your radio and the circuit. Keep the radio at a specific channel, and then tune the variable slowly, when a signal is heard stop and the bandwidth on the radio is the required bandwidth.

The microphone was attached with wires although it would have been more appropriate to solder it instead of using tapes; this is because when soldering is used there is much less noise. The LED used is only optional, one might choose to use it or not but one setback with using the LED is that it will most likely drain the battery. Also, the 9V batteries are a good power source but Li-ion battery would provide longer transmission. There are numerous mini FM transmitters but a transmitter soldered on top of a 9V clip is quite rare and this provided insights into my construction.

The authors in [31] researched and designed an FM transmitter positioning system based on UAV. They emphasized on direct finding (DF) and positioning of frequency modulating transmitting station with known frequency as important technologies in radio transmission. Their research looked to solve the recent emergence of illegal radio stations which were resulting in negative social impact. The study introduced a three-dimensional positioning of the FM radio by making use of multi rotor unmanned aerial vehicle equipped with a radio DF equipment. Their study was technically inclined although it could be regarded as a step towards solving a more social problem given that the illegal stations could not be monitored. This research provided a new technical means for monitoring and positioning of radio stations.

In [32], the author mathematically derived some parameters involved in Frequency modulation. In this study, the differential equation of frequency modulated transmitter is considered and the expression of current as a function of time is derived. According to the paper, when the function undergoes frequency analysis it results in Sinusoidal frequency modulation and Right-angle frequency modulation. The amplitudes and distribution of these frequencies are dependent on the value of a parameter known as the **frequency modulation index**.

In [33], the authors comparatively studied amplitude, phase and frequency modulation. The three forms of modulation were first mathematically derived and were expressed as amplitude equations, side band equations and modulation vector equations. The amplitude equations indicate the envelope of the radio-frequency directly. The side equations refer to the number, amplitude and phase of the side produced by modulation. In the modulator vector equations, corresponding side bands are combined in pairs to form a "modulation vector".

In [34], the authors analyzed a simple low-power paper-based electronic circuit that has stable electric characteristics comparable to copper pattering. The combination of colorimetric bioassay and electric signal are likely to lead to more productive analysis in point-of-care application. The electrode is designed to catch electrical signals during bioassay. This research provides insight into the basics of PCB board.

The authors in [35] emphasized on the importance of PCB in the university system, which adds to the larger message of radio sensitization across tertiary institutions. In their paper they stressed the relevance of PCB in university curriculum, pointing out the benefits in the long run. They showed some previous experiments and proposed the methodology of the subject. This paper serves as another call to the relevance radio plays in the educational system and it advocates for radio communication in social development.

In [36], a method of individual radio transmitter identification was analyzed, this method was based on collaborative representation. The square integral was extracted to characterize the radio transmitters in the feature space. After that, based on collaborative representation, they computed the square coefficients with low computation complexity. On the actual collected FM radio dataset, the experimental results verify the effectiveness and robustness of this method.

In [37], the authors presented recorded developments on transmitter and receiver circuits for emerging Terahertz Applications i.e. in the sub-millimeter wave region of the electromagnetic spectrum. In their research, the circuits were attached to a secondary silicon lens and packaged low cost FR$ printed circuit board. The study sheds light on some circuit components and functionalities of transmitters and receivers.

A 76-108MHz transmitter was studied in [38]. The transmitter was a compact mobile FM transmitter with automatic embedded antenna tuning and a low spurious emission in 65nm CMOS. In this study, there was a proposed on-chip calibration scheme that digitally tunes an on-chip capacitor to center the embedded antenna resonance circuit with an external inductor at the desired FM channel. For this transmitter, the spurious emission level for coexistence with other radio bands is very low, mostly around -102 dBm or less. This transmitter is similar to the one in this project in terms of mobility and the addition of an embedded antenna.

In [39], the authors studied the speed of radio transmission under certain practical conditions. In this study it is first shown that for waves in a vacuum, the speed of transmission is equal to the velocity of light. They opined that when waves at certain frequencies are propagated at height of a fraction of a wavelength above the earth's surface, their speed is reduced by an amount dependent upon the electrical conductivity of the earth overland transmission, the speed is about

299,775km/s. for higher frequencies propagated at a height of several wavelengths, the speed of the waves is determined by the refraction index of the air rather than by the wavelength.

In [40], the relative importance of Different Propagation mechanisms for Radio Coverage and Interference Prediction in Urban Scenarios was documented. The authors highlighted that radio coverage and interference in communications can be provided by various propagation mechanisms depending on the frequency of the radio waves and the propagation environment. Few of the propagation mechanisms are diffraction, incoherent scattering and specular reflections. They stressed that knowledge of which propagation mechanisms dominate for coverage and interference calculations is important. They presented a novel surface model unifying scatter and fresnel models and use them to evaluate the relative importance of the different propagation mechanisms used in an urban scenario at three frequency of interest through simulation.

CHAPTER THREE

3.0 METHODOLOGY

This chapter discusses the methods used in implementing the project. It details the hardware construction techniques used in designing and constructing a mini broadcast frequency modulation transmitter with a 15W power rating. It also sheds light on the software simulation of the circuit, its components and their arrangement. Each construction phase of the project is shown in the implementation flowchart of the project.

Thus, the purpose of the construction phase of the project is to achieve a specific task and certain results, so that it does not stay isolated from the project objectives.

Several steps were taken in developing this project and are stated thus:

1) Understanding the problem and gathering of information.

2) Choosing the appropriate methods suitable for solving the problem based on the information gathered.

3) Selection of construction tools and sourcing of components.

4) Hardware construction and testing.

5) Software and hardware integration and final testing.

