DESIGN AND CONSTRUCTION OF A TRANCEIVER CIRCUIT

BY

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DEDICATION

I owe my very existent to God Almighty who even before my conception right through elivery to this historic moment of my project work defense has shown that he is my El-lohim. he project work is therefore dedicated to God. my parents and siblings he used as instruments f blessings to me.

ATTESTATION

I sincerely declare that this project work was wholly carried out by me under the guidance and supervision of Engr. (Dr.) Y. A. Adediran, H.O.D, Electrical/Computer Engineering Department, Federal University of Technology, Minna.

05-11-08

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(Student`s Name)

CERTIFICATION

This is to certify that this project work "Design and Construction of a transceiver circuit" was carried out by Agada Owoicho Emmanuel under the supervision of Engr. (Dr.) Y.A. Adediran (H.O.D Elect/Comp. Engineering Dept) and submitted to Electrical and Computer Engineering Department, Federal University Of Technology, Minna, in partial fulfillment of the requirement for the award of Bachelor of Engineering (B.Eng) Degree in Electrical and Computer Engineering.

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(Project Supervisor)

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(H.O.D Electrical/Computer Engineering)

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External supervisor Date

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I express my unending praise and thanks to God Almighty, my fortress. As i undertook this project work, the realities of the practical application of theoretical principles were greatly achieved. Thanks to God who made it possible and endowed me with this wonderful opportunity and fulfilling experience.

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ABSTRACT

The use of private mobile communication network integrating new technology is the basis for the design of this project work, borne out of the desire to achieve flawless service where GSM service providers suffer loss of signals as a result of insufficient base stations, inefficient service delivery and epileptic power supply. Transceiver circuits enhance secure and effective connectivity between people across vast distances, even under harsh weather conditions. The need for a reliable communication services is an especially critical requirement, hence the need to provide a non-network based communication tool.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction

Communication is the process of sharing ideas, information, and messages with others in a particular time and place. Communication could be done via writing and talking. In every society, humans have therefore developed spoken and written language as a means of sharing information. The most common form of daily communication is interpersonal i.e. face-to-face. This is done at the same time and in the same place. From the earliest times, people have needed to communicate across distances or over time.

A communication media is therefore a means for recording and trausporting a message or information. The word medium comes from the Latin word "*medius*", meaning middle or between. It is a channel or path for sending a message between communicators. A single channel such as a transceiver as designed and employed in this project work is called a medium. Media comes in when we have a dual set. A transceiver is a combination of Transmitter/Receiver in a single package. The term applies to wireless communications devices such as cellular telephones, cordless telephones sets, hand held two-way radios, and mobile two-way radios, occasionally the term is used in reference to transmitters/receivers devices in cable or optical fiber systems. In a radio transceiver, the receiver is silenced while transmitting. An electronics switch allows the transmitter and receiver to be connected to the same antenna and prevents the transmitter output from damaging the receiver. With a transceiver of this kind, it is impossible to receive signals while transmitting. This mode is called half duplex, transmission and reception often, but not while transmitting. This mode is called half duplex, transmission and reception often, but not always, is done on the same frequency. Some transceivers are designed to allow reception of signals during transmission periods. This mode is known as full duplex, and requires that the transmitter and receiver operate on substantially different frequencies so that the transmitter signal does not interfere with the reception. Cellular cordless telephone set uses this mode, satellite communications also employs full duplex transceivers at the surface-based subscriber points.

Transmitters initially used amplitude modulation (AM) to superimpose audio signals onto radio waves [1]. The invention of frequency modulation (FM) mode of transmitters provided much more sensitive and clear transmission and reception. Tuners became more sensitive, and more broadcast signals were sent over the air at different frequencies. In the 1950s and 1960s, manufacturers began replacing the bulky and heat-generating vacuum tubes with transistors, resulting in smaller sizes of circuit.

The transceiver circuit employs the point-to-point form of communication as messages can only be sent from one sender to a single receiver [2]. The principle of telecommunication, which the transceiver circuit is based on, simply involves a transmitter which generates and emits radio waves. The transmitter electronically modulates or encodes sound via the microphone onto the radio waves by varying the frequencies (number) of the waves within an established range. A receiver tuned to a specific frequency will pick up the modulated signal added to the radio waves, detects (demodulates) the signal and it is converted back to sound by the speaker. Being a wireless telecommunication device, a transceiver circuit uses radio waves sent through the space from the transmitting to the receiving antenna. Hence a transceiver is commonly called a combined radio transmitter and receiver in a single portable unit.

1.2 Aims and objectives.

To facilitate effective communication in remote areas where GSM service providers are non-existent, the transceiver finds useful and important application. Electronic signals, (electromagnetic waves) typically travel along the medium. When the signal reaches its destination, the device on the receiving end converts the signal back into an understandable message.

Transceiver circuits enable immediate link and contact with emergency medical services, fire departments and security agencies within a very large community or agency. Further applications of the transceiver circuit include the oil and gas companies, and engineering laboratories and hospitals, where safety cannot be compromised with potentially catastrophic consequences [2].

Analogue signal broadcast and frequency-modulated circuit allows for efficiency and ease in communication providing a means for command-centered personnel at the field to communicate with response staff, lecturer-student communication and the passage of information across security networks in a school, office complex or large organization where it is extremely difficult to personally access each department .

1.3 Methodology

In the design of the transceiver circuit, simplicity of operation coupled with the use of limited number of components was instituted in the approach. The introduction of the push / pull button to switch between the transmitting and receiving circuit and an added advantage of sharing common circuits was achieved in the method of design, thereby yielding a compact circuit construction.

The transceiver circuit employs the point-to-point form of communication as messages can only be sent from one sender to a single receiver [3]. The principle of telecommunication which the transceiver circuit is based on simply involves a transmitter which generates and emits radio waves. The transmitter electronically modulates or encodes sound via the microphone onto the radio waves by varying the frequencies (number) of the waves within an established range [1]. A receiver tuned to a specific frequency will pick up the modulated signal added to the radio waves, detects (demodulates) the signal and it is converted back to sound by the speaker.

1.4 Sources of materials used

After considerable research adopted, textbooks, online materials, CD-ROMS were instrumental to the success of the project work coupled with experiences attained in the course of my industrial attachment program with a firm involved in the installation and maintenance of FM transmitters and studio equipments.

1.5 Constraints

One major constraint encountered in the construction of the transceiver circuit was the unavailability of precise component parts allowing for the use of similar components performing the same function. Because these components were minute and small in size, it was extremely difficult to attain efficiency in workability on the breadboard as so much cross over wires had to be used allowing for clumsiness and voltage drop.

