ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

IMPLEMENTATION OF OPTICAL COMMUNICATION SYSTEM FOR VOICE TRANSMISSION

This thesis is Submitted as a Partial Fulfillment of the Requirement
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In Electronics and Communication Technology Management

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CERTIFICATE

The project design and implementation of an **Optical communication system for voice transmission** is by **Buraka, Muluken, Seid** and **Tamirat** has been carried out under my supervision and this work has not been submitted elsewhere for a degree. This project has been submitted for examination with my approval as a University advisor.

Advisor Name: **Dr. Pushparaghavan.A** Signature ________________ date: ____________

DECLARATION

We **Buraka Teferi**, **Muluken Alemu**, **Seid Kebede** & **Tamirat Ayele** hereby declare that this project entitled Optical communication system for voice transmission is entirely our own work and to our knowledge it has not been done or presented by other person. The result of our own work carried out under the supervision of **Dr.Pushparaghavan.A**

We verify (swear) that all the material used has been properly referenced.

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ABSTRACT

As voice communication is the most important activity among whomever living in the society. Different modes of communication are used for voice communication. From the beginning of technological advancement, many processes have been used for the voice communication purpose and among those; Laser Voice Transmission Process is much more useful because of wireless connectivity and free from disadvantage of radio frequency interference. This project includes analysis and system level development of voice transformation between transmitter and receiver. The light beam is transmitted through free space and it deals with the designing of a very low cost voice transmission system. The carrier used for the transmission signal is typically generated by a LASER source. Hardware of this voice transmission is performed by Laser communication system.

Keywords: LASER source, voice transmission, Phototransistor.

ACKNOWLEDGEMENT

In the name of greatest All mighty GOD who has always bless us with potential knowledge and success. It gives us great pleasure in presenting the project report of “Optical Communication System for Voice Transmission.

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ACRONYM

Abbreviation	Description
OWC	Optical Wireless Communication
RF	Radio Frequency
LASER	Light Amplification by Stimulated Emission of Radiation
IC	Integrated Circuit
VR	Variable Resistor
AF	Audio Frequency
LED	Light Emitting Diode
Hz	Hertz
KHz	Kilohertz
AC	Alternating Current
PCB	Printed Circuit Board
DC	Direct Current
OP	Operational Amplifier
AOL	Amplifier Open Loop Gain
V_{in}	Input Voltage
V_{Out}	Output Voltage
FET	Field Effect Transistor
E	Emission
P	power
IV	Input Voltage
SCR	Silicon Controlled Rectifier
TVR	Television Receivers
S/N	Signal to Noise Ratio
BER	Bit Error Rate
Tx	Transmitter
Rx	Receiver
R_{asp}	rate of spontaneous emission
μ_{in}	efficiency (Internal quantum)

Notation

No	Symbol	Definition
1.	nm	Nanometer
2.	mV	Millivolt
3.	τ	phase degree
4.	ln	natural logarithm
5.	Φ	phase angle
6.	e	exponential
7.	m	Meter
8.	mA	Milliampere
9.	dB	Decibel
10.	kΩ	Killohms (unit of resistance)
11.	uF	Microfarads (unit of capacitance)
12.	mW	Milliwatt (unit of power)

CHAPTER ONE

1. INTRODUCTION

1.1 Background

As LASER (Light Amplification by Stimulated Emission of Radiation) is stimulated radiation, problem of interference occurs in electromagnetic wave is eliminated, it can be a good substitution of present day voice communication systems.

It transmits high quality voice and the link is virtually impossible for anyone else to tap into. An important feature of transmission by laser beam is privacy. Because a laser beam is intentionally narrow, it's virtually impossible for someone to tap into the link without disturbing the link. If someone intercepts the beam, the link is broken, signaling the interception. Fiber-optic cables also have high security, as it's very difficult to splice into the cable without breaking the link. However it's theoretically possible; so for the highest security, we probably cannot beat a line-of-sight laser beam.

Also it cannot be detected with use of spectrum analyzers and RF meters and hence can be used for diverse applications including financial, medical and military. Laser can also transmit through glass; however the physical properties of the glass have to be considered. Laser transmitter and receiver units ensure easy, straightforward systems alignment and long-term stable, service free operation, especially in inaccessible environments, optical wireless systems offer ideal, economical alternative to expensive leased lines for buildings. LASER communication is both wide-band and high-speed.

1.2. Statement of the Problem

The present systems used in our country is mostly telephone or mobile phone for voice communication purpose which always require charging for any call whether neighboring or far away. To overcome this voice communication problem, and to reduce cost, laser communication for voice transmission can serve as additional alternatives, since it requires only initial cost and installation cost. So our motivation is to increase service and reduce cost.

1.3. Objectives

1.3.1. General Objective

The main aim of this project is to construct a Laser communication system by using low cost laser source.

1.3.2. Specific Objectives

- To implement light based voice transmission and reception system by using light from a laser source as the carrier of the signal.
- To provide a better voice transmission between one node (Tx) to another node (Rx).
- To simplify the circuit for optical transmission and reception.

1.4. Scope of the Project

The working scope of this project is to design and built one way voice communication systems by using Laser source. In this project work the simplex method includes the design and application of hardware of optical Laser transmitter and receiver (photo transistor) that can solve specific problems of communication systems on short distance communication.

Optical wireless communications (OWC) have attractive attention from many researchers worldwide for their potential advantages over radio links.
Also this project work has supporting more for domestic applications/ mobile phone /telephone consumers in our Ethiopia country in near future.

1.5. Significance of the Project

Laser communication is a wireless communication system which is economic, reliable and can replace costly optical fiber communication and radio signal. Vast data can be transmitted with less interference and crystal clarity with the help of Laser. Different kinds of Laser based transmission system has been implemented for different purposes by using various electronic equipments. It can also be used for inter building communication like in office or in a conference room. It is the cheapest design within the range of lower middle class society.

The design is so easy, inexpensive and makeable with the available equipments that the technical as well as non technical person can construct it by themselves for their personal use. This device can eliminate the expenditure by setting it over the roof top with only minimum construction cost**.** No communication license is required, no cables need to be burial, no complex network of switches and amplifiers are needed and also large information capacity transmitted.

1.6. Limitations of the Project

- The factors such as beam dispersion, background light, shadowing, rain, fog, snow, pollution, smog causes an attenuated received signal and lead to higher bit error rates.
- Limited up to the range of 100m.
- For longer distance communication high power Laser is required which is costly.

1.7. Project Outlines

This project is entitled as “optical communication system for voice transmission” and consists of the following chapters with detail description. Chapter one introduce the project. Chapter two gives a summary of literature review relating within the thesis scope. Chapter three describe the working principles of designed system while Chapter four deals with System design and analysis. Chapter five describes the design and simulation analysis. Chapter Six conclude the project and also recommend for the future work.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Literature Review of Related Project

Optical communications has not been started in modern era. All Modern day optical fiber communication is based on ancient system. The functioning Laser was first operated by Theodore H. Maiman [1] and first visible light laser diode was demonstrated by Nick Holonyak [2] and latter it was improved by several scientist of the world including USA at IBM, MIT Lincoln Laboratory [3]. Laser diode is suitable for using in optic communication as it is monochromatic (coherent) light source and easy modulates [4]. A project has been done to transmit voice data from one station to other for short distance by using different types of high quality and costly lasers such as Gas lasers, Chemical lasers, Excimer lasers, Fiber-hosted lasers, Photonic crystal lasers, Semiconductor lasers, Dye lasers, free electron laser etc. where one condenser microphone for capturing sender voice, one transistor BC548 as amplifier, a photo transistor as receiver and a LM386 basic power amplifier IC and 0.5w Speaker was used [5].

In other project, signal was transmitted by using laser torch through laser beam just like fiber optic communication. In this system, in transmitter a 9v condenser is used for taking the audio signal coupled with laser beam and in receiver an NPN photo transistor, common emitter amplifier and speaker is used [5]. Another project of laser torch based voice transmission system was constructed with Laser torch (up to wave length of 920nm), IC 741 as volume controller, BC 548, BD 139 as electrical signal amplifiers, Condenser (electrostatic microphone) in transmitter and IC 741, IC 386, with 2N5777 Photo Transistor and 0.5w/8Ω Speaker in receiver [5].

CHAPTER THREE

3. WORKING PRINCIPLES OF DESIGNED SYSTEM

3.1. Methodology

Systematic design approach is called design methodology which is necessary for successfully designing a complex hardware. This may be involving systematic approach of development. This project consists of six steps; problem analysis, circuit design, circuit simulation, circuit constructing, testing and implementing.

Figure 3.1 shows one of the possible block diagram treatment of the Optical Communication System for Voice Transmission. It is broken down into Input subsystem, Amplifier subsystem, Modulation sub system Transmitting subsystem Receiver subsystem Demodulation subsystem and output subsystem.