3.0.1 COMPONENTS USED:

In this project I designed the circuit in such a way that the circuit will collect input through the microphone and broadcast it with an FM radio. I used the following components

Transistors:

The transistor used for this project is a 2N3866 RF transistor. The transistor buffer in the project is capable of strengthening the transmitter signal because a transistor is a semiconductor device commonly used to amplify or switch electronic signals. A transistor is made of a solid piece of a semiconductor material, with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals changes the current flowing through another pair of terminals. Because the controlled (output) power can be much more than the controlling (input) power, the transistor provides amplification of a signal. The transistor is the fundamental building block of modern electronic devices, and its presence is ubiquitous in modern electronic systems. The bipolar junction transistor (BJT) was the first type of transistor to be mass-produced. Bipolar transistors are so named because they conduct by using both majority and minority carriers. The three terminals of the BJT are named emitter, base, and collector. The BJT consists of two p-n junctions: the base–emitter junction and the base–collector junction, separated by a thin region of semiconductor known as the base region (two junction diodes wired together without sharing an intervening semiconducting region will not make a transistor). The BJT is useful in amplifiers because the currents at the emitter and collector are controllable by the relatively small base current.

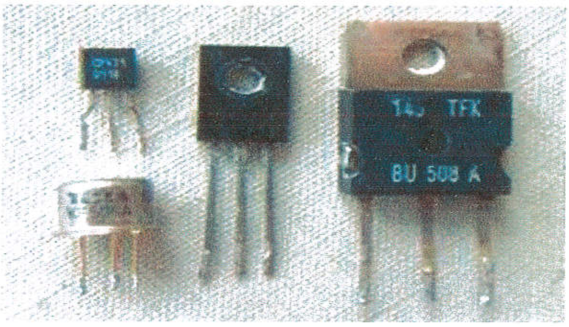


Fig 3.1: Transistors

Resistors:

A resistor is a linear, passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals. Thus, the ratio of the voltage applied across a resistor's terminals to the intensity of current through the resistor is called resistance.

This relation is represented: Ohm's law: $I = V/R$

Resistors are common elements of electrical networks and electronic circuits and are applicable in most electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits. The electrical functionality of a resistor is specified by its resistance: common commercial resistors are manufactured over a range of more than nine orders of magnitude. When specifying the resistance in an electronic design, the required precision of the resistance may require attention to the manufacturing tolerance of the chosen resistor, according to its specific application. Practical resistors are also specified as having a maximum power rating which must exceed the anticipated power dissipation of that resistor in a particular circuit: this is mainly of concern in power electronics applications. Resistors with higher power ratings are physically larger and may require heat sinks. In a high-voltage circuit, attention must sometimes be paid to the rated maximum working voltage of the resistor.

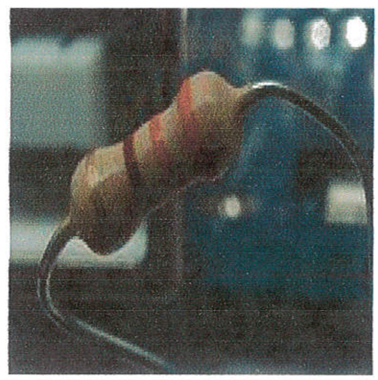
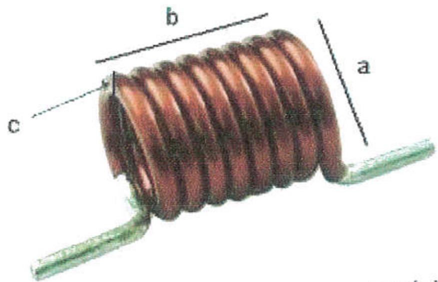


Fig 3.2a: Resistor

Inductors:

An inductor, also called a coil or reactor, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. When a current flows through it, energy is stored temporarily in a magnetic field in the coil. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor, according to Faraday's law of electromagnetic induction, which opposes the change in current that created it. An inductor is characterized by its inductance, the ratio of the voltage to the rate of change of current, which has units of henries (H). Inductors have values that typically range from 1 μH (10^{-6}H) to 1 H. Many inductors have a magnetic core made of iron or ferrite inside the coil, which serves to increase the magnetic field and thus the inductance. Along with capacitors and resistors, inductors are one of the three passive linear circuit elements that make up electric circuits. Inductors are widely used in alternating current (AC) electronic equipment, particularly in radio equipment. They are used to block the flow of AC current while allowing DC to pass; inductors designed for this purpose are called chokes. They are also used in electronic filters to separate signals of different frequencies, and in combination with capacitors to make tuned circuits, used to tune radio and TV receivers.



$$L = \frac{0.2a^2n^2}{3a + 9b + 10c}$$

Fig 3.2b: Inductor coil

Capacitors:

Capacitors are two-terminal electrical component separated by a dielectric (insulator) and used for storing electric charges. It consists of metal foils separated by a layer of insulating film. When there is a potential difference (voltage) across the insulated films, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads.

Capacitors are widely used for blocking direct current while allowing alternating current to pass. In this project it is used as a filter network, for smoothing the output of the power supply and preventing radio frequency interface.

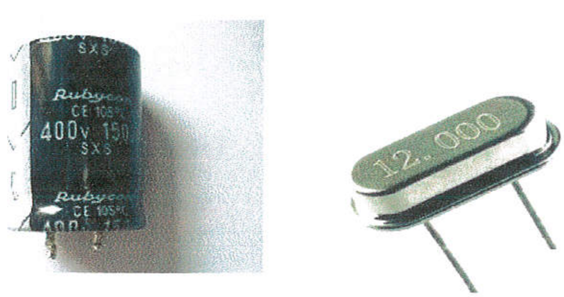


Fig 3.3: Capacitor

Switch:

The power ON and OFF of this project is a switch. A switch is an electrical component that can break an electrical circuit, interrupting the current or diverting it from one conductor to another. The most familiar form of switch is a manually operated electromechanical device with one or more sets of electrical contacts. Each set of contacts can be in one of two states: either 'closed' meaning the contacts are touching and electricity can flow through them, or 'open', meaning the contacts are separated and the switch is not conducting.

Diode:

A diode plays a very important role in this project. It allows an electric current to pass in one direction (called the diode's forward direction), while blocking current in the opposite direction (the reverse direction).Diodes can be used for rectification, to convert alternating current to direct current and to extract modulation from radio signals in radio receivers. It is a type of two-terminal electronic component with a nonlinear current–voltage characteristic. A semiconductor diode is a crystalline piece of semiconductor material connected to two electrical terminals.