CHAPTER TWO

LITERATURE REVIEW

2.1 Historical Background

Early forms of telecommunication included smoke signals and drums. Drums were used by natives in Africa, New Guinea and South America whereas smoke signals were used by natives in North America and China. Contrary to what one might think, these systems were often used to do more than merely announce the presence of a camp. In the middle ages, chains of beacons were commonly used on hilltops as a means of relaying a signal. Beacon chains suffered the drawback that they could only pass a single bit of information. One notable instance of their use was during the Spanish Armada, when a beacon chain relayed a signal from Plymouth to London. The Dutch government used the system in Java and Sumatra early in the 19th century, the birds being obtained from Baghdad. Reuter started in 1849 a pigeon service to fly stock prices between Aachen and Brussels, a service that operated for a year until the gap in the telegraph link was closed.

In 1832, James Lindsay gave a classroom demonstration of wireless telegraphy to his students. By 1854, he was able to demonstrate a transmission across a distance of two miles (3 km), using water as the transmission medium. In December 1901, Guglielmo Marconi established wireless communication between St. John's Newfoundland (Canada) and Poldhu, Cornwall (England), earning him the 1909 Nobel Prize in physics (which he shared with Karl Braun). However small-scale radio communication had already been demonstrated in 1893 by Nikola Tesla in a presentation to the National Electric Light Association. A lot of design over the years had overridden the issue of cost even though smaller components and solid state devices were widely used.

For instance, the TDA 7000/LM 386 models designed and constructed of recent is a monolithic integrated circuit consisting of two ICs. Numerous capacitors were incorporated in the circuits which are unavoidably spaced to prevent mutual capacitances giving rise to large circuit space occupied and huge cost of production. Common among previous works also consist of the NXP UHF 900-MHz transceiver SA58646 [5]. In that particular design, the volume in the earpiece amplifier is controlled via software or hardware in the baseband receiver section which could be disastrous in the event of just a single component malfunction in the control section. Apart from this, the device is housed in a plastic low-profile quad flat package (LQFP) with 64 leads, 3 modes of operation (active, receiver and inactive mode) and an AC power rectifier source which is not only tasking in terms of cost but also not usable where electricity supply is non-existent.

2.2 Theoretical background

The method of design incorporated in this project tends to minimize the number of transistors used and also provides compact-sized circuit and cost effectiveness. The circuit is also designed in such a way that the supply is a 9-volts battery, a type which is readily available. The switches form an electrical connection between the two users and the setting of these switches is determined electronically when it is held down, switching to the transmitting stage. Once the connection is made, the caller's voice is transformed to an electrical signal using a small microphone (Dynamic type) in the caller's handset. This electrical signal is then sent via the antenna to the user (recipient) at the other end where it is transformed back into sound by a small speaker (Moving coil type) in that person's handset. The fixed-line telephones in most residential homes are analogue; the speaker's voice directly determines the signal's voltage.

In addition, the design of transceiver circuits involves a unicast method of transmission. The high-frequency wave sent by the transmitter is modulated with a signal containing the audio information. The antenna of the receiver is then tuned so as to pick up the high-frequency wave and a demodulator is used to retrieve the signal containing the audio information. The unicast signal is an analogue signal which varies continuously with respect to the information.

2.2.1 System overview

The previous chapter established what common communication system is and what makes up the system. The functions required of an analog communication system are explored in this chapter. Different component blocks perform various functions, thereby making up the transceiver device. The information signal is modified in various ways by the different blocks of the transmitter and receiver. This chapter analyses the sub processes which combine to give the overall device function.

This chapter also analyses the operational principle of the different stages of the transceiver circuit. Most stages however are common to each part of the transceiver (Tx-Rx) circuit. A breakdown of the various stages are elaborated below

2.2.2 Transmitter Circuit

A transmitter is a unit that converts the information to be transferred from baseband form into a form that can be transferred over the transmission link. This can be as simple as the microphone of a public address system, or a more complete unit as a telephone. Transducers are devices that convert the information into electrical signals to be processed by electronic circuits, or take the output electrical signals and convert them into non-electrical energy in a useful form. A microphone is the transducer for the transmitter. In almost every analog system, there is a need for amplification, to increase the voltage signal amplitude, the amount of current supplied to a load or the signal power level. These changes in level are called gain.

The modulator performs the function of modulation, which is the modification of a carrier signal with the information that is to be transmitted. The carrier is a single frequency signal, and the information is the baseband signal with its band of frequencies. To allow for proper modulation, the carrier is generally much higher than the baseband signal. There are three basic types of analogue modulation techniques which are as follows:

Amplitude modulation (AM) – in which variations in the amplitude of the modulating signal cause the carrier signal amplitude to vary accordingly.

Frequency modulation (FM) – in which the carrier frequency is varied according to the variations in the frequency of the modulating signal.

Phase modulation (PM) – where the phase of the carrier is varied according to amplitude variations in the modulating signal.

The method adopted in this project work is the frequency modulation technique. Analog circuit amplifiers in which either the voltage or current level must be increased, but no large power gain is required, are called small-signal amplifiers. This is because signal levels are typically of the order of micro-volts or milli-volt and current levels are in microamperes to mill amperes. Semiconductors devices, both bipolar and field-effect transistors, handle the power dissipation with or without cooling, unlike large-signal devices which may require cooling systems. However, to enhance efficiency, simplicity and uniformity in design, only bipolar transistors were used.

The power amplifier and driver are usually class C tuned amplifiers. Class C amplifiers are amplifiers that are biased below cut-off point. Biasing refers to the setting of the no-signal operation point around where small AC signals vary. The transistor does not conduct, until the input signal drives it above cut-off point. The class C amplifiers are not a linear amplifier; they are usually designed to operate at high frequencies and over a small band of frequencies. Class A amplifiers are not able to amplify the amplitude changes of the input waveform and it is therefore not good as a linear amplifier. They typically have high power gains and efficiency.