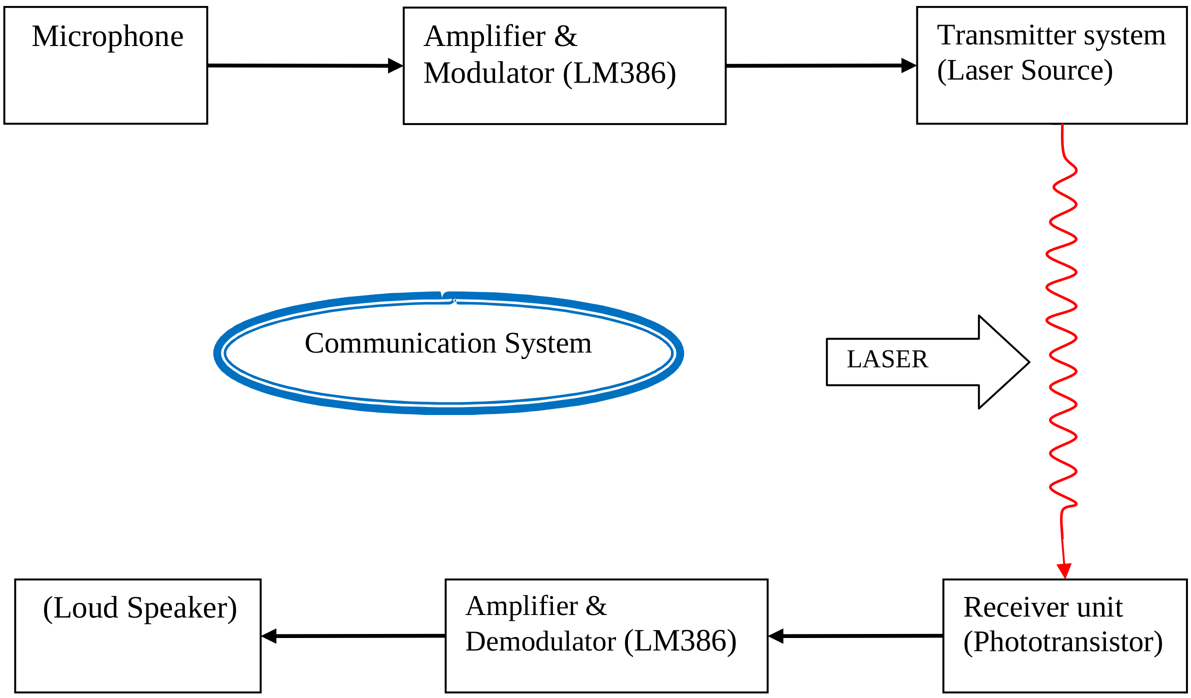


Figure 3.1: Block diagram of optical communication system

The Voice transmission through optical wireless communication link using a Laser is to create a new form of optical communication to society and marketed with small size and low cost.

The link consist a transmitter and a receiver both of which are battery powered and permanently fixed. The transmitter circuitry takes a data stream and then modulates the current through a LASER. The LASER sends photons with intensities proportional to input data bits across the Voice transmission through Optical wireless communication link to a phototransistor. The phototransistor is connected to the receiver which converts Optical power into an Output voltage.

3.2. Design and Working of the System

There were two sections, transmitter and receiver, both powered by a separate 9V fixed voltage power supply. The transmitter board contained a microphone and a laser torch at opposite ends. The electronics equipments controlled the intensity of the laser beam according to the output of the microphone. A photo transistor was in the receiver as a receiving element and the high gain amplifier with a basic audio output stage powers a small speaker.

Laser torch starts emitting light after its threshold current. The output light is proportional to the current through the torch. Amplitude modulation can lessen the distortion in laser beam output. A 650nm, 5mW laser torch used in this project can give its maximum output with a threshold current of 30mA. Further increasing the current can damaged the torch. The block diagram of working principle of the system is shown in Figure 3.2 below.

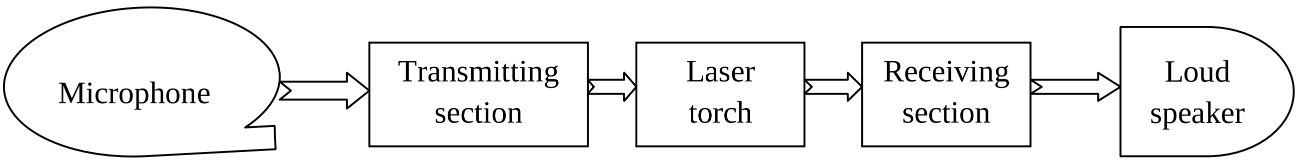


Figure 3.2: Working Principle of Voice Transmission System

3.3. Input and Output Voice Signal

We have observed a small difference between the input analog signal from microphone and the output analog signal from speaker is due to the thermal noise effect as shown in the figure 3.3. The input and output voice signal is addressed by this flow chart below.

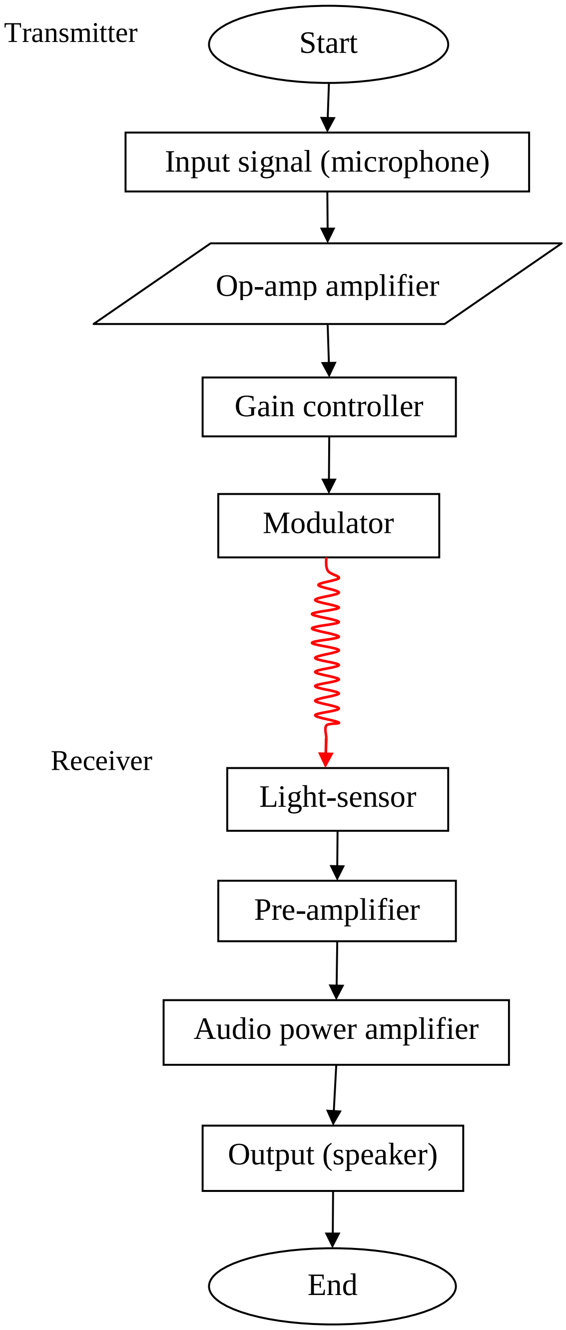


Figure 3.3: Flow chart of total working order of the system.

CHAPTER FOUR

4. SYSTEM DESIGN AND ANALYSIS

4.1. Transmitter Circuit Operation analysis

The microphone is the audio input. C1 is a coupling capacitor that connects the audio from the microphone to VR1. VR1 couples the audio to IC1 (LM386) which amplifies the input audio to some more. The audio from the IC is then routed to R2 which transports the power to the LASER Torch. This puts the audio onto the light beam. VR2 is a variable resistor which adjusts the gain of the IC1 LM386. C4 and R1 are power filters that remove noise from the power supply. The other resistors just supply the right voltage to the various parts.

The microphone was powered through C1 which was faded to both inverting and non inverting input of IC1 (LM386) through VR1. The overall system sensitivity and the intensity of the LASER beam depended upon the adjustment of VR3. The audio modulation voltage comes from the VR1 is driven by audio amplifier stage IC1 (LM386), was faded to the +ve polarity of the LASER torch and the laser current varied by around ±3mA beyond its set point.