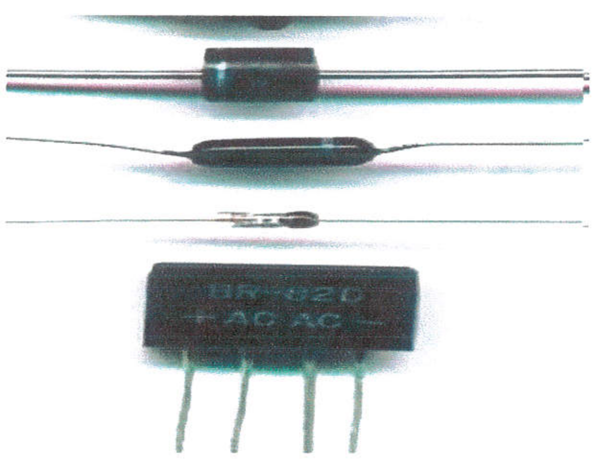


Figure 3.4: Diodes

LED

An LED is a solid-state lamp that uses light–emitting diode as the source of light. The two light emitting diodes (LED) used in this project indicates when there is voltage supply to the system and the transmitter works.

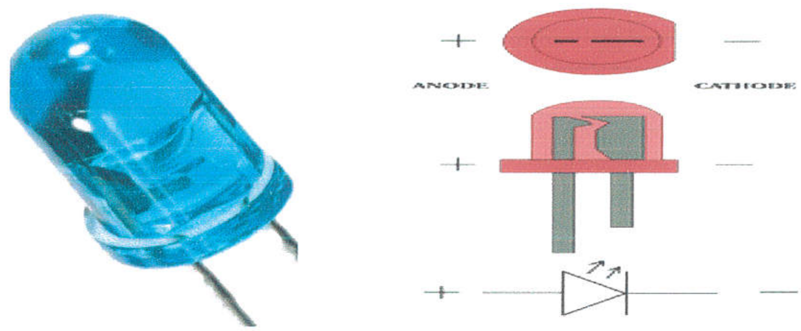


Fig 3.5: A LED bulb and its polarities

Microphone:

A microphone is an acoustic-to-electric transducer or sensor that converts sound in air into an electrical signal. Microphones are used in many applications such as telephones, tape recorders, karaoke systems, hearing aids, motion picture production, live and recorded audio engineering, FRS radios, megaphones, in radio and television broadcasting and in computers for recording voice, speech recognition, VoIP, and for non-acoustic purposes such as ultrasonic checking or knock sensors.

Most microphones today use electromagnetic induction (dynamic microphone), capacitance change (condenser microphone) or piezoelectric generation to produce an electrical signal from air pressure variations. Microphones typically need to be connected to a preamplifier before the signal can be amplified with an audio power amplifier or recorded. In this project, the microphone is connected to the small signal transistor which amplifies the audio signal.

DC Voltage Regulator

A LM7805 DC voltage regulator keeps the output voltage constant. The regulator appears to be a comparatively simple device but it is actually a very complex integrated circuit. A regulator converts varying input voltage and produces a constant "Regulated" output voltage. Voltage regulators are available in a variety of output, typically 5 volts, 9 volts and 12 volts. The last two digits in their respective name indicate the output voltage. The voltage regulator usually has three pins.

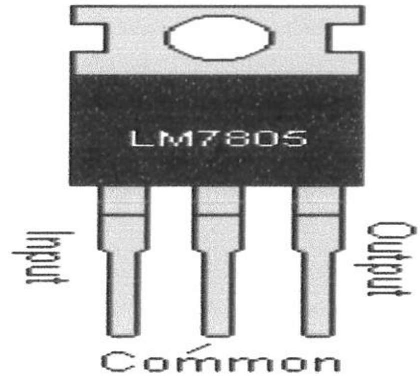


Figure 3.6: DC Voltage Regulator

Examples of regulators are listed:

Name	Voltage
LM7805	+ 5 volts
LM7809	+9 volts
LM7812	+12 volts
LM7905	-5 volts
LM7909	-9 volts
LM7912	-12 volts

Table 3.1: Different types of Voltage Regulator

The "LM78xx" series of voltage regulators are designed for positive input while "LM79xx series are used for negative input.

3.1 CONSTRUCTION PROCEDURE

Before the hardware construction, the circuit was previously simulated on the computer using Proteus 7 software. This is to ensure that the circuit diagram will actually work in real life. After several modifications and testing of the schematic circuit diagram on the computer aided design software (Proteus 2007) and breadboard, the next stage is the mounting of the components.

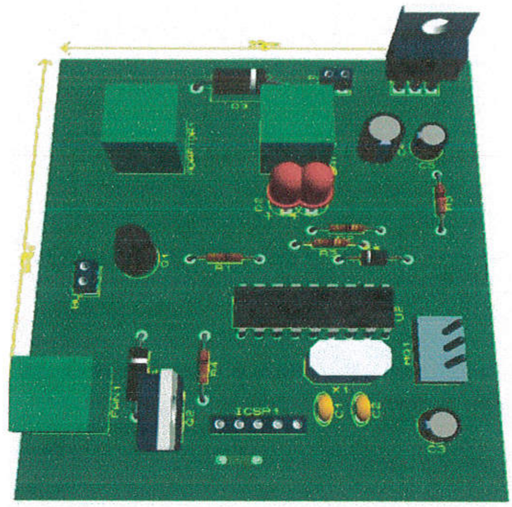


Fig 3.7a: A 3D representation of the circuit

Circuiting:

I attached a PCB layout, and then I attached a file of circuit. Once the PCB is prepared, insert the components in to the PCB according to the circuit and solder it. For the inductor I used a 22-gauge, forming an inductor with 8-10 turns of ¼ inch. After this I soldered the inductor to the circuit. When making the PCB I used a permanent marker as a protective coating for the PCB, before performing the time consuming task of tuning the transmitter. By varying the trimmer capacitor I varied the transmission frequency until I heard some distortion in the radio, then slowly varied in that area until transmitter and receiver frequency thereby obtaining a clear output from the radio.

The project hardware was constructed on a Printed Circuit Board (PCB) Strip Board according to the schematic simulated on the computer.