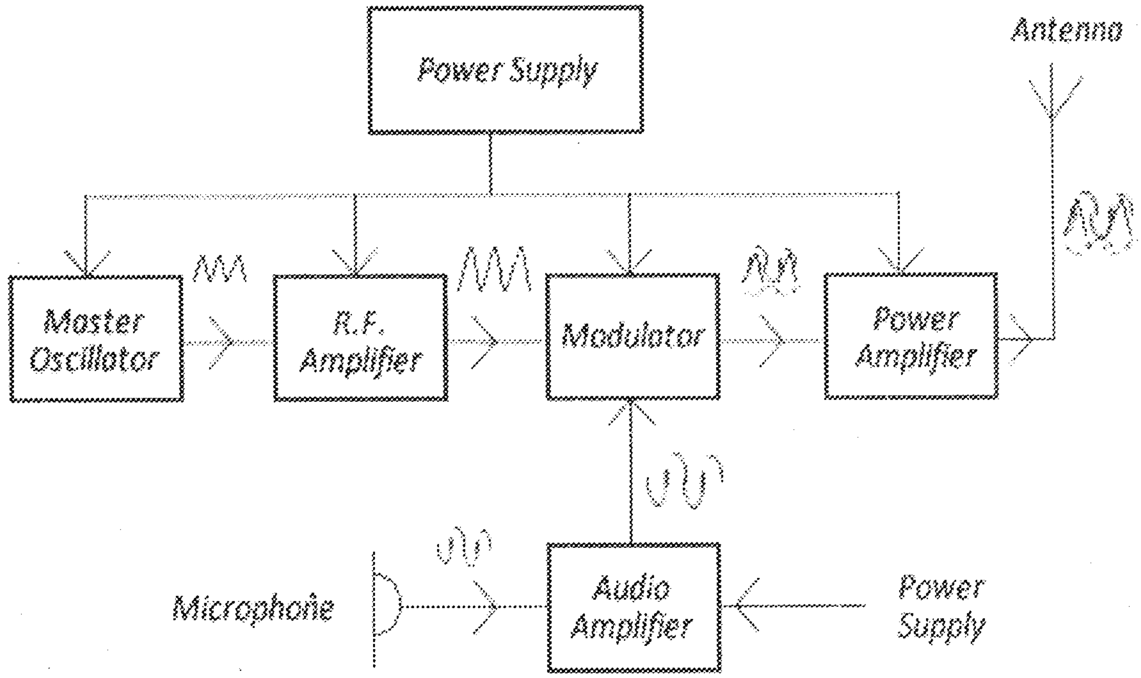

Fig 2.1 Block diagram of the transmitter.

2.2.3 Receiver overview

A receiver intercepts the transmitted signal and restores it (in most cases) to a form similar to, or exactly the same as, the original through the process of encoding. It can be as simple as a telephone earpiece, or as complex as a TV set. It may be built with one or a combination of sub- functions to provide the overall receiver function. The overall system is usually a combination of different blocks as shown in the figure 2.2 below:

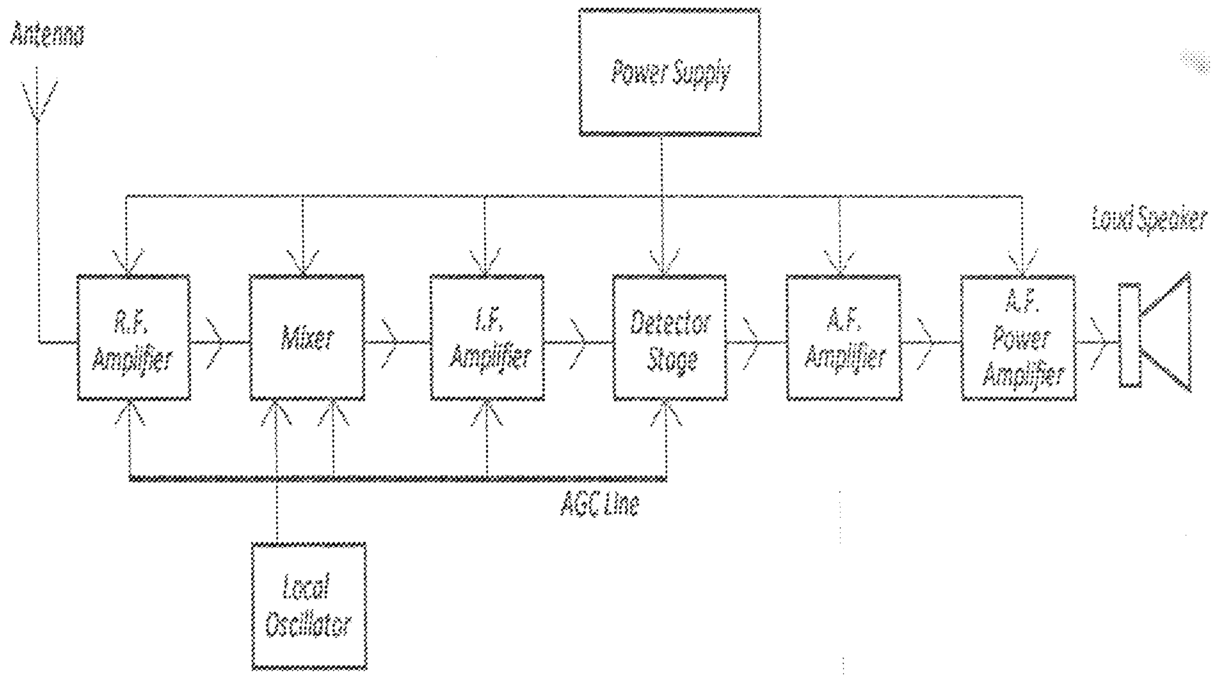

Fig 2.2 Block diagram of the receiver.

The transducer in the receiver circuit is a loudspeaker which converts the electrical signals into sound. An intermediate frequency (IF) amplifier is included at the output of the mixer, before the detector stage.

2.2.4 Microphone/Speaker (Input/output transducer)

The microphone is the input transducer in the transmitter device while the speaker serves as the output transducer in the receiver circuit. The dynamic microphone works like a speaker in reverse. Sound waves amplified at the input moves a diaphragm attached to a moving coil with a magnet along its center. A voltage is induced in the coil according to the intensity of the sound pattern.

2.2.5 Operational principle of the Dynamic/moving coil speaker.

The basic operation is based on fundamental electrical principle that a voltage is induced in a wire or coil which moves across a magnetic field. Better quality of production is attained with this speaker type, hence its preference in the circuit. This type of speaker requires no external voltage; it is light in weight, practically free from the effect of mechanical vibrations and highly sensitive yielding a uniform output.

However in selecting microphones for use in the design of this circuit, certain considerations were analyzed;

(i) **Frequency response**: produces a high frequency response yielding a uniform output.

(ii) **Directional properties**: This microphone is highly directional and picks up sound from only one direction and insensitive to other sounds. This factor is very important in design.

(iii)**Impedance**: Low impedance microphone require step-up microphone transformer to match their output to the high impedance input of an audio amplifier to yield high impedance and give a reduced noise output.