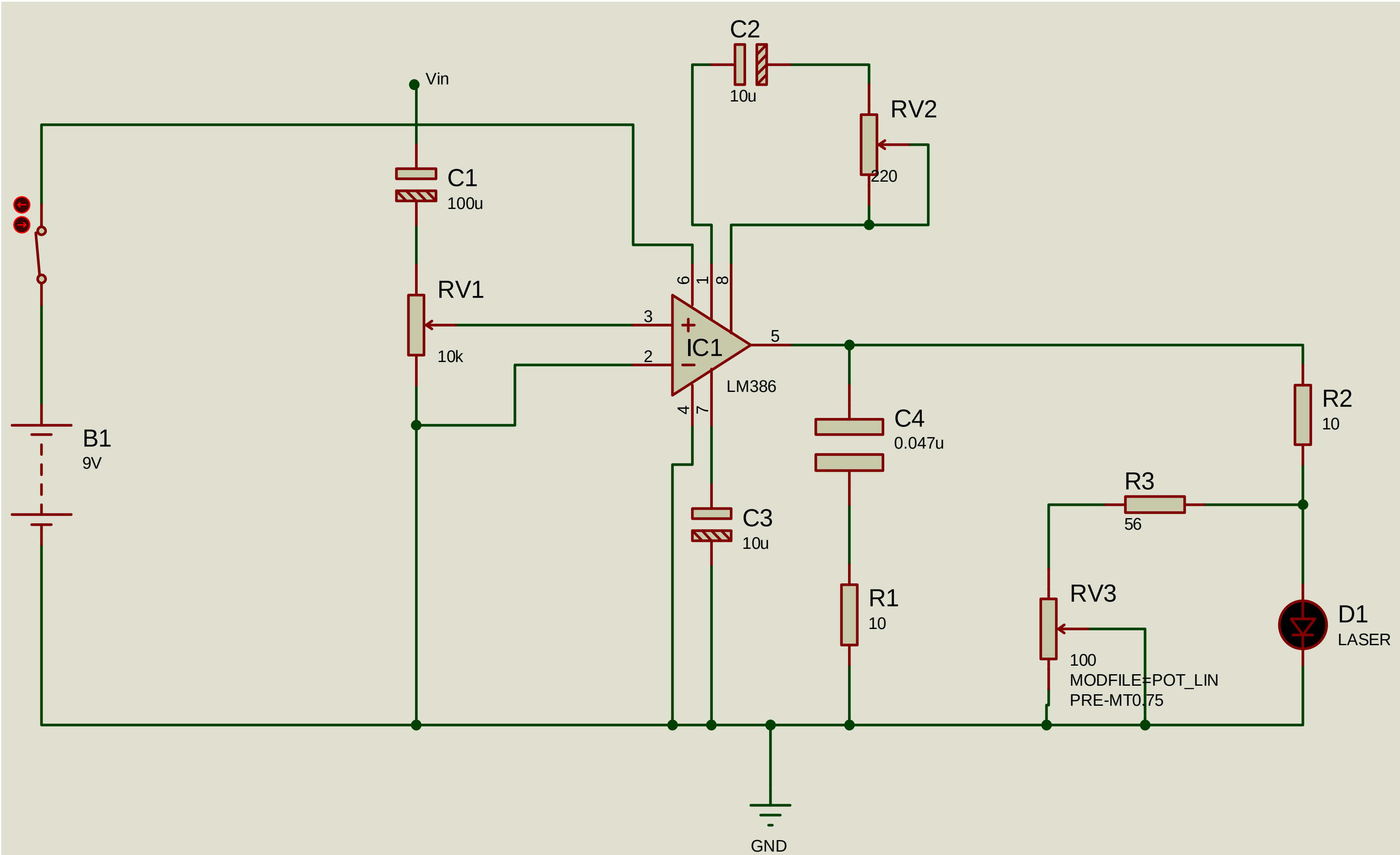


Figure 4.1: Laser source based voice transmitter circuit proteus (simulator)

- **Transmitter**

C1= $1/2\pi fR_1 = \frac{1x10^{-4}}{2x3.14x\ 1.6kHz\ x10}$ = **100uF**

Vo = $(V_{cc}*R_{uot})/(R_{out}+R_{in}) = \frac{9v\ x\ 10\Omega}{10\Omega+10\Omega}$ = **4.5V**

C4 = $\frac{1}{2\ x\pi\ xf\ xR} = \frac{1}{2x3.14x20kHz\ x\ 10\Omega}$ = **0.0796uF**

$f_H= 1/(2\pi fC_4) = \frac{1\ x\ 10^6}{2x3.14x\ 220x10}$ = **7.2kHz**

$f_L= 1/(2\pi fC_1) = \frac{1\ x10^6}{2x3.14x50Hz\ x\ 100}$ = **1.6kHz**

Bw= f_H - f_L = 7.2kHz-1.6kHz = **5.6KHz**

The project enables us to communicate with our neighbors wirelessly. Instead of RF signals, light from a laser torch is used as the carrier in the circuit. The laser torch can transmit light up to a distance of about 100 meters. The phototransistor of the receiver must be accurately oriented towards the LASER beam from the torch. If there is any obstruction in the path of the LASER beam, no sound will be heard from the receiver. The transmitter circuit (Figure 4.1) comprises condenser microphone followed by an Opamp stage built around LM386 (IC1). The AF output from LM386 (IC1) is coupled to R2, which in turn, modulates the laser beam.

The transmitter uses 9V power supply. However, the 3-4.5volt laser torch (after the removal of its battery) can be directly connected to the circuit with the body of the torch connected to the resistor of 56Ω and the spring loaded lead protruding from inside the torch to circuit ground.

4.2. Receiver Circuit Operation

The Transmitted Laser beam was detected by photo transistor whose resistance is inversely proportional to the intensity of receiving light. A resistor R1 was used to drop voltages of supply before connecting to the photo transistor.

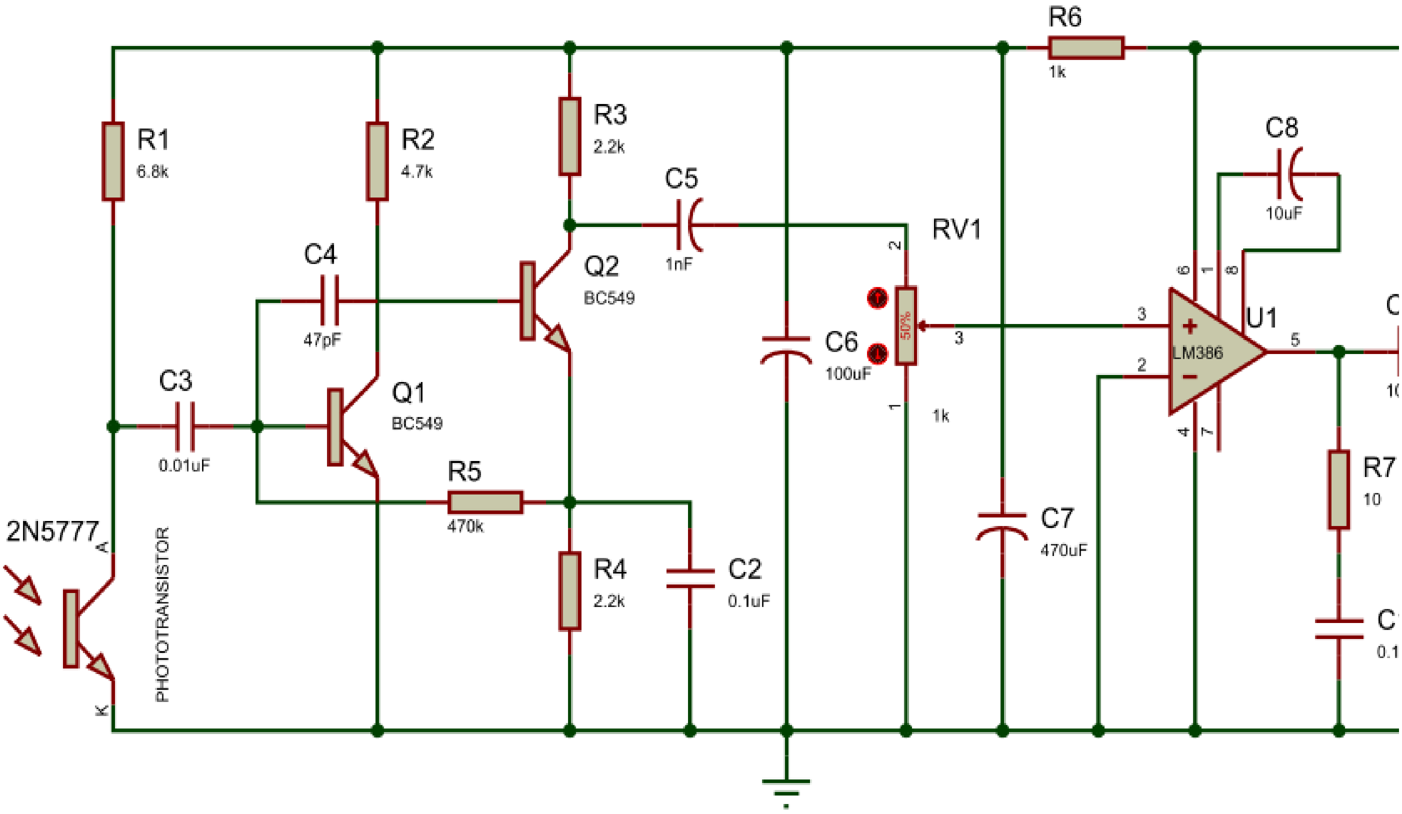


Figure: 4.2: Designing of receiver circuit by using Proteus software (simulator)

- **Receiver**

$V_{B1}= \frac{V_{cc}R_{B1}}{R_{B1}+R_5} = \frac{9V \times 6.8k}{6.8k+470k} = \frac{61.2V}{476.8} = 0.128V = 128mV$

$R_{B,}\ Q1 = R_9 ll\ R_{10} = \frac{R_9 \times R_5}{R_9+R_5} = \frac{6.8k \times 470k}{6.8k+470k} = 6.7k$

$R_{B2,\ Q2} = R_{B1}\ ll\ R_2 = \frac{R_{B1} \times R_2}{R_{B1}+R_2} = \frac{6.7k \times 4.7k}{6.7k+4.7k} = 2.76k$

$I_{c1} = (V_{B1} + 0.7 - V_{cc})/(R_2 + R_{B1}/\ \beta + 1) = \frac{(0.128V+0.7V-9V)}{4.7k+\frac{6.7k}{151}} = 0.00173A$

$V_{B2}= Vcc - I_{c1}xR_2 = 9V- 0.00173Ax4.7k= 1.01V$

$I_{C2}= \frac{V_{B2} + 0.7V - V_{CC}}{R_3+\frac{R_{B2}}{\beta+1}} = (1.01V+0.7V - 9V)/\ (2.2k+\frac{2.76k}{151}) = 0.00328A$

The receiver circuit (Figure 4.2 above) uses an NPN phototransistor as the light sensor that is followed by a two-stage transistor preamplifier and LM386-based audio power amplifier. The receiver does not need any complicated alignment. Just keep the phototransistor oriented towards the remote transmitter's laser point and adjust the volume control for a clear sound. Photo transistor is a photo sensitive transistor which receives the light from the LASER diode of transmitter. The transistor puts out a signal that is proportional to the light from the LASER. This is not only receiving the signal it's also demodulate the signal. C1 couples this audio to Q1 and Q2 which amplify the signal. The signal is then coupled through C4 to VR4. VR4 is a volume control for IC LM386. LM386 (IC2) amplifies the signal more and drives the speaker (LS).