The construction procedure methods used include:

- The PCB was inspected for wrong linkages of its metallic tracks which may have been mistaken during ironing or etching. The drilled holes of the board were made sure to be through for passing the lead or copper terminals of the components for soldering.
- Components are placed on the plain side of the board according to the project schematic circuit diagram. The component leads are passed through the holes of the board and the lead

or copper component terminals are then soldered to the copper tracks on the other side of the board to make the desired connections. Any excess wire is cut off.

- The soldering process was carried out using a lead and soldering iron. This was done by joining the supposed terminals together before soldering. After soldering each unit, test was carried out using a multimeter to ensure continuity.

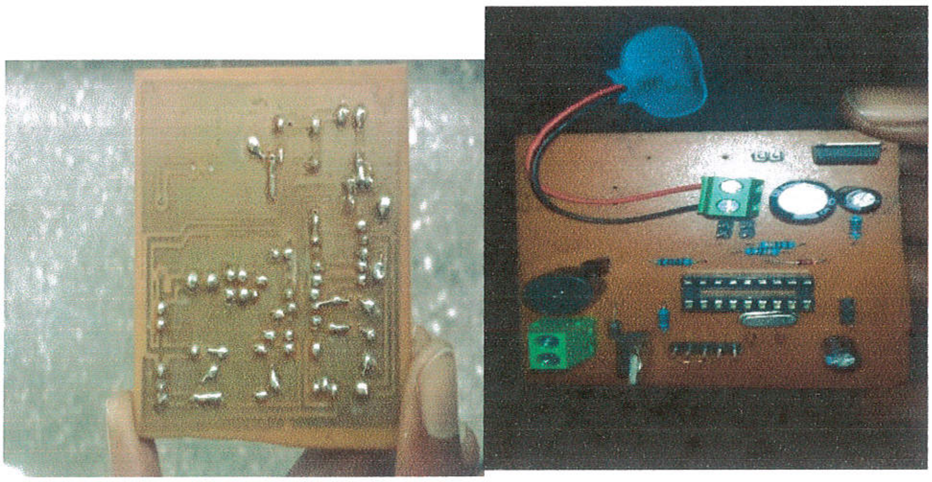


Figure 3.7b: PCB after soldering components (Back & Front)

Soldering

The soldering exercise was carried out with 40watt soldering iron and it was performed with due regard to safety. Before starting to solder the bit of the soldering iron was cleaned when hot by wiping it across a wet sponge or fine abrasive paper. I melted some solder onto the bit in a process known as tinning and wiped it off in the sponge to help this clean it as solder contains cores of flux, which is a cleaning agent.

For a successful result, all parts of the board to be soldered were dry and free from dirt and grease. A hot soldering iron was used to produce good solder joints. The joints were made hot but not too hot to overheat it because overheating can cause damage. The soldering iron was placed so that it was touching both the lead to be soldered and the copper track to which it was to be joined. After a few-seconds the solder was applied to the track to melt and flow up around the base of lead forming a wedge. Solder flows from cold to hot and therefore if either the lead or track was cold, solder would not flow and dry. A dry joint is one which has failed to bond sufficiently strongly with the copper track and as a result it provides a poor conducting path for current. The dry joints were put right by applying a clean soldering iron to the joint and leaving it long enough for it to melt the solder so that it flows properly.

Apart from dry joints another problem encountered in the soldering was solder bridges linking tracks. This happened when too much solder was applied to the joint and an adjacent track was heated at the same time as the joint, perhaps by using a soldering iron bit which was too large. The situation was dealt with immediately as it occurred. Solder sucker was used to remove the hot solder. Any component that has been picked and placed in the hole was soldered immediately so that it did not fall. Soldering is one important factor in electronics systems design which if poorly done can undermine the operation of the system.

Software Implementation

The implementation of this project was based on research, quoted specifications, information and circuit models gathered from the internet. This guided me to partition different circuits using the top-down design and construction flowchart, and then it was simulated on the computer aided software known as Proteus. An assembly language program was written in MIDE (Microsoft integrated development environment) for the project source code. The programming software used was MPLab, and then the code was compiled using CCSC Compiler.
A microcontroller based project implementation is characterized by the following:

- Definition of task,
- Requirements,
- Factors that influence choice.

In defining a task, every construction comes from an idea or a problem that requires a solution. Questions may be generated on what exactly is required to be achieved and the feasibility of the ideas as regards to the implementation. If these questions are analyzed critically with tangible solutions to the problem, a development of this idea into a reality is the next step.

Requirements for implementation process have to be considered once an idea has been established. The need to determine whether or not the idea requires a PC or not, depending on the complexity of the circuitry or whether the circuit to be constructed deals with complex data.

Preferably, a PIC16F628A microcontroller will be the best option based on the circuits to be constructed with less hardware connections and more flexibility.

The program used in this project was written in assembly language with MPLab. The MPLab is a software program and a CCSC compiler used to generate HEX burned in the chip using a programming machine.

During the simulation, my concern was on how the system functionality will be and how the part of the sub-circuits will be fixed together. The tool used in this phase of the project work is the system block diagram which reveals how the system hardware and software components interact and interface with one another while the flowchart in figure 3.7 shows the steps and order of the system implementation from start to finish.

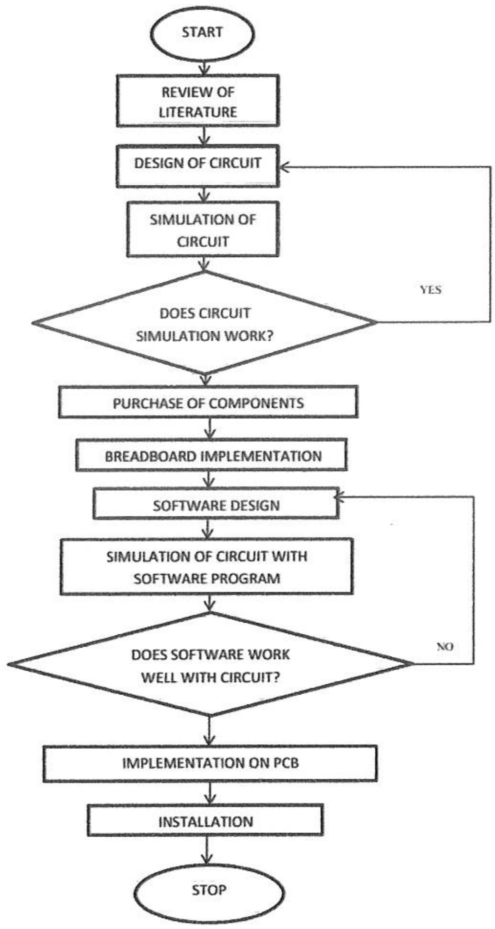


Fig 3.8: Order of implementation chart

The circuit diagram of the system is as below:

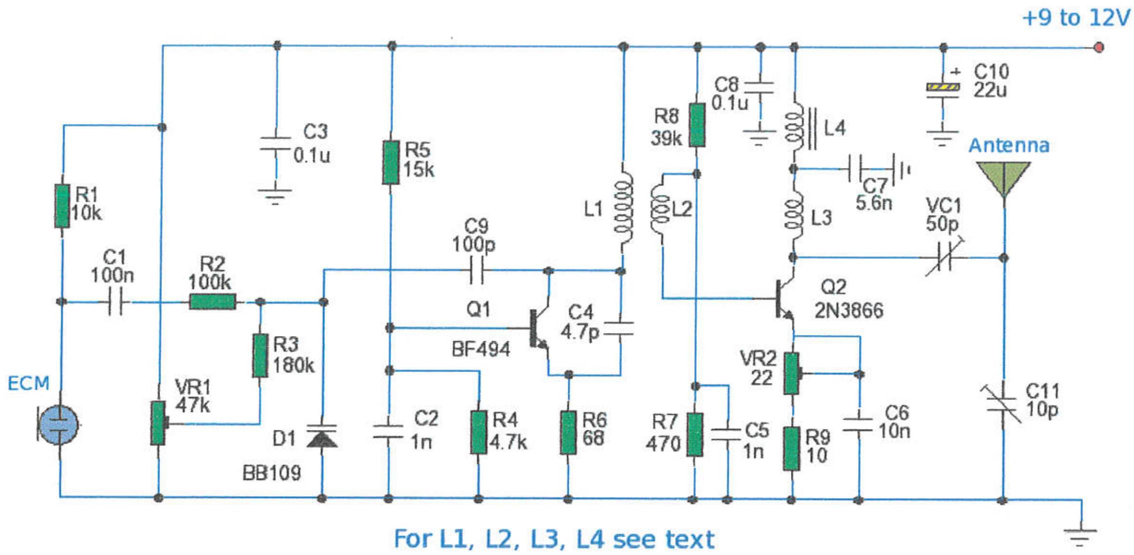


Fig 3.9: Circuit Diagram

3.2 CIRCUIT DESCRIPTION

The power output of many transmitter circuits is very low because no power amplifier stages are incorporated. The transmitter circuit described here has an extra RF power amplifier stage using 2N3866 RF power transistor after the oscillator stage to increase output power to 250 milliwatts. With a good matching 50-ohm ground plane antenna or multi-element Yagi antenna, this transmitter can provide reasonably good signal strength up to a distance of about 2 kilometers. Transmitter's oscillator is built around BF494 transistor T1. It is a basic low-power variable-frequency VHF oscillator. A varicap diode circuit is included to tune the frequency of the transmitter and to provide frequency modulation by audio signals. The output of the oscillator is about 50 milliwatts. 2N3866 transistor T2 forms a VHF-class A power amplifier. It boosts the oscillator signal power four to five times. Thus 250mW of power is generated at the collector of transistor T2.

3.2.1 TRANSMITTER ASSEMBLY NOTES

For better results, assemble the circuit on a good-quality glass epoxy board and house the transmitter inside an aluminum case. Shield the oscillator stage using an aluminum sheet. Coil winding details are given below:

L1 - 4 turns of 20 SWG wire close wound over 8mm diameter plastic former.
L2 - 2 turns of 24 SWG wire near top end of L1.
(Note: No core (i.e. air core) is used for the above coils)
L3 - 7 turns of 24 SWG wire close wound with 4mm diameter air core.
L4 - 7 turns of 24 SWG wire-wound on a ferrite bead (as choke)

Potentiometer VR1 is used to vary the fundamental frequency whereas potentiometer VR2 is used as power control. For hum-free operation, operate the transmitter on a 12V rechargeable battery pack of 10 x 1.2-volt Ni-Cd cells. Transistor T2 must be mounted on a heat sink. Do not switch on the transmitter without a matching antenna. Adjust both trimmers (VC1 and VC2) for maximum transmission power. Adjust potentiometer VR1 to set the fundamental frequency near 100 MHz

An impudence matching ANTENNA is required in the circuit, without the antenna the circuit will never work.