2.3 R.F Amplifier/Oscillator circuit

The RF amplifier should be low-noise design, because it amplifies all of the low-level signals (including noise) from the antenna with significant amount of gain. As a result, the RF amplifier has a great effect on the noise performance of the receiver. The better its low-noise design, the better the mixer circuit must be in terms of noise. Also called a pre-selector, most RF amplifiers have frequency selection properties that are tuned to amplify one frequency or a narrow band of frequencies reflecting all other frequencies.

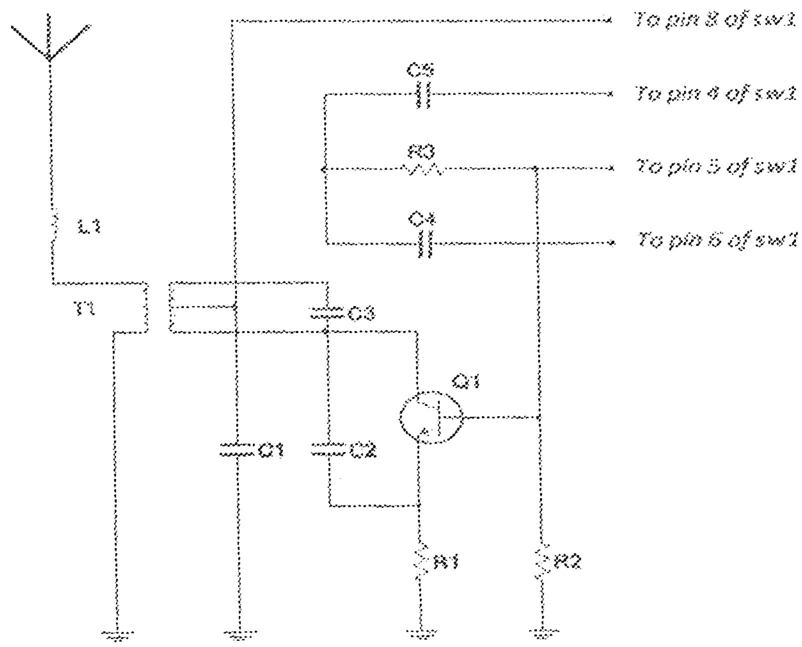

Figure 2.3 Circuit diagram of the oscillator stage.

From the oscillator circuit, the transistor Q1 serves the purpose of generating the carrier signal in the transmitter circuit. It is a C9014 bipolar transistor. Its collector is directly coupled to the secondary of the R.F type transformer T1. The primary of T1 is attached directly to inductor L1 which provides resonance and the needed frequency output to the antenna. Resistor R3 provides the stabilized audio output to be fed and coupled to transformer T1. Capacitors C2 and C3 are ceramic capacitors which aids in the filtering of unwanted R.F interference generated in the circuit.

2.4 Mixer circuit

The mixer performs the function of mixing, as implied by its name. Mixing allows signals to be translated to lower or higher frequencies where they can be processed in different ways. The signals may be translated either up or down in frequency, but only one of the translated signals will be used. Heterodyning is a radio receiver technique using mixer circuit in conjunction with tunable oscillators to select individual frequencies, translating them to a single intermediate frequency (IF) for further signal processing.

Diodes and both bipolar and field effect transistors may be used. The LC tuned circuit passes only a narrow band of frequencies, so that only the difference or sum frequency is selected. The signal translation does not affect the information. The variations of the inductances and capacitances with frequency can give rise to a condition known as resonance. Resonance describes the point where inductive reactance equals capacitive reactance. The frequency at which resonance occurs is known as the resonant frequency.

This circuit is a special kind of circuit called a tuned circuit. The advantage of tuned circuit lies in their frequency selection capabilities and the fact that they can be designed to operate in any frequency range. The quality factor of a tuned circuit is a value relating the reactance at resonance to the resistance. Referring to figure 2.4, the purpose of the mixer is to provide I.F output to be fed to the detector stage. Two signals are heterodyned (mixed) at this stage via transistor Q2, The input from the antenna (local oscillator signal) and that from the transistor Q1. The resultant output signal is the intermediate signal I.F which goes through capacitor C7 to the base of transistor Q2.

2.5 Detector stage

Detection is the reverse process of modulation. It is the recovery at the receiver, of the original information that was modulated onto the carrier at the transmitter. The information is usually a low-frequency signal modulated onto the higher frequency carrier. Detection can also be referred as the recovery of the baseband signal by translating the sidebands centered on the carrier frequency back to the original baseband frequency position in the spectrum.

FM detection is more complex than that of AM but more efficient in broadcasting. Since the information contained in the carrier's frequency changes, it is the frequency deviation of the carrier that must be detected to recover the baseband signal. As information is processed at different stages, unwanted signals are added to the original information signal by the electronic circuits in the equipment, by the power sources and by environmental conditions of the transmission link. These unwanted signals present with the original signal are called noise. Noise must be maintained at low level compared to the received signal level, so that the original signal can be transferred accurately, hence the need for the detector circuit. The figure 2.4 shows the circuit diagram of the detector stage.