To avoid 50Hz human noise in the speaker, keep the phototransistor away from AC light sources such as bulbs. The reflected sunlight, however, does not cause any problem. But the sensor should not directly face the sun.

4.3. Full circuit diagram for optical transceiver module

The transceiver circuit diagram below shows the general transmitter and receiver of optical communication system for voice transmission separately on the same plane.

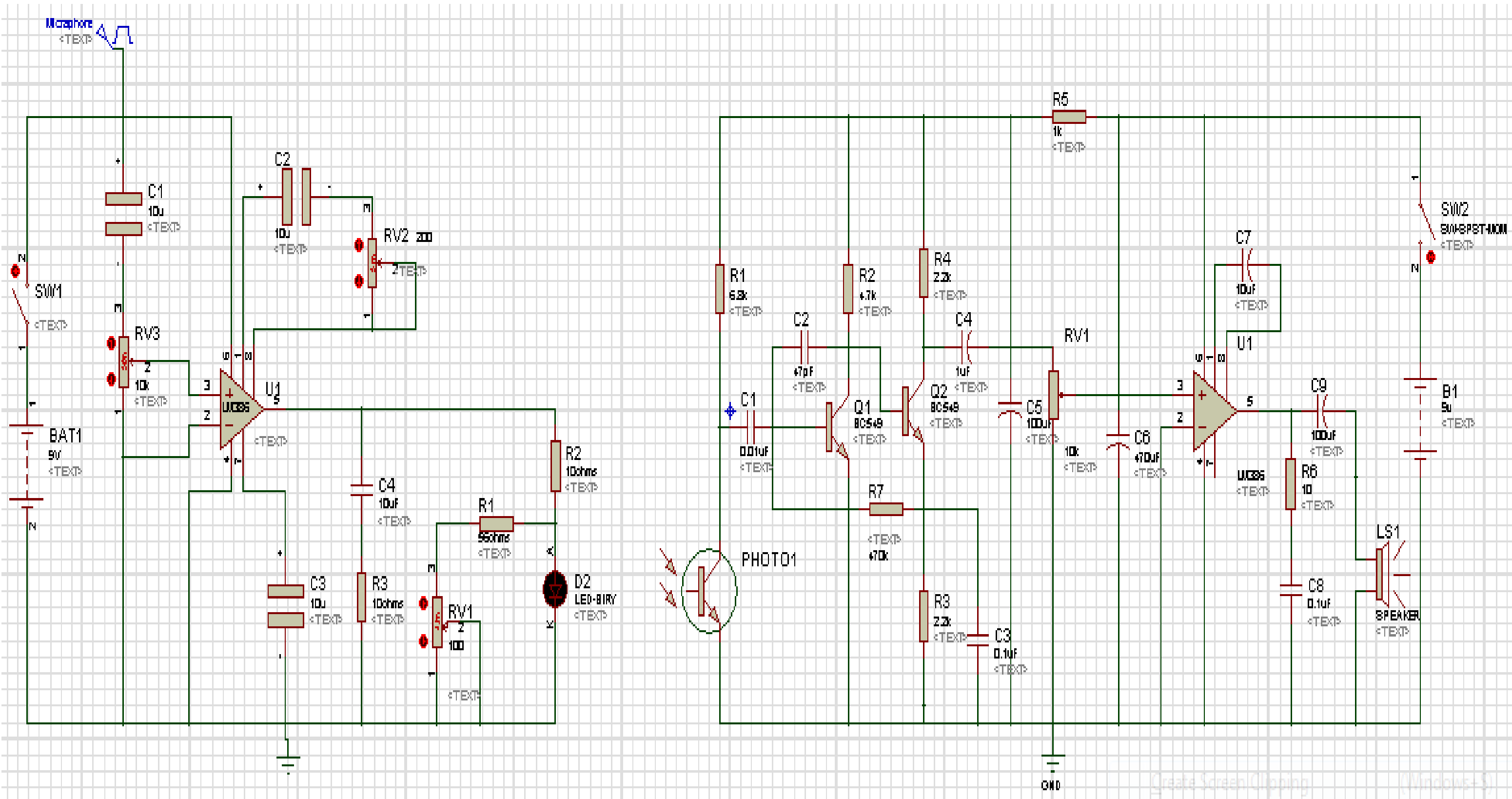


Figure 4.3: Circuit diagram of transceiver of optical communication system for voice transmission.

4.4. List of Components used in this project work

i. LM 386 (IC)
ii. Laser source
iii. Condenser Mic
iv. Resistors-6.8kΩ, 2.2kΩ, 4.7kΩ, 470kΩ, 1kΩ, 10Ω, 56Ω.
v. Variable resistor (potentiometer)-10kΩ, 200Ω, 100Ω
vi. NPN Photo Transistor (2N5777)
vii. Speaker-0.5w/8 Ω
viii. Ceramic Capacitors-47pF, 0.01µF, 0.1µF, 0.047µF.
ix. Electrolytic capacitor-(1µF,100µF,10µF,470µF) 16V,(10µF,100µF) 25V
x. Battery- 9v
xi. Battery Connector
xii. ON/OFF Switch
xiii. Printed circuit board (PCB)

4.4.1. Low Voltage Audio Power Amplifier (LM386)

The LM386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value up to 200. The inputs are ground referenced while the output is automatically biased to one half the supply voltages. The quiescent power drain is only 24 mill watts when operating from a 6 volt supply, making the LM386 ideal for battery operation.

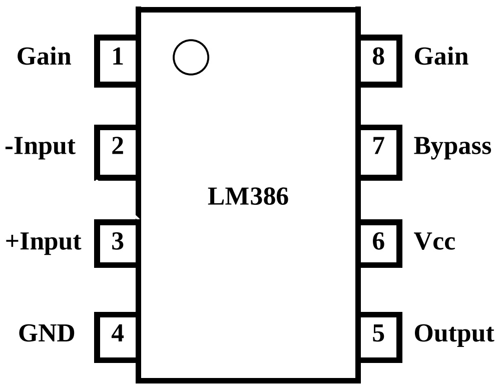


Figure 4.4: Pin Diagram of Operational Amplifier (LM386)

4.4.1.1. Application and Gain Control

To make the LM386 a more versatile amplifier, two pins (1 and 8) are provided for gain control. With pins 1 and 8 open the 1.35 kΩ resistor sets the gain at 20 (26 dB). The capacitor is put from pin 1 to 8 and bypassing the 1.35 kΩ resistor, the gain will go up to 200 (46 dB). If a resistor is placed in series with the capacitor, the gain can be set to any value from 20 to 200. Gain control can also be done by capacitive coupling a resistor (or FET) from pin 1 to ground.

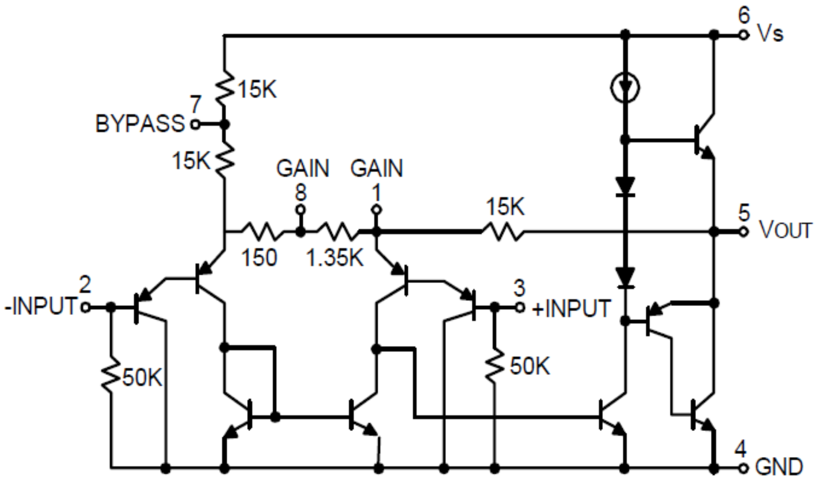


Figure 4.5: Schematic diagram of LM386.

Additional external components can be placed in parallel with the internal feedback resistors to tailor the gain and frequency response for individual applications. For example, we can compensate poor speaker bass response by frequency shaping the feedback path. This is done with a series RC from pin 1 to 5 (paralleling the internal 15kΩ resistor). For 6 dB effective bass boost: Resistor 15kΩ, the lowest value for good stable operation is R = 10kΩ if pin 8 is open. If pins 1 and 8 are bypassed then R as low as 2kΩ can be used. This restriction is because the amplifier is only compensated for closed-loop gains greater than 9.

4.4.1.2. Input Biasing

The schematic shows that both inputs are biased to ground with a 50 kΩ resistor. The base current of the input transistors is about 250nA, so the inputs are at about 12.5 mV when left open. If the DC source resistance driving the LM386 is higher than 250 kΩ, it will contribute very little additional offset (about 2.5 mV at the input, 50 mV at the output).

If the dc source resistance is less than 10kΩ, then shorting the unused input to ground will keep the offset low (about 2.5 mV at the input, 50 mV at the output). For dc source resistances between these values we can eliminate excess offset by putting a resistor from the unused input to ground, equal in value to the dc source resistance. Of course all offset problems are eliminated if the input is capacitive coupled. When using the LM386 with higher gains (bypassing the 1.35kΩ resistor between pins 1 and 8) it is necessary to bypass the unused input, preventing degradation of gain and possible instabilities. This is done with a 0.1µF capacitor or a short to ground depending on the dc source resistance on the driven input.