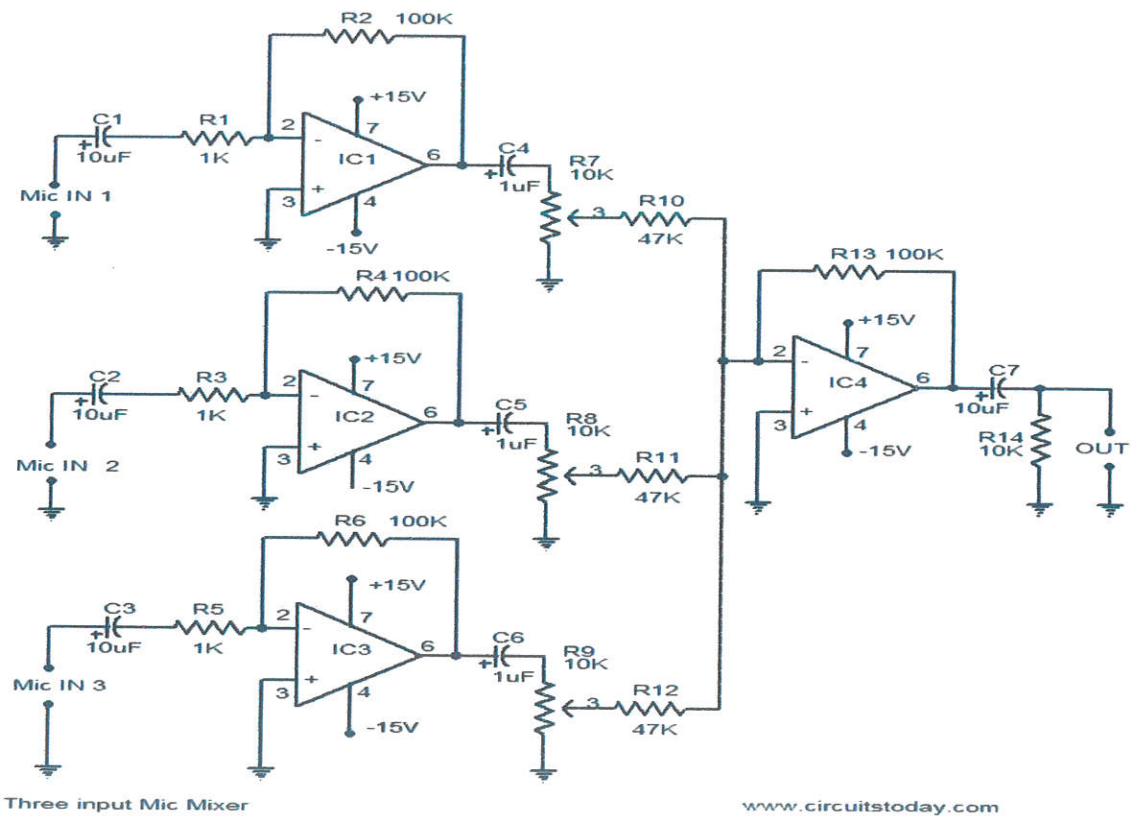


Fig 3.10: Mixing console circuits

3.2.2 CIRCUIT OPERATION

The circuit is basically a radio frequency (RF) oscillator that operates around 100 MHz Audio from audio jack is fed into the audio amplifier stage built around the first transistor. Output from the collector is fed into the base of the second transistor where it modulates the resonant frequency of the tank circuit (the 8 turn coil and the trimcap) by varying the junction capacitance of the transistor. Junction capacitance is a function of the potential difference applied to the base of the transistor. The tank circuit is connected in a Colpitts oscillator circuit. It works on the principal of COLPITTS Oscillator.

An impudence matching ANTENNA is required in the circuit, without the Antenna the circuit will never work.

A 22 Gauge enameled copper wire was wound it on the ball-pen and make 8 turns on it tightly. The wound is shown as below:

As a conclusion, every project will have different methodologies that are used to make the project successful and efficient. Generally, the methodologies are divided into three parts; they are planning, implementing and analysis. The planning phase includes reading activity and research of requirements of hardware and software to be used.

In reading activity I did research through several sources such as text books, journals, paper references, the Internet and more sources to get information on the project. While in the requirements of hardware and software to be used I studied and found out the functional and operational workings of the hardware and software related.

Next step is implementing phase where I employed a third party due to produce the project circuit board. When the PCB was ready to mount the electronic components, the process of construction circuit is followed. The process of checking, testing and tuning were all observed in order to complete the part of implementing.

Finally, in analysis phase, I was looking at the combination of electronic circuits that are rectifier, oscillator and power amplifier. The functions and the operations were duly analyzed. With appropriate steps and methodology, any process of completing the project can be managed wisely and can make a good result.

CHAPTER FOUR

4.0 TESTING, ANALYSIS OF RESULTS AND DISCUSSION

After the implementation phase, the system built had to be tested for durability, efficiency, and effectiveness and to ascertain if there is need to modify the system. The system was assembled using a Printed Circuit Board (PCB) and was tested to ensure that the system is working properly. During the practical experimentation, all components were properly inserted and soldered into the PCB from whence some tests were carried out at various stages. To ensure proper functioning of components' expected data, the components were tested using a digital multimeter (DMM). Resistors were tested to ensure that they were within the tolerance value. Faulty resistors were discarded.

In building this project, the following procedures were properly considered,

I. Lining out of the entire materials / Components needed

ii. Resistance check of the components bought with the help of ohmmeter before making the necessary connection with the components

iii. Drafting out a schematic diagram or how to arrange the materials / components.

iv. Testing the completed system to see if the design works and

v. Finally, implementation of design of the project.

Having procured all the materials, I processed into the arrangement of the components into the PCB board, proper soldering of the components then followed. The components were all soldered into the board after which it was correctly confirmed done.

4.1 TESTING TECHNIQUES

Every new assembly requires testing before it can be connected to the power supply in order to ensure that it will function correctly and safely (IEE Regulation, 1988).

1. The following tests were carried out on this device.

2. Continuity test is required to detect all section that have open circuits.

3. Polarity test is required to ensure that every live terminal are done in such a way that there is no bridge between the terminals.

In this chapter, the required tools and materials have been presented. The components have been listed with the design calculations of some of these components carried out to ascertain their performances in the circuit. The fabrication has been explained with emphasis on printed circuit board and soldering techniques.

Continuity Test

When all the components had been soldered on the printed circuit board (PCB) continuity test was carried out before the connecting the system to power supply. The test revealed open circuit faults, which could be due to:

1. A break in the circuit.

2. The failure of a component leading to it having an unusually high resistance or.

3. An increase in the insulation at certain points caused by dirt, grease or corrosion.

4. It also revealed that short circuit faults which were due to;

Transmitter range testing involved the process required to determine the distance from transmitter its signal will be received. This test required a radio receiver with FM band, a cassette player or an assistant producing direct audio that will be feed into the microphone. The test also requires an antenna installation described below. The transmitter, cassette player and radio receiver were switched on simultaneously. The radio receiver set to FM band was tuned gradually to capture the main frequency then moved away from the transmitter to the farthest point signal could be received.

While designing the FM transmitter circuit, I faced a problem with the electronic components such that the transistor and the variable capacitor referred with the serial number and the value to be used.

In the course of the construction process I found that several components provided a challenge in the course of the soldering. This arose from the fact that the track circuit design is too thin on the project circuit board (PCB) and it makes the copper on the track draw out when the soldering process is done too many times. This should be paid attention to because the PCB needs to be intact at the end of the construction.