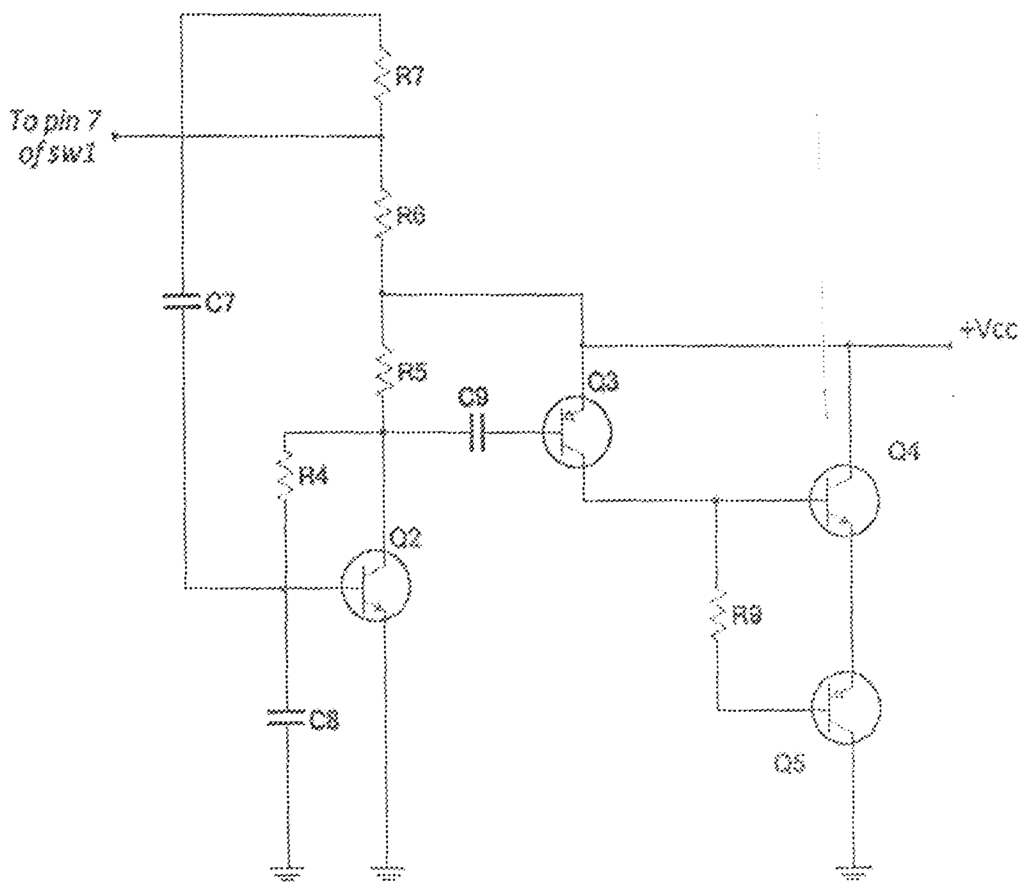

Figure 2.4 Circuit diagram of the Detector stage.

The basic function of the detector is to filter out unwanted interferences which could cause unclear audio output at the receiving end of the transceiver circuit since the quality of sound output cannot be compromised. The transistor Q3 is directly coupled to transistors Q4 and Q5 which are arranged in the Darlington pair mode to enhance current gain of the circuit. Resistors R5, R6, R7; and R9 provide fixed biasing, maintaining the voltage level thereby keeping oscillator voltages constant. The purpose of the capacitors C7, C8; and C9 which are of ceramic-types are specifically to aid in the filtering of unwanted R.F interference from the final audio frequency stage. Amplification of the audio signal is finally attained and fed to the speaker for sound and audio output.

CHAPTER THREE

DESIGN AND CONSTRUCTION.

3.1 FM Circuit and Modulation unit Analysis

By the definition of FM,

$\omega(t) = \omega_c + k_f v_m(t)$ ....(1)

where k_f = frequency sensitivity of the modulation circuit and measured in radian per volt second, $v_m(t)$ is a voltage signal, and $\omega(t)$ and ω_c are the instantaneous frequency and the unmodulated carrier frequency respectively. By integrating the equation with respect to time, we get the instantaneous phase angle, thus,

$\theta(t) = \int\omega(t)dt = \omega_c t + k_f \int v_m(t)dt$ ....(2)

Therefore, the frequency modulated (FM) wave is given by the expression

$V_{FM}(t) = V_c \text{Cos}\theta = V_c \cos(\omega_c t + kf \int v_m(t)dt)$ ....(3)

Consider a single time frequency modulated signal with modulating signal expressed as

$v_m(t) = v_m \cos\omega_m t$ ....(4)

Substituting equation (4) into equation (1) to get the instantaneous frequency of the FM signal.

i.e. $\omega(t) = \omega_c + k_f v_m(t)$

$= \omega c + kf(v_m \cos\omega_m t)$

$= \omega c + \Delta\omega.\cos\omega_m t$ .... (5)

Where $\Delta\omega = k_f v_m$

That is, the instantaneous frequency is

$2\pi F(t) = 2\pi(F_c + \Delta F.\cos\omega_m t)$

$F(t) = F_c + \Delta F.\cos\omega_m t$ ....(6)

Where $\Delta F = \frac{\Delta\omega}{2\pi} = \frac{k_f V_m}{2\pi}$ ....(7)

ΔF is known as the frequency deviation which is defined as the maximum departure of the instantaneous frequency of the FM wave from the carrier frequency F_c. ΔF, as could be observed from equation (7) is proportional to the peak amplitude of modulating wave, but is independent of the modulating frequency[5].

If the frequency deviation of the carrier is known and the frequency of modulating voltage (FM) is known, we now establish the modulating index (β): (deviation ratio).

$\beta = \frac{\Delta F}{F_m}$ ....(8)

Some notable important characteristic of the modulating index (β) are

- Modulation index (β) is independent of the amplitude and frequency of the carrier signal.
- The greater the frequency deviation (ΔF), the greater the β.

The above expressions are so relevant to note because of the bandwidth limitation placed in wide-band FM transmitting station by the regulating agencies throughout the world. For this project, the carrier frequency is made adjustable under the receiving band range of 88-108MHz. however, it is preset to be 87.5MHz.

Modulation unit analysis and calculations.

The term modulation is generally defined as the process by which the parameter (e.g. amplitude, frequency, or phase) of a high frequency signal {known as the carrier} is modified in accordance with the instantaneous value of the message signal {or modulation signal}. Modulation unit is, therefore, a unit where the audio signal is combined with a carrier frequency to produce the frequency modulation. At this stage the audio signal is used to vary or shift the frequency of a carrier. The frequency of the carrier is determined by the value of the capacitance and inductance.

This purpose is achieved with an oscillator circuit which encompasses the modulation circuit and the carrier circuit that work together to generate the required modulation signal for transmission. The carrier frequency for this design is meant to be 87.5MHz, the value of the capacitance and the inductance were carefully evaluated to achieve a 87.5MHz carrier frequency. At the FM modulation and amplification stage, referring to figure 2.3, resistor R1 set the base emitter bias, R2 set the collector emitter bias. C2 and L1 combined to form an oscillator to provide the carrier frequency needed for modulation. The resulting signal is then passed through a series of frequency multipliers that produce the required operating frequency. The final RF power amplifiers boost the power to a level high enough for radiation and subsequent propagation by the antenna.

From figure 2.3, the inductor used in the circuit is 12 turns, therefore to evaluate its value, we use the formular below:

$L = \frac{N^2 \mu_r \mu_o A}{l}$ ……………………………………………………………………………(9)

where L = inductance

N = Number of turns = 12

μ_r = Relative permeability of soft iron = 70

μ_o = Permeability of free space = $4\pi \times 10^{-7} Hm^{-1}$

A = Cross sectional area = πr^2 (taking=3.14, radius, r=0.25cm) = 3.14 × $(0.25E\text{-}2)^2$ = 1.96E-5m^2

l = span length = 0.5cm × 12 = (0.5E-2) × 12 = 0.06m.

