Li-Fi BASED HOME NAVIGATION

Major Project report submitted in partial fulfilment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

By

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UNDER THE GUIDANCE OF

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DECLARATION

We hereby declare that the work reported in the B.Tech Project Report entitled **"Li-Fi based home navigation"** submitted at **Jaypee University of Information Technology, Waknaghat, India** is an authentic record of our work carried out under the supervision of **Dr. Shweta Pandit.** We have not submitted this work elsewhere for any other degree or diploma.

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This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

Dr. Shweta Pandit

Date:

Head of the Department/Project Coordinator

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ABSTRACT

Li-Fi (Light Fidelity) is the binary data serving technology that can overcome the drawbacks of Wi-Fi because of its faster data transmission capability, better bandwidth, efficiency and security. Keeping these advantages of Li-Fi technology in mind, we came up with a project called “Li-Fi based home navigation”.

This project proposes an idea to make indoor navigation easy for visually impaired people. This navigation system is basically using visible light communication with a frequency of 400 and 800 THz and wavelength of 780–375 nm, that has LED (light emitting diode) as data sender/transmitter and LDR (light dependent resistor) as data receiver. LED lights emit visible light with location data while an embedded system with a visible light receiver receives the data, demodulates it and informs the actual destination to the visually impaired through an audio device.

In the transmitter part, when an electrical current is applied to an LED(light emitting diode) bulb, a constant stream of light is emitted which we can see as an illumination. Since LED bulbs are electronic devices, the current and therefore, the light can be modulated at high speed as per the incoming information signal, which are invisible to the human eye.In the receiver unit, LDR (light dependent resistor)in the light range can easily detect the modulation of the stream and convert it back to the electric signals as its resistance decreases with the increase in intensity of light.This is the basic working principle of Lifi. The receiver device demodulates the binary data which has been encoded and responds to the user by speaker. The LDR in the receiver unit gathers data from the LED by changing its resistance with the change in intensity of light emitted by a particular LED attached to the transmitter.The information includes location, and whenever the receiver module enters the range of the transmitter area, a message with the corresponding location is sent to the receiver. This message is stored in the microcontroller & processed further

to start the voice guidance and vibrator motor navigation systems, which can help people with visual impairments navigate in enclosed spaces. In order to reduce interference filters are used at the transmission side whereas movable LED panels are used to get rid of clear Line of Sight (LOS) problem while transmitting the data from each room to the blind user.

As we know that most of us are using LEDs as the light source in our homes, the LED can be fitted at the ceiling of the entrance doors of all the rooms that can send data through a microcontroller embedded at the main electricity board of the house. The receiver unit with an audio device can be embedded in the stick of the visually impaired person at home. This idea makes installation of this proposed navigation device easier and makes data transmission safer and faster.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This project focuses on making indoor navigation easier for visually challenged people in our localities using a new emerging technology called Li-Fi .WHO suggested that around 285 million people in the world are with visual impairment. They go through different tough challenges in their day-to-day life, one of them being localization and navigation in their own home.

Li-Fi(light fidelity) is a new technology that incorporates the use of visible light to send and receive data at a very high speed for mobile and networked communication. It is bidirectional as visible light and infrared can be used as uplink and downlink respectively and full duplex communication where data is sent and received at the same time resulting in a very fast and reliable user experience[1].

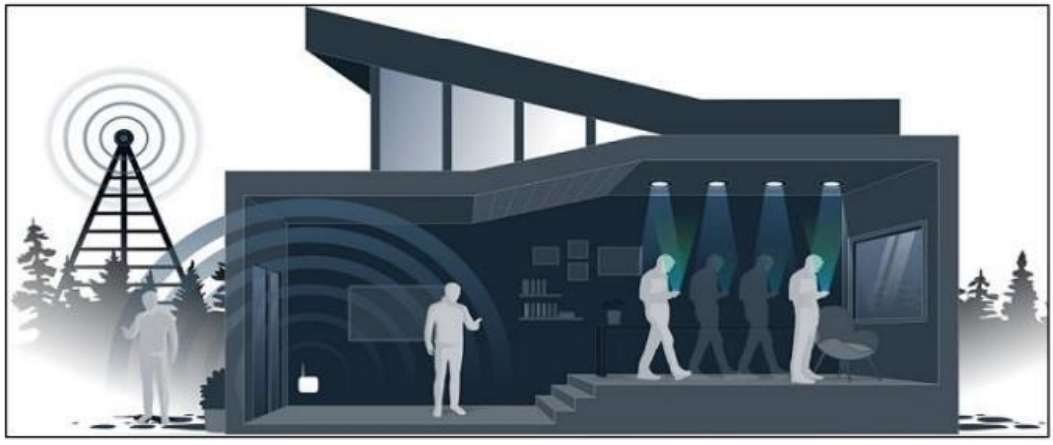


Figure 1.1 Li-Fi system in real environment

Now, all of us know how the lightbulb works. When an electrical current is applied to an LED(light emitting diode) bulb, a constant stream of light is emitted which we can see as an