4.4.2. Laser Diodes

A laser is a device that emits light (electromagnetic radiation) through a process of optical amplification based on the stimulated of photons. The term "LASER" originated as an acronym for Light Amplification by Stimulated Emission of Radiation. The emitted laser light is notable for its high degree of spatial and temporal coherence. Stimulated emission of radiation is a natural process first identified by Einstein. It occurs when a beam of light passes through a specially prepared medium and initiates or stimulates the atoms within that medium to emit light in exactly the same direction and exactly at the same wavelength as that of the original beam.

Lasers are devices that amplify or increase the intensity of light to produce a highly directional, high-intensity beam that typically has a very pure frequency or wavelength. Lasers are a primary component of some of our most modern communication systems and are the probes that generate the audio signals from our compact disk players.

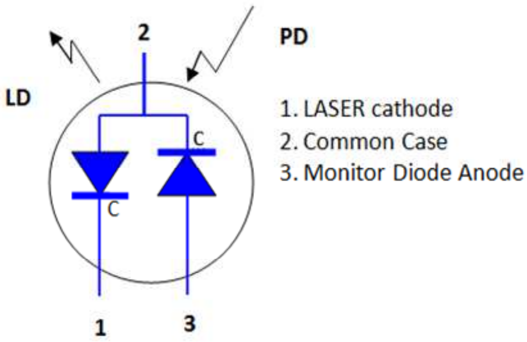


Figure 4.6: Pin out Diagram of Red LASER Diode.

The wavelength of this visible laser diode light output is 650nm, its Optical power output is 5mW CW and Package type is 5.6mm with Built-in photo diode for monitoring laser output.

i. The Rate Equations

Rate of change of photon numbers = stimulated emission + spontaneous emission + loss

$$\frac{d\emptyset}{dt} = C_n\emptyset + R_{sp} - \frac{\emptyset}{\tau_{ph}} \qquad 4.1$$

Rate of change of electron numbers = Injection + spontaneous emission + stimulated spontaneous.

$$\frac{dn}{dt} = \frac{J}{q_d} - \frac{n}{\tau_{sp}} - C_n\emptyset \qquad 4.2$$

J is the current density, *Rasp* is the rate of spontaneous emission, the is the photon rate, *its* spontaneous recombination rate, and C is the constant

ii. Efficiencies of Laser diode

Internal quantum efficiency

$$\mu_{in} = \frac{number\ of\ photons\ generated\ in\ the\ cavity}{number\ of\ injected\ electron} \qquad 4.3$$

External quantum efficiency

$$\mu_{ext} = \frac{P_e}{I_{Eg}} \qquad 4.4$$

External power efficiency

$\mu_{ep} = \frac{p_e}{P}$…………………………………………………………………………………...….4.5

Where P = IV…………………………………………………………………………………4.6

The stimulated emission process yields an increase in photons as they travel along the wave guide.

iii. Lasing Condition

Combined with the waveguide losses, stimulated emission yields a net gain per unit length, g. The number of photons can therefore be maintained if the roundtrip amplification in a cavity of length, L, including the partial reflection at the mirrors with reflectivity R_1 and R_2 equals unity.

This yields the following lasing condition:

Roundtrip amplification = $e^{2gL}R_1R_2 = 1$………………………………………………..4.7

If the roundtrip amplification is less than one then the number of photons steadily decreases. If the roundtrip amplification is larger than one, the number of photons increases as the photons travel back and forth in the cavity and no steady state value would be obtained. From equation (4.6) above the gain required for lasing therefore equals:

$g = \frac{1}{2L} \ln \frac{1}{R_1 R_2}$ ………………………………………………………………4.8

Initially, the gain is negative if no current is applied to the laser diode as absorption dominates in the waveguide. As the laser current is increased, the absorption first decreases and the gain increase.

4.4.3. Photo Transistor (2N5777)

The standard symbol of a phototransistor, which can be regarded as a conventional transistor housed in a case that enables its semiconductor junctions to be exposed to external light. The device is normally used with its base open circuit, in either of the configurations shown in figure 4.7 and functions as follows.

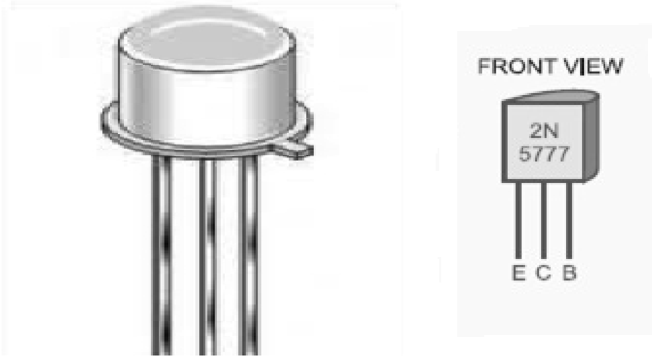


Figure 4.7: phototransistor (2N5777)

In practice, the collector and emitter current of the transistor are virtually identical and, since the base is open circuit, the device is not subjected to significant negative feedback.

In practice, the collector and emitter current of the transistor are virtually identical and, since the base is open circuit, the device is not subjected to significant negative feedback. Consequently, the alternative figure 4.8 circuit, in which R1 is connected to Q1 emitter, gives a virtually identical performance to that of figure 4.7. The sensitivity of a phototransistor is typically one hundred times greater than that of a photodiode.

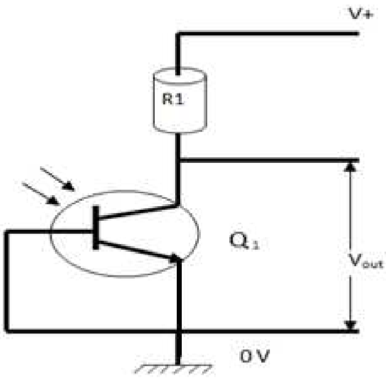


Figure 4.8 Schematic diagram of phototransistor.

Phototransistors are solid-state light detectors with internal gain that are used to provide analog or digital signals.

They detect visible, ultraviolet and near-infrared light from a variety of sources and are more sensitive than photodiodes, semiconductor devices that require a pre-amplifier. Phototransistors feed a photocurrent output into the base of a small signal transistor. For each illumination level, the area of the exposed collector- base junction and the DC current gain of the transistor define the output.

4.5. The Power Received in Free Space Optical Link

We found that the amount of the received power is proportional to the amount of power transmitted and the area of the collection aperture ($R_{eceiver}$). It is inversely proportion to the square of the beam divergence (Div) and the square of the link range(R). It is also inversely proportion to the exponential of the product of the atmospheric attenuation coefficient (μ) .The total power of the received signal through the earth's atmosphere can be calculated by:

$P_{receiver} = P_{transmit} \times \frac{Areceiver}{(Div * Range)^2} \times e^{(-\mu * Range)}$ ……………………………….……..4.9

$A_{receiver} = JIB \times (\frac{D_2}{4})$………………………………………………………..,…….4.10

The system designed in clear weather, which is the attenuation coefficient equal to 0.1km-1. The differences between the theoretical calculations and the experimentally measured values for the received laser power at long distances are due to the absorption and scattering effect on the divergent laser beam.

4.6. Signal to Noise Ratio Calculations

The total signal to noise ratio (S/N) at the optical detector for the distance 100m can be calculated according to the equation

S/N in dB=20 log10 (S/N) (using voltage or current ratio)..4.11

The signal to noise ratio of the system could be calculated as follows:-

S/N = 20 log (0.36*100m / 31.4 an) = 21.1 dB……………………………………………..4.12

4.7. Power Budget of the PWM System

The power budget is calculated if the transmitted power is Pt and the minimum required receiver power is Pin, the power budget is the ratio of;

Power budget = $\frac{P_t}{P_{min}}$ ……………………………………………………………….....4.13

4.8. Channel Characterization & Modeling

Channel models constitute more of a characterization of some important measures, such as path loss, large scale fading (shadow fading), and power delay Profile, delay spread, etc.

- ✓ **Pathloss and Large-scale Fading**

The pathloss can be defined as the ratio of the transmitted power to the received signal power as a function of the Tx-Rx separation distance. A good pathloss model is essential for link budget analysis and network planning. Before we consider the general pathloss models, we will briefly look at the free space pathloss (FSPL), which is the pathloss for two isotropic antennas in free space, separated by a distance d, and is given by

$$\mathrm{FSPL(d)} = \left(\frac{4\pi \mathrm{d}}{\lambda}\right)^2 = \left(\frac{4\pi \mathrm{df}}{\mathrm{c}}\right)^2 \text{..........} 4.14$$

Where, $\lambda = c/f$

Here, it is seen that the FSPL is proportional to the square of the carrier frequency,

i.e. FSPL $\propto f_c^2$, resulting in a much more severe FSPL for mm-wave systems. as a function of distance is varied, the FSPL at 50Hz is also varied,. Compared to the FSPL for a 100m distance at 50Hz, the FSPL is about 4.382 $x10^{-8}$ dB.