Substituting the values into equation (9) above, L = 4.13×10^{-6}H

Also, amplification factor of the transistor C9014 = 100 and

Input current I_i = 0.25mA

Output current I_o =?

$I_o = I_i \times hfe$

$= 0.25 \times 10^{-3} \times 100 = 25mA$

Deviation ratio (modulating index) = $(\beta) = \frac{\Delta F}{F_m}$

Where ΔF = carrier frequency deviation = 75 kHz

F_m = Modulating frequency = 15 kHz

$\beta = \frac{75}{15} = 5$ i.e. the maximum allowed index in commercially broadcast FM

The carrier power P_c is given as follows:

$P_c = \frac{V_c^2 \, [r.m.s]}{R}$

where V_c = carrier voltage = 9v

R = carrier resistance = 10ohms

$P_c = \frac{[^9/_{\sqrt{2}}]^2}{R} = \frac{9^2}{2 \times 10} = \frac{81}{20} = 4.05W$

Signal power P_s = VI

where V = signal current = 25mA

$P_s = 9 \times 25mA = 0.225W$

Modulation power (P_m) is the summation of the carrier power and signal power which is given as:

$P_m = P_c + P_s$ where $P_c = 4.05W$

$P_s = 0.225W$

$P_m = 4.05 + 0.225$

$= 4.275W$

3.2 DC Analysis and calculations of Bipolar Junction Transistor (BJT)

Most of the transistors used in this design are in common emitter configuration. Hence, emphasis shall be given to its DC analysis. The BJT has three modes (or regions) of operation; cut-off, active (or normal) and saturation modes. In the cut-off region both junctions are reversed biased. The transistor is off because the base current is not large enough to turn it on. In the active mode the transistor acts as an amplifier and a linear relationship exist between collector and base currents. The CBJ is reversed biased while the BEJ forward biased. In the saturation modes, both CBJ and BEJ are forward biased. The base current is relatively high and collector emitter voltage drop (V_{CE}) is low.

From the common-emitter configuration, we have

$R_B = \frac{R_1 R_2}{R_1 + R_2}$ ....(i)

By voltage divider theorem

$V_B = \frac{R_2}{R_1 + R_2} \times V_{CC}$ ....(ii)

From fig (b), applying KVL

$V_B = I_B R_B + V_{BE}$ ....(iii)

But $I_E = I_B + I_C$ ....(iv)

Also $I_C = \beta I_B$..(v)

$I_E = I_B(1 + \beta)$ ....(vi)

From equation (iii)

$I_B = \frac{V_B - V_{BE}}{R_B}$ ....(vii)

Similarly,

$V_{CC} = I_C R_C + V_{CE} + I_E R_E$ ....(viii)

Therefore;

$V_{CE} = V_{CC} - I_C R_C = V_{CC} - \beta I_B R_C$ ....(xi)

Also

$V_{CE} = V_{CB} + V_{BE}$ ....(x)

V_{CC} = Common collector voltage

I_C = Collector current

R_C = Collector resistor

R_1 and R_2 = Load resistors

R_E = Emitter resistor

I_E = Emitter current

V_B = Base voltage

R_B = Base resistor

V_{BE} = Base emitter voltage

V_{CE} = Collector emitter voltage

DATA

$V_{CC} = 9v$

$R_2 = 5.6k\Omega$

$R_3 = 1k\Omega$

Substituting the above data into the formulars earlier derived, we obtain:

$$R_B = \frac{R_1 R_2}{R_1 + R_2} = \frac{5.6 \times 1}{5.6 + 1} = 0.85k\Omega$$

$$V_B = \frac{R_2}{R_1 + R_2} \times V_{CC} = \frac{5.6}{6.6} \times 9 = 7.64V$$

$$I_B = \frac{V_B - V_{BE}}{R_B} = \frac{7.64 - 0.6}{0.85 \times 10^3} = 8.28mA$$

$$\frac{I_C}{I_B} = 100$$

$$I_C = 100 \times I_B = 100 \times 8.28 \times 10^{-3} = 0.828A$$

$$I_E = 0.00828(1+100) = 0.8363A$$

3.3 Power supply stage specifications.

A 9v DC, 0.5w battery is used to power the circuit. Power supplies are designed to supply constant voltage or voltages, with the capability to provide current at prescribed levels to all circuits in the system. The power supply voltage output is maintained within the system design and incorporated in the transceiver case to make it compact, avoiding clumsiness. This approach also eliminates cumbersome and loose arrangement of the entire circuit as the aim of the design is to achieve a more efficient, cost-effective; and compact size circuit limits, even though the parameter requirements of components may change. Other means of providing power to a system include;

1. Direct use of supplied power
2. IC voltage regulation
3. Voltage divider
4. Zener diode regulation

Generally stiffness, tolerances in the power supply for an analog system results in fewer circuit problems. In general, this analog circuit operates from the portable equipment 9v batteries for power supply which are readily available. They do not require regulation and dependence on the public power supply for its operation. The signals passing through the device must be coupled from stage to stage, and there are four (4) different types of coupling used in electronic circuit.

1. Dc coupling - refers to the direct feeding of the DC voltage between stages. The end of one stage is coupled directly to the input of the next.
2. AC coupling - uses a capacitor or an inductor between stages. Signals at different frequency levels will not be coupled together through the capacitor or inductor.
3. Transformer coupling - depends on the coupling of a changing magnetic flux between the primary and secondary winding of the transformer. Time changing or AC signal are required to produce the changing flux.
4. Optical coupling - uses light waves, the variations in the light output of an LED (light emitting diode) are picked up by a phototransistor.

3.4 Antenna Specification.

Antennas have various characteristics that contribute to the overall strength of the radiated signal. The primary characteristics that may be used to define an antenna are listed below:

1. Selectivity
2. Sensitivity
3. Radiation pattern
4. Gain and directivity

A telescopic antenna is collapsible. It is a series of small diameter tubes of 6 to 8 inches in length nested, one inside the other. This antenna is 12cm long when closed and 50cm long when opened. The antenna can be extended to its full length or retracted to a small length for storage of portability, hence its preference and adoption in this project design.