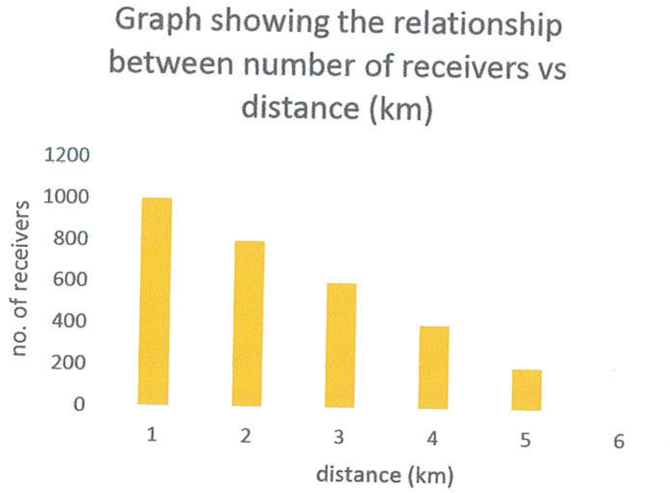
I paid close attention to the components because the value of the components will affect the output of the FM transmitter circuit. After adjustment of the component's values I had to do the simulation whereas the simulation result is performed by waveforms. I analyzed the waveforms and did comparisons with the theory in order to check for any errors.

Fig 4.1: Internal arrangement of the mini-broadcast transmitter.

4.2 ANALYSIS

After assembly, soldering, casing etc. the project was tested and as discussed earlier, the system gave a good response to different factors of testing. After then, analysis of my result. The subsections below show the analysis of my result

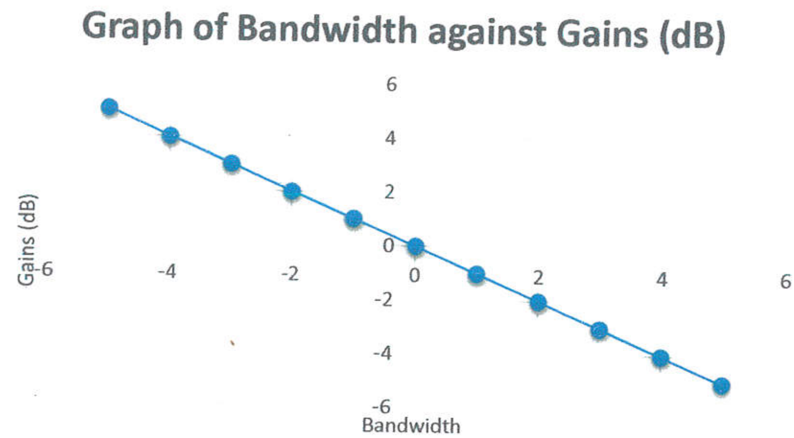
4.2.1 ANALYSIS OF RECEIVERS BASED ON THEIR DISTANCE



From the graph above, we can see the relationship between the numbers of receivers based on their distance in (km). As the distance increases, the number of the receiver decreases as shown in the graph based on the strength of the antenna used. It can also be seen that at distance 6km we have zero (0) numbers of receivers, this implies that no receiver can receive at distances beyond 5km.

4.2.2 ANALYSIS OF THE STRENGTH OF THE ANTENNA

The graph below shows the relationship between the bandwidth (MHz) and Gains (dB). It can be seen from the graph that as the gain increases, the bandwidth also decreases. The bandwidth of the antenna is the frequency range between the frequencies at which the gain drops 3dB (on-half the power) below its maximum. However, the bandwidth of this antenna have the frequency range over which it has high gain, is narrow, a few percent of the center frequency, and decreases with increasing gain, so therefore this antenna is best used in fixed frequency applications like FM transmission.



4.3 PROJECT MANAGEMENT

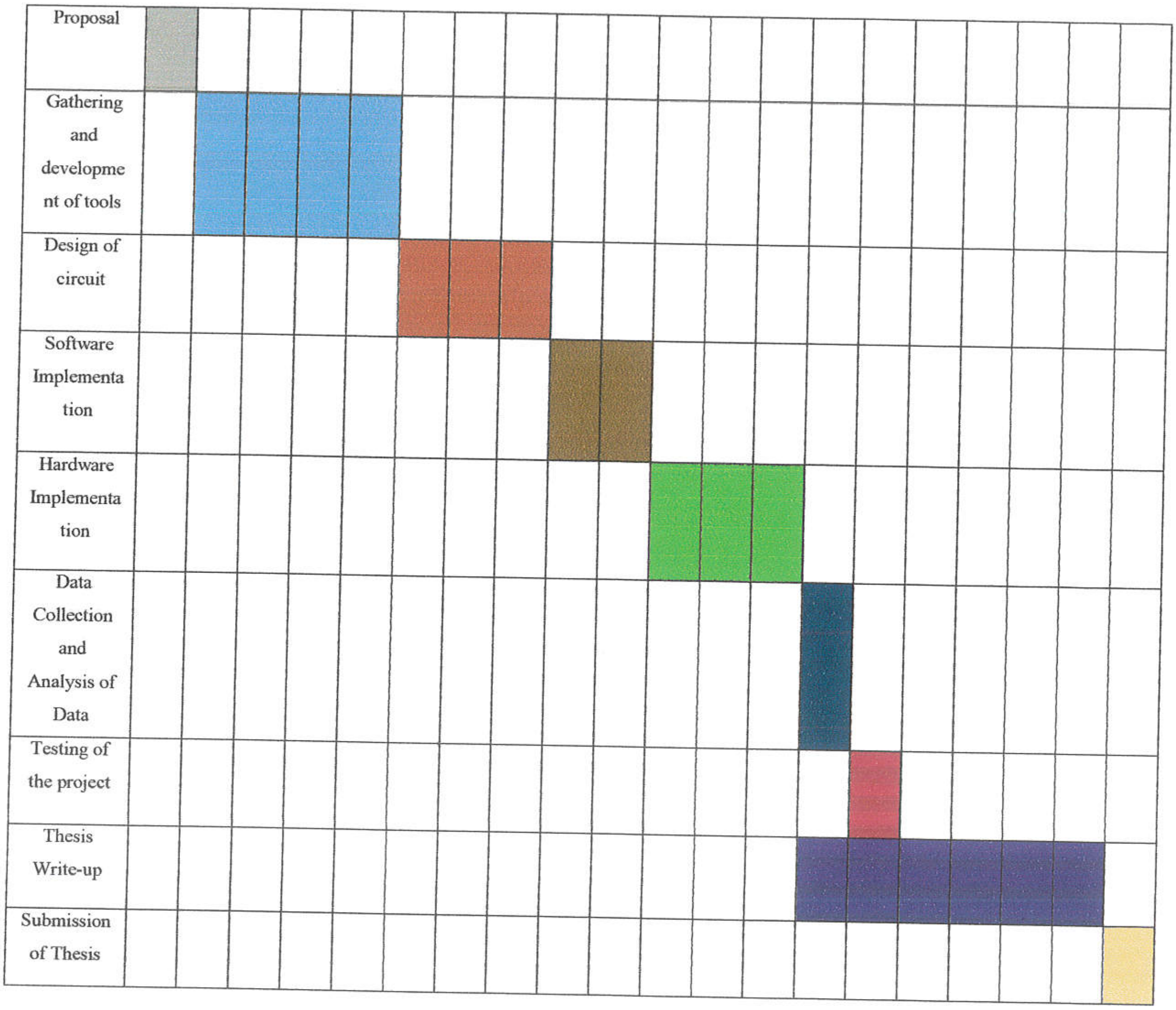
The following subsections show how the achievement of the aim of this project is managed.