CHAPTER FIVE

5. ANALYSIS AND SIMULATION PART

5.1. Software Implementation

In our project, the information is carried in the pulse duration of the laser beam. The information is quantized, i.e. the pulse duration within a certain period denotes one character, whereas the pulse duration within another period denotes other character. This is achieved by associating delays along with the output of the port to which the laser is connected. The transmitter design is simulated by using oscilloscope as shown in figure 5.1 below

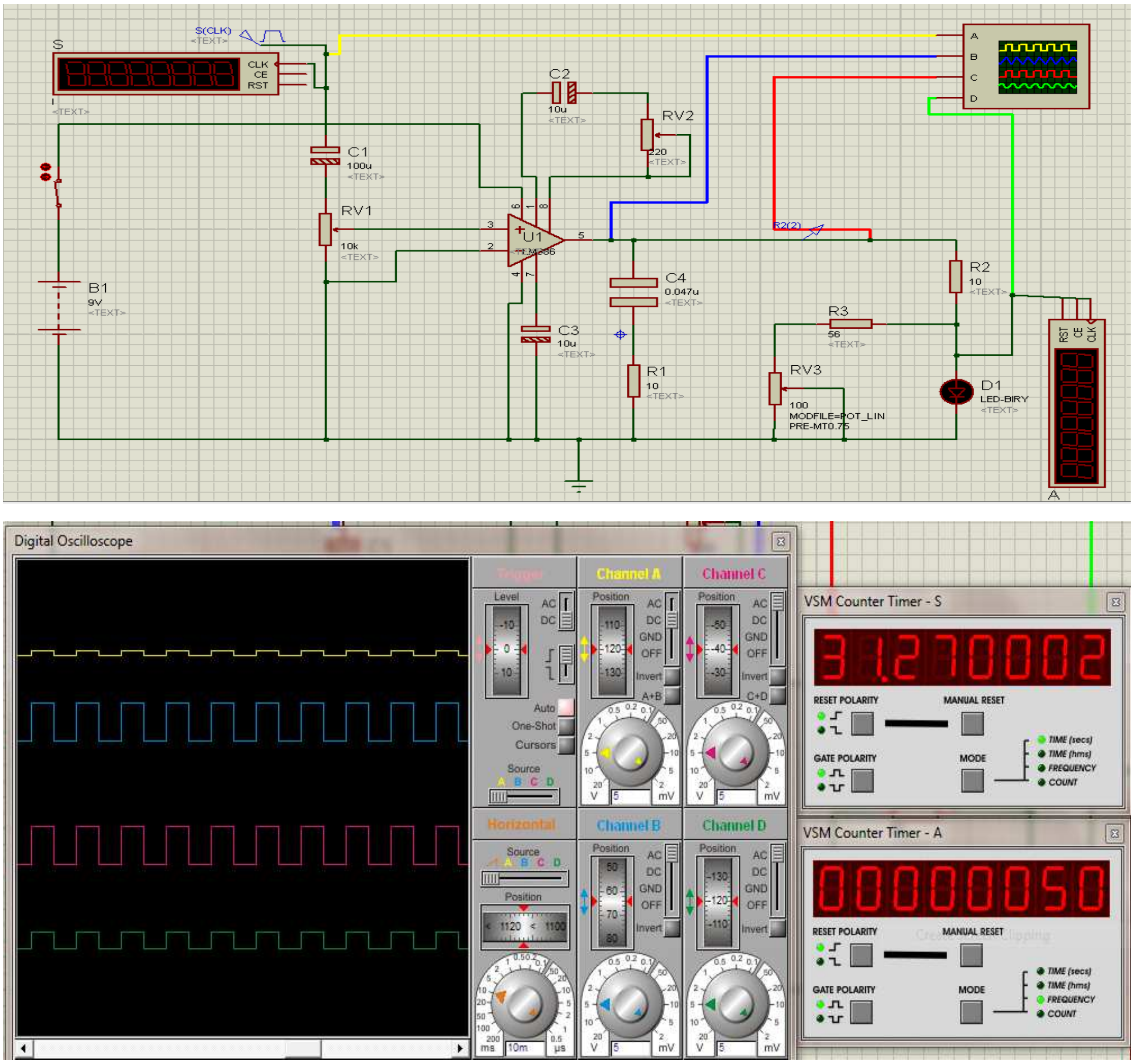


Figure 5.1: Simulation of transmitter circuit by using oscilloscope (by using proteus simulation).

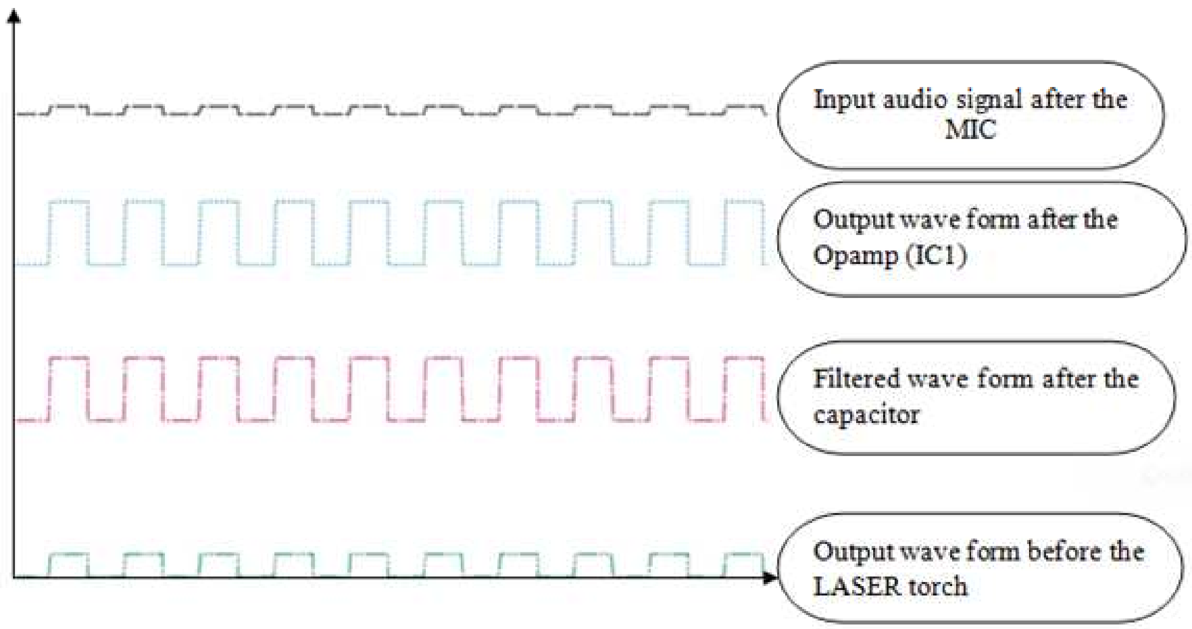


Figure 5.2: Wave form of the transmitter signal at different stages of the designed circuit (by using proteus simulation).

Table 5.1: Output data of Oscilloscope for figure 5.2 waves

	Channel A	**Channel B**	**Channel C**	**Channel D**
V/Div	5.00 V	5.00 V	5.00 V	5.00 V
Offset	60.00 V	20.00 V	-20.00 V	-60.00 V
Invert	Normal	Normal	Normal	Normal
Coupling	DC	AC	AC	AC
	Horizontal			**Trigger**
Source	Trace		Level	Channel A
Position	104.58 mS		Coupling	0.00 V
S/Div	10.46 mS		Edge	DC
			Mode	Rising
			Level	Auto

The first wave form indicates the input audio after the MIC; the second wave form is the output of Opamp wave signal, the third wave form is the filtered wave after the capacitor and the last wave indicates the output wave before the laser diode. The transmitter circuit is simulated by using oscilloscope. The receiver design is simulated by using oscilloscope as shown in figure 5.3 below.