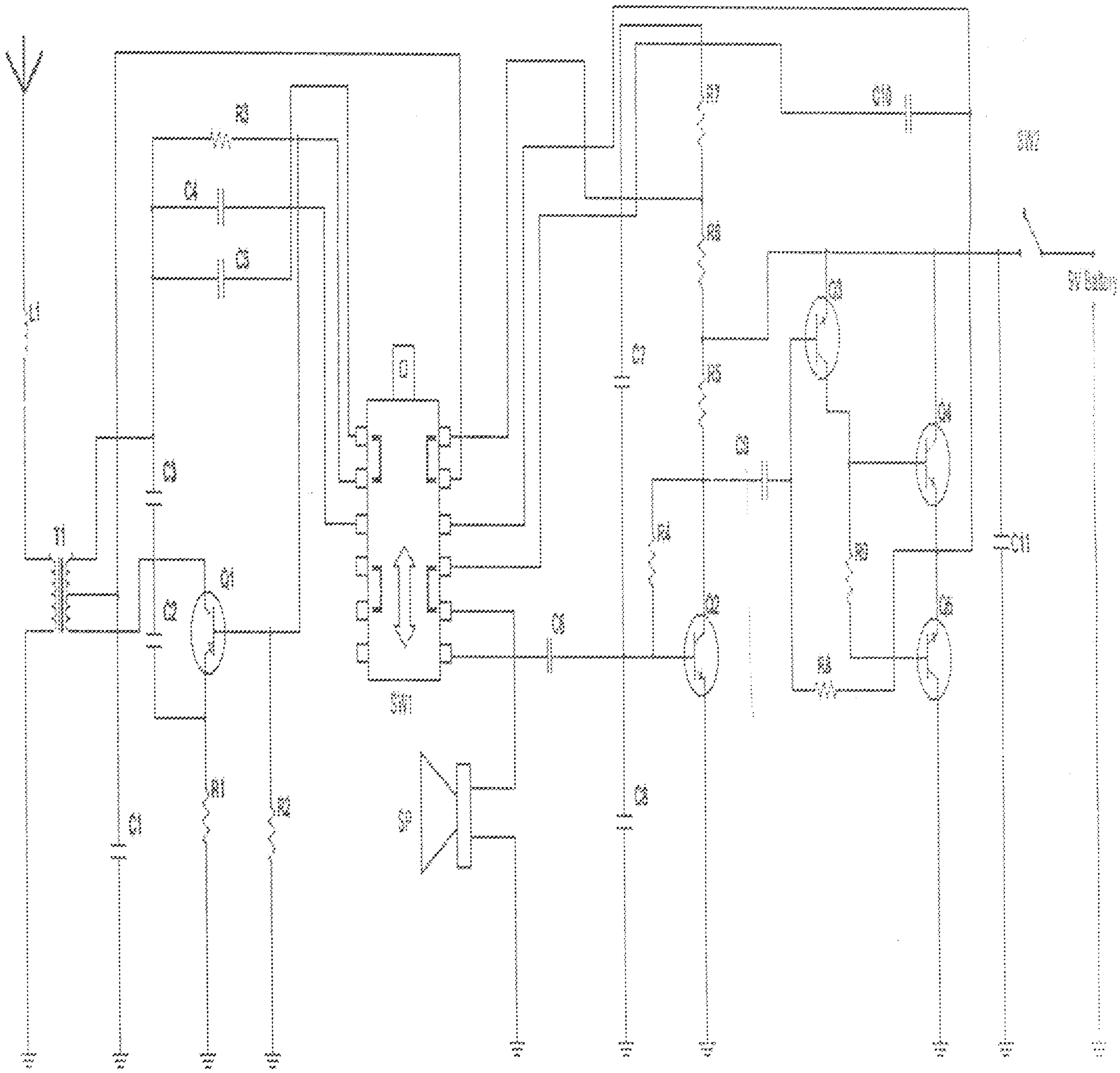

Fig. 3.1 Circuit Diagram of the Transceiver Circuit

Component	Value
$Q_1 - Q_5$	C9014
L_1	12T
T_1	RF Transformer
SW_1	Push Pull Switch
SW_2	Power Switch
SP	16Ω Dynamic Type
R_1	10kΩ
R_2	5.6kΩ
R_3	1kΩ
R_4	5.6 kΩ
R_5	10 kΩ
R_6	5.6 kΩ
R_7	18 kΩ
R_8	330 kΩ
R_9	220Ω
C_1	502pF
C_2	35pF
C_3	47pF
C_4	15pF
C_5	502pF
$C_6 - C_7$	104Pf
C_8	47pF
$C_{10} - C_{11}$	100µF / 10V

Table 3.1 Components and Value Table

CHAPTER FOUR

TESTS, RESULTS AND DISCUSSION.

4.1 Circuit construction and testing.

The design of the various circuits comprising the transceiver device was built on the breadboard, transferred to a vero board and tested using the specified components to ensure the fully functioning state of the design. When the system's working condition was certified, the components were then permanently fixed by soldering on a mica board for optimum efficiency and conveniance.

Breadboards are prototype boards, which are modules containing well arranged pin-sockets for fixing-in components, as it serves as a temporary construction board. For this project, all the components used in the work were laid out on the vero board according to specification of the project design. The complete transceiver circuit design consist of five main stages, the pre-amplifier stage, the modulation stage, the oscillator stage, the R.F amplifier stage and detector stage. These stages perform the various functions to achieve the desired goal of this project

The design was carried out in stages, one unit after the other using a breadboard. The first stage, which is the pre-amplification stage, consists of carbon microphone for transducing voice or sound into electric signals. Capacitors were also used to filter and block any DC signal at the output of this stage from upsetting the next bias. At this stage, resistors were also used to establish the required bias voltage and current levels for the other components in action. The second stage which is the modulation unit consists of a transistor, capacitor, resistor; and an inductor. The transistor here amplifiers the audio signals to an ideal level for modulation, the second stage which is the modulation unit consists of a transistor, capacitor, resistor, and an inductor. The transistor here amplifiers the audio signals to an ideal level for modulation, the resistor established bias at various terminals for the transistor operation. The third stage which is the oscillator stage consists of an inductor, capacitor, resistors and a transistor. The capacitor and inductor combine in parallel to produce an oscillator which produces the carrier frequency to be modulated. The transistor amplifies the carrier frequency and also acts as a feedback for the oscillator in order to stabilize the frequency of oscillation. The resistor here, also establish the required bias for the transistor terminal. The fourth stage which is the R.F amplifier stage, consist of a class C amplifier, resistor and capacitor. The class C amplifier which is ideal for RF amplification is used to amplify the RF signal, to an ideal level for broadcasting. The resistors here also establish the necessary bias for the terminals of the class C transistors. The capacitor also filters the signal output and blocks all the DC components of the signal from affecting the next bias.

After these stages were assembled in different breadboards and tested accordingly, they were later connected together sequentially, for final testing before assembling and soldering on veroboard. The result of the test was satisfactory after minor adjustment in the circuit design.