4.3.1 PROJECT SCHEDULE

The chart below shows the tasks involved in this project and the time period to complete each of this task.

The fundamental Gantt chart of the project is shown below:

	JUNE 2018				JULY 2018				AUGUST 2018				SEPTEMBER 2018				OCTOBER 2018			
	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	WK 9	WK 10	WK 11	WK 12	WK 13	WK 14	WK 15	WK 16	WK 17	WK 18	WK 19	WK 20
Literature Review																				



4.3.2 RISK MANAGEMENT

In the design and implementation of this project, the likely threats to encounter are:

i. Frequency Instability
ii. Electrical Hazard
iii. Components Failure
iv. System Error

These threats are been mitigated by:

(i) Provision of surplus components to serve as redundancy thereby improving the reliability of the system.

(ii) It was ensured that the project is handled by an expert.

(iii) I ensured I put on my safety wears.

(iv) I ensured the components were mounted close together to minimize the stray inductance, connection points were also small to minimize stray capacitance.

In the course of this project, no risk materializes simply because of the proper planning.

4.3.3 SOCIAL, LEGAL, ETHICAL AND PROFESSIONAL CONSIDERATIONS

This project was ensured to have been designed and implemented to meet and conform to the standards of Institute of Electrical and Electronics Engineers (IEEE). It was also ensured that all safety rules and regulations were duly observed during the project.

According to the Nigerian Broadcast Commission (NBC) any persons or entities seeking to operate on any frequency shall apply and obtain a permit from the Commission except for community broadcast which the distance of broadcast should not exceed 5km in radius and this falls under the jurisdiction of the project to serve the school campus and its nearest environs.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 CONCLUSION

So, far the test result of this project which is the outcome of construction procedures has revealed the successful achievement of the primary objective; the design and construction of an FM transmitter of appreciable range operating on 12v power supply. Because of the impressive good result, obtained from the usability test, the FM transmitter is now ready for either instructional or entrepreneur purposes. The successful completion of this study has indicated that practical FM transmitter requiring low power input can be designed and constructed.

5.1 RECOMMENDATIONS

In the light of the setbacks encountered by the researchers through the course of conducting this project successfully, and the general findings, the following recommendations are hereby made.

- Higher institution students studying technology related courses should be encouraged to undertake design and construction projects, not just in their final year but also through the course of their program. This should also be used as a means to grade them. In the long run this will develop the educational system and the drive for technological advancement in Nigeria.
- Universities, Polytechnics, Research institutes and individuals alike should be encouraged and supported by the government and the general public in technological pursuits. This can be done in terms of funding, provision of basic/advanced equipment, and recognition.

5.2 CONTRIBUTION TO KNOWLEDGE

This study contributes to the understanding of the broadcast transmitter and its role in electronic communications and broadcasting. Frequency modulation is found is used in radio and TV broadcast stations worldwide. In the write up I also elaborated on the process of constructing a mini broadcast transmitter on a step-by-step basis. I evaluated previous works on the same topic and gave insights into simulation of electric circuits on a software platform known as MPLab.

5.3 LIMITATIONS OF THE PROJECT

In the course of this project I encountered some challenges ranging from scarce supply of components to causing damage to my PCB. Some of these challenges were due to poor tools and substandard materials provided.

5.4 FUTURE WORKS

The relatively low output of FM transmitters sometimes makes it unsuitable for use in large urban areas because of the number of other radio signals in the same region. This is due to the fact that strong FM signals can leak into neighboring frequencies and this can cause the transmitter to be unusable with the frequencies. This is why the removal of a cars antenna can improve transmitter reception.

Some transmitter models that connect via ports instead of the headphone jack have no means of controlling the volume; this can cause the radio to emit sound loudly and improperly. There are devices that can use automatic level control or audio limiter circuit to overcome this problem although they are scarce in supply. It will contribute a lot to this project if this problem can be tackled.

5.5 CRITICAL APPRAISAL:

This study is relevant in the fact that it answers certain questions pertaining to the construction of a broadcast transmitter. Through the course of my construction and implementing I encountered challenges that I worked around. I did not get the full data I needed from experimenting and testing my transmitter due to lack of time to work extensively on my results. The values of my components were adjusted to my desire, however there might have been slight errors in getting the final tuning due to worn out components as finding components posed a challenge. Despite all that the strength of this study lies in the fact that I provided in-depth knowledge on the construction of this device, shedding light on the setbacks that can be encountered during design and construction. I also introduced software simulation, an approach that is not commonly used yet has many benefits in terms of efficiency and avoiding errors.

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