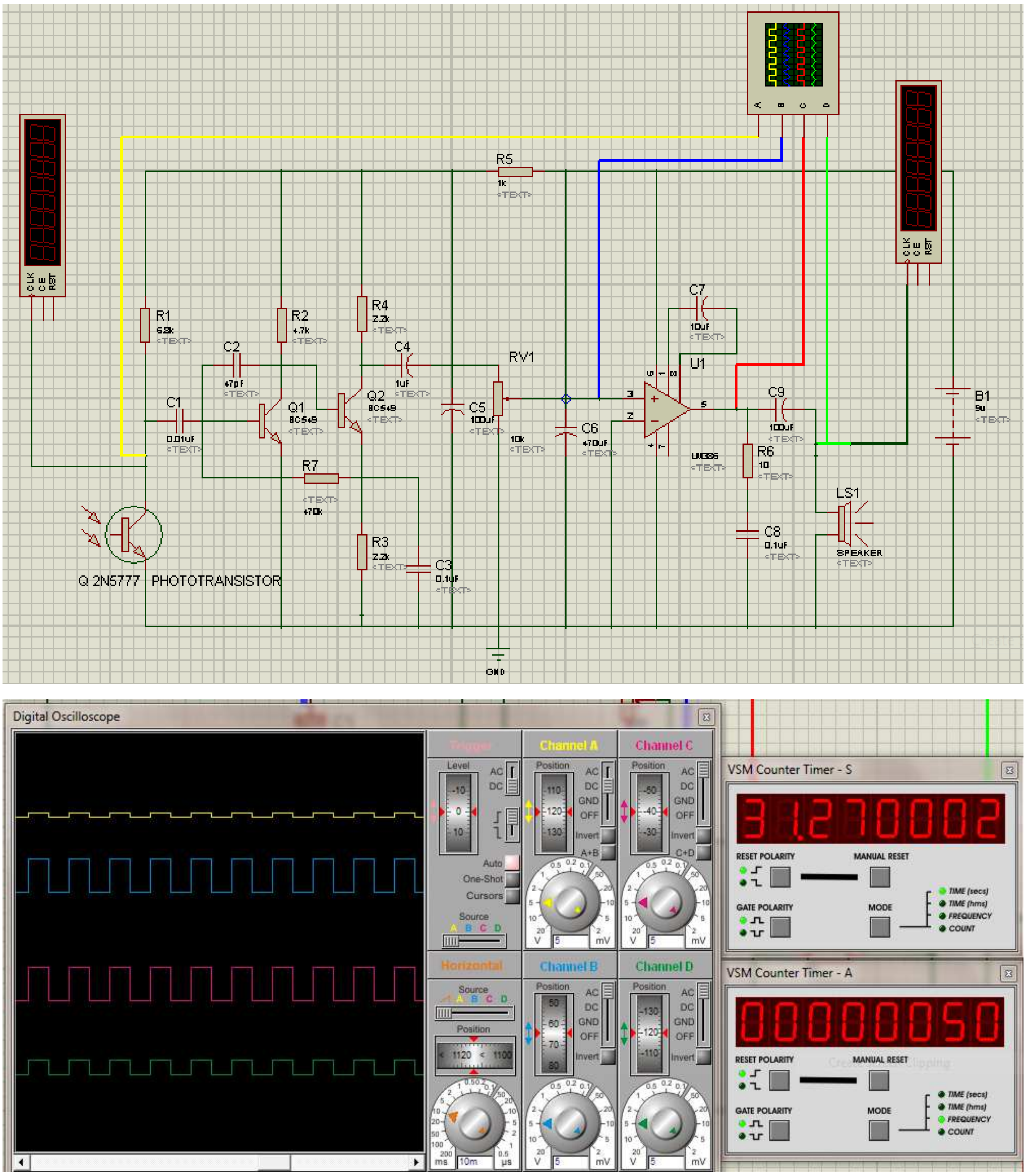


Figure 5.3: Simulation of receiver circuit by using oscilloscope (by using proteus simulation).

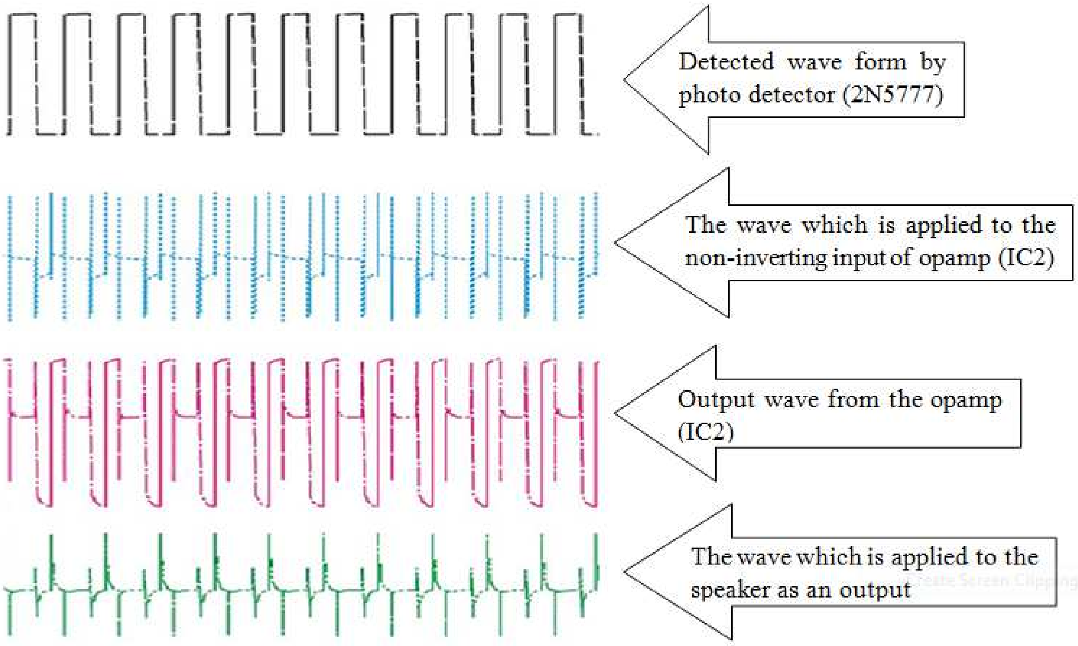


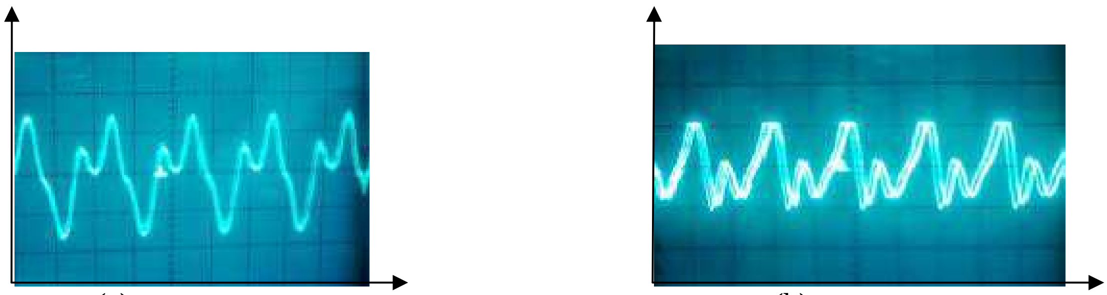
Figure 5.4: Wave form of the receiver signal at different stages of the designed circuit (by using proteus simulation).

Table 5.2: Output data of Oscilloscope for figure 5.4 waves

	Channel A	Channel B	Channel C	Channel D
V/Div	485.00 mV	500.00 mV	2.43 V	2.42 V
Offset	6.79 V	2.00 V	-9.73 V	-41.22 V
Invert	Normal	Normal	Normal	Normal
Coupling	AC	AC	AC	AC
	Horizontal		Trigger	
Source	Trace	Source	Channel A	
Position	175.00 mS	Level	0.00 V	
S/Div	17.50 mS	Coupling	DC	
		Edge	Rising	
		Mode	Auto	

5.2. Hardware Implementation

The designed system is actually measurable by using oscilloscope. The measured output from the oscilloscope is as given in figure 5.5 below.



(a) (b)

Figure.5.5: (a) the waveform voice signal after the microphone & amplifier and

(b) The waveform of voice analog signal output before the speaker (by using oscilloscope).

Table 5.3: Voltage of the photo detector versus distance

V_{ought}(photo detector)	Distance (m)
643mV	1
585mV	2
440mV	3
367mV	4
227mV	5
169mV	6
88mV	7
86mV	8
84mV	9
80mV	10

The result of the above table 5.2 is collected from the detected laser source light by using photo transistor as the distance is varying. The relation ship between V_{out} at the photo ditector and the distance between transimmiter and receiver is explained by using figure 5.6 below.

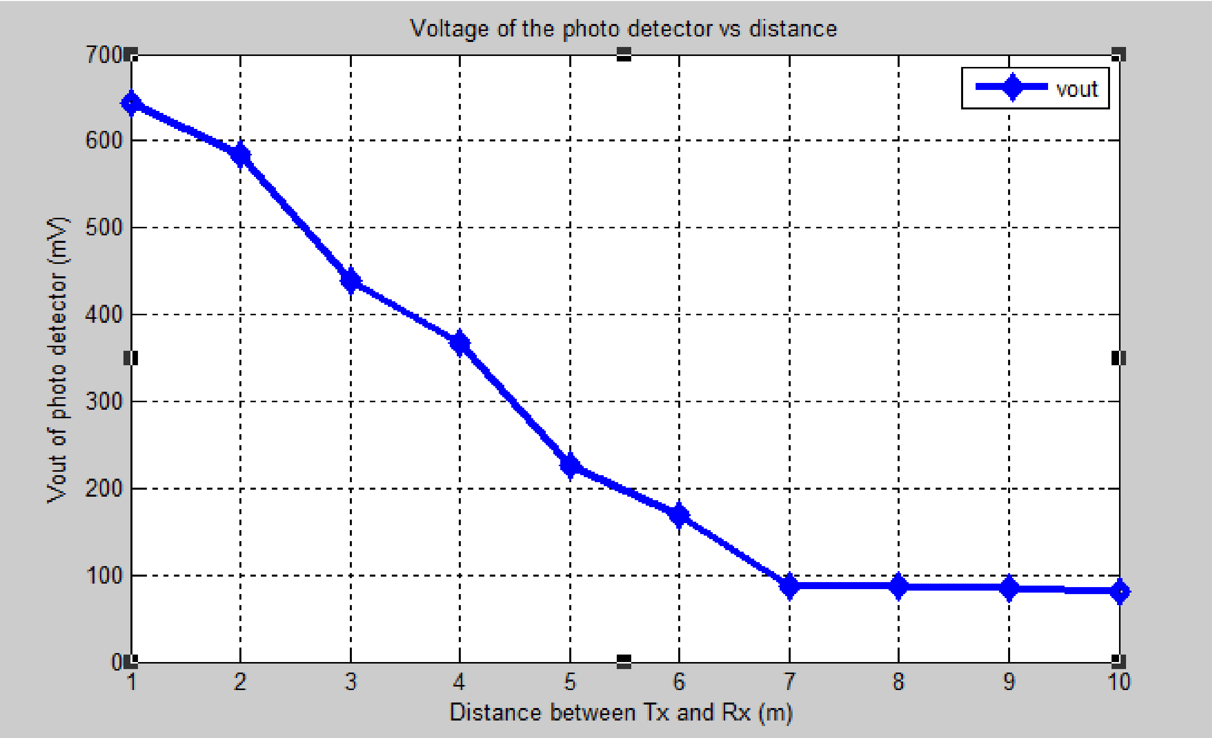


Figure 5.6: Output Voltage of the photo detector versus distance. (By using MAT LAB simulation)

The figure 5.6 above indicates the output voltage of photo detector as the distance between transmitter and receiver is varying. As the distance between transmitter and receiver is increased the voltage at the photo detector is decreased, because of the illumination of light from the laser source is decreased. At high distance the variation of voltage is small.