4.1.1 Oscillator circuit test

To ensure high reliability of any system or device, design of the system prototype and testing to reveal system behaviors and weakness is highly inevitable. It is the result obtained that would be worked upon to reduce the system failure rate and increase its performance by readdressing the necessary steps in the processes that produced the distortion, then the reliability of such system would be assured.

The oscillation stage consists of an inductor, capacitor, resistors and a transistor. The capacitor and inductor combine in parallel form to produce an oscillator which produces the carrier frequency to be modulated as was earlier stated. After the construction of the dual sets, the R.F trimmer transformer at the oscillator stage was used to finally synchronize the frequencies to ensure uniformity in operating frequency.

Project test was carried out to determine its behaviors after which the steps were traced back to give the target objectives of the project. An oscillator is simply an amplifier whose positive feedback is greater than the negative feedback, resulting in a signal which is amplified over and over again (by the same amplifier) until the output can increase no further. This generally results in a square wave if the frequency of oscillation is low enough relative to the amplifier's bandwidth. There are several things that must be done in order to create a usable audio oscillator:

I. The frequency must be defined with a suitable filter, so the output will be at a known frequency

II. The frequency response of the amplifier should be considerably greater than the highest frequency to be generated to ensure amplitude stability at all frequencies

III. Output impedance must be low enough to ensure that there is no significant loading from the input circuitry of any expected load

4.1.2 Speaker/microphone test

The dynamic-moving coil microphone was adopted in the construction of this project work since it also operates as a speaker in reverse. During the operation of the circuit, the push-pull switch handles the task of switching the functionality to a microphone during transmission and subsequently a speaker during reception. One of the terminals of the speaker is connected to pin 11 of the push-pull switch while the second terminal is connected to the audio amplifier to boost its output. Hence, the transmitter circuit could be extracted with the microphone attached as the input transducer.

A speaker is connected to the transmitter output as the output transducer to ascertain the operation and workability of the circuit when both the transmitter and receiver stages are combined via the push-pull switch. It is important to observe the quality of audio output when testing, as well as the clarity of the voice signals. In the event of poor audio quality, the oscillator R.F trimmer transformers are further tuned to obtain the best audio output in the overall circuit.

4.2 Results

After the testing was done, the following point were noticed and deduced:

It was noticed that, as the inductor of the oscillator stage was varied, the carrier frequency also changed. This particular property is very useful, in the sense that the transmitting frequency can be changed in case the transmitting frequency interferes with other broadcasting station's transmitting frequency.

The transmitting range of this system occupies about 200meters. The distance of transmission depends on the transmitting power and the type and height of the antenna. High quality antenna like the Yagi-Uda antenna is mostly preferred when transmitting at a greater radius.

4.3 Trouble-shooting techniques employed

The following trouble checks will help to locate minor or major faults occurring in the transceiver circuit;

1. When the system is on but does not provide power to the circuit, the supply unit must be checked.
2. When the system is on but there is no audio output, the speaker terminals should be checked. The fault may be a disconnection of the speaker terminals.
3. When a loud humming sound is heard from the receiver unit, the dual sets might be too close to each other.
4. Once the circuit is powered, by default, it maintains the receiver stage. The transition from the receiver to transmitter stage is achieved by holding down the push-pull switch. Unsuccessful transmission can therefore be traced to this device.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Summary of work done

The transceiver circuit constructed has a total coverage area of 140m-200m on a frequency of 87.5MHz. This transceiver is mobile, portable and also easy to use. It has a fixed frequency; hence the need for tuning does not arise. In the course of construction, the use of jumpers must be minimized or ignored. This is because jumpers increase the inductance of the circuit, thereby causing distortion or an undesirable output. Taking note of these factors mentioned above made the transceiver's operation a reality.

5.1.1 Results obtained

It was deduced that transmitting at about 200 meters depends mostly on the transmitting power and type of antenna. If the required antenna is gotten, then, there is possibility of having a greater radius of transmitting not below 2 kilometers, which falls beyond the scope of this project. Reception is achieved at 87.5MHz of the FM band as tested.

5.1.2 Limitations

In the cause of the design and construction of the transceiver circuit, the best method of testing the transmitter was by using a vero board (most preferably a mica board) and not a bread board, using a breadboard resulted in clumsiness in the circuit as numerous crossover wires had to be introduced to compensate for components whose terminals were very small, considering the thickness of the breadboard.

Since this project was analogue-based, noise and distortion even though minimized, could not be totally eradicated. The process of synchronizing the frequencies also proved to be a tedious task as both sets had to be fine-tuned to the desired and exact frequency to provide for clarity in the course of transmission and reception.

5.2 Recommendations

The scope of this work leaves room for more improvement. The circuit could be enhanced further by adding another amplification stage; this will increase the distance or coverage area. Another method suggested for an increase in coverage area is by grounding the antenna point to a ground electrode, then using a stronger antenna.

The source of power supply used is 9v cell, this can be replaced with a 9v D.C power supply (hence the need for rectifier diodes and transformers will arise) which will have a constant and continuous supply and will eliminate the need for "cell" replacement from time to time. A more efficient alternative is the use of rechargeable batteries and the construction of a charging circuit to enhance efficiency and recharge of the battery once discharged.

A variable capacitor may be introduced in the RF stage. This will enable tuning of the transmitter so as to prevent interference, especially in areas with occupied frequencies, such as in radio stations. A microphone jack may also be introduced so that a microphone can be attached and removed at will.

5.3 Conclusion

The design and construction of the transceiver circuit was effectively realized with minimal distortion. Having spent considerable amount of time to ensure efficiency in the operation of the circuit, the application of practical skills blended with theoretical knowledge attained in the course of my studies proved to be of immense advantage. The use of cost-effective components, simplicity in construction, its adaptive use in harsh weather conditions and rural areas is also of tremendous advantage.

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APPENDIX

Tx - Transmitter

Rx - Receiver

GSM - Global system of mobile telecommunications

CD-ROM - Compact disk Read only memory

LQFP - Low-profile quad flat package

CBJ - Collector base junction

BEJ - Base emitter junction

LED - Light emitting diode

BJT - Bipolar junction transistor.

P_s - Signal power

P_c . Carrier power

O/P - Output

I/P - Input

R.F - Radio Frequency

A.F	-	Audio Frequency
I.F	-	Intermediate Frequency
A.G.C	-	Automatic Gain Control
A.F.C	-	Automatic Frequency Oscillator
D.C	-	Direct Current
A.C	-	Alternating Current
F.M	-	Frequency Modulation
A.M	-	Amplitude Modulation