5.2.1. Output Power

The current for which the gain satisfies the lasing condition is the threshold current of the laser, I_t. Below the threshold current very little light is emitted by the laser structure. For an applied current larger than the threshold current, the output power, P_{out}, increases linearly with the applied current as illustrated with Figure 5.7.

The output power therefore equals:

$$P_{out} = \mu \frac{hv}{q}(I - I_{th}) \qquad \text{5.1}$$

Where, hv is the energy per photon. The factor, h, indicates that only a fraction of the generated photons contribute to the output power of the laser as photons are partially lost through the other mirror and throughout the waveguide.

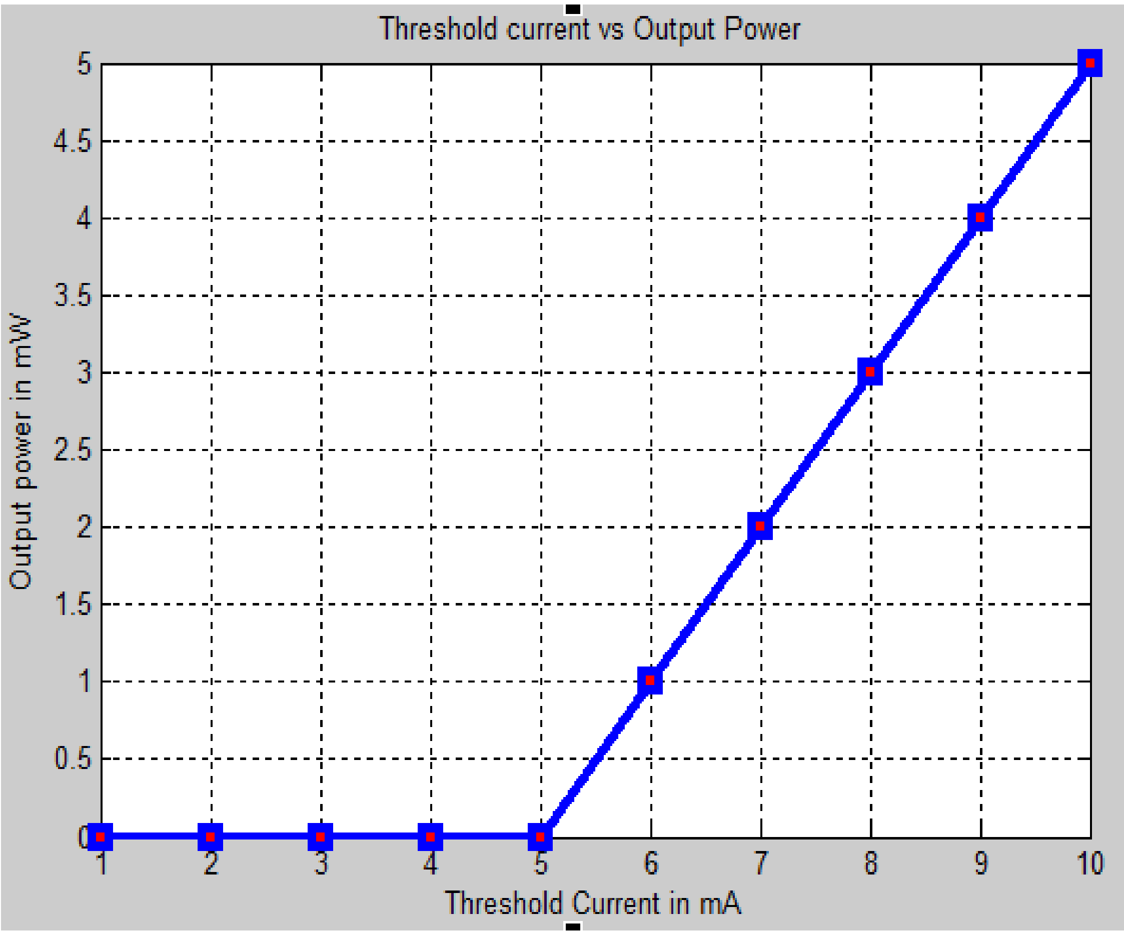


Figure 5.7: Output power from a laser diode versus the applied current (by using MATLAB).

5.2.2. Real Prototype of Transmitter

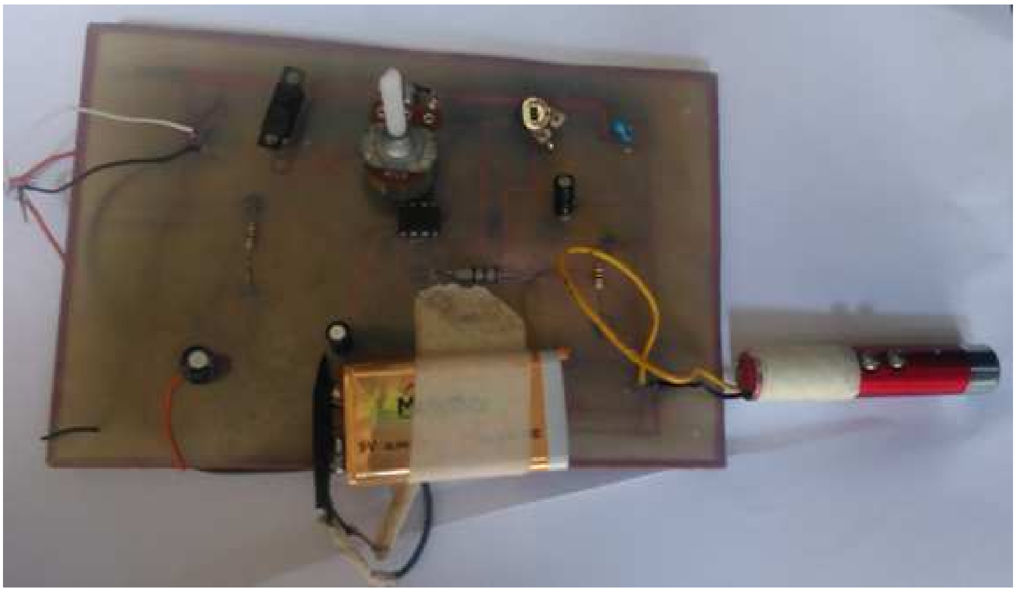


Figure 5.8: Transmitter of optical communication system for voice transmission.

5.2.3. Real Prototype of Receiver

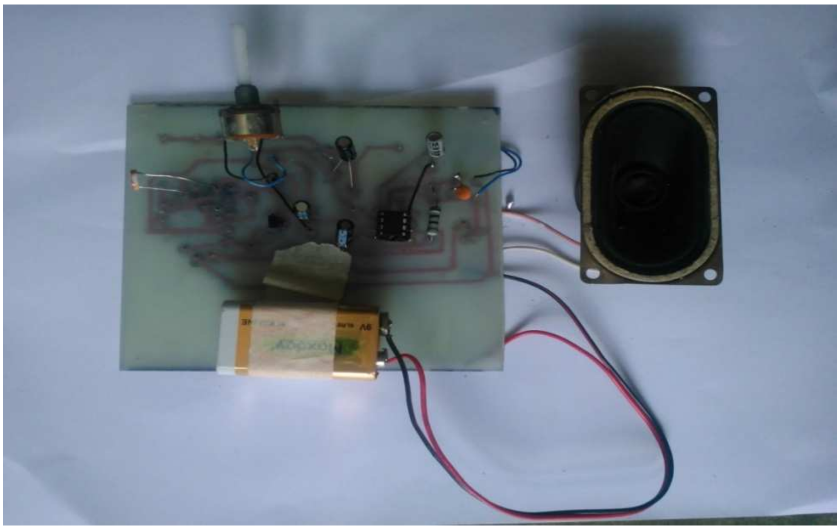


Figure 5.9: Receiver of optical communication system for voice transmission.

CHAPTER SIX

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

The project was successful according to the initial goals of the project. A link was achieved at a distance of 100m. In the final product it was discovered that the link range had little effect on the overall performance. It is possible to achieve greater speeds with future revisions of both the transmitter and receiver boards. Link alignment should be studied further to achieve a more reliable audio transfer at wider angles.

This better result is gained by using visible red light LASER and photo transistor. Also, the pre-bias and modulation currents should be studied using the evaluation board and the custom receiver to determine if it is possible to further reduce thermal noise created by the LASER. It will also be necessary to interface the transmitter and the receiver with an audio source and Opamp. The receiver prototype should be developed into a commercial receiver with more filtering and error correction stages along with interfacing.

After the successful working of the project, it can be concluded that this project is suitable for easily communication. Using this project we can communicate with our neighbors wirelessly. It can be also used in inaccessible areas and conference halls.

6.2. Recommendation

- Multiple voice, data, picture, video can be multiplied simultaneously to perform communication using Multiplexer.

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Appendix –A Table 1: pin configuration of LM386

Pin Number	**Name**
1	Gain 1
2	Non Inverting Input (-IV)
3	Inverting Input (+IV)
4	Ground (GND)
5	Output Voltage (Vo)
6	Input Power (+IP)
7	Bypass
8	Gain 2