illumination. Since LED bulbs are electronic devices, the current and therefore, the light can be modulated at high speed as per the incoming information signal, which are invisible to the human eye. But a LDR (light dependent resistor)in the light range can easily detect the modulation of the stream and convert it back to the electric signals as its resistance decreases with the increase in intensity of light.This is the basic working principle of Lifi.

The main advantage of using Li-fi is that we do not need any new infrastructure to implement this system as every house is equipped with LEDs. Moreover, Li-fi can prove to be a future of secure wireless data transmission networks as penetration through walls is impossible which ensures no data leakage or hack. Thus, we can say that it is the light revolution in the field of the internet world.

Wi-Fi is already a well established data communication system but Li-Fi has some major advantages over it like:[2]

a] Higher speed- Wifi works on the frequency of 2.4GHz while Li-fi has the potential to work on the frequency of more than 1000THz.

b] Availability- LI-Fi is available wherever the light is but wifi cannot work under water and on aeroplanes.

c] Power consumption- less in Lifi as compared to Wifi due to the use of LEDs.

d] Cost- cost of implementation and data transfer is very low using Li Fi as every home has LEDs and basic power board for Li Fi implementation.

e] Secure- The security in Lifi is very high as the light through LED cannot penetrate through walls in this point to point communication which can be beneficial for blind people living alone in a house.

f] Interference- Wifi works in the radio frequency spectrum whereas Lifi works in the visible light spectrum. Light faces less interference than radio waves.

g]Bandwidth efficiency- Capacity of accommodating so many users in Wifi bandwidth is getting less with the evolution of Internet of Things. Using LiFi at homes or in any deserted areas can be beneficial for data communication in future internet technology.This model consists of two units:

1) transmitter unit- installed at the ceiling of the indoor entrance gates

2) receiver unit- embedded in the stick of the user.

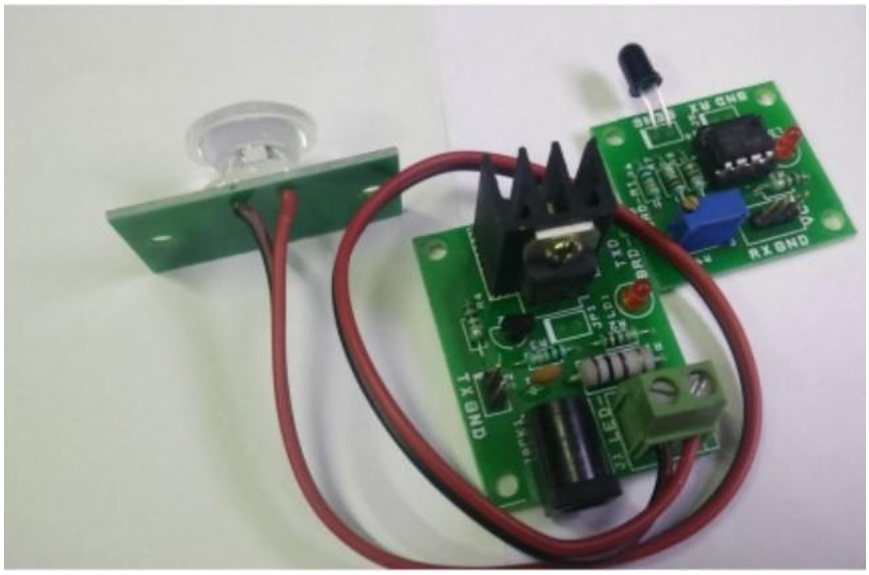


Figure 1.2 LI-FI Module

Visually challenged can be benefited by using this technology as it can guide them in an indoor system. The data transmission occurs only when a person has entered the room i.e. receiver(LDR) comes in range of transmitter (LED).The property of LiFi that it can work in a line of sight only provides more security accuracy to blind people living alone in a house.

LED lights emit visible light with location data while an embedded system with a visible light receiver receives the data and informs the actual destination to the visually impaired through an audio output device. [4] Location data through Li-Fi is transmitted through various bit streams by using LEDs which are detected and demodulated by the photodiode module. Transmission of data is in binary form, where ‘0’ means that LED is in OFF state and ‘1’ means that LED is in ON state.

Thus, the proposed model can be an easy, user friendly and secure indoor navigation device for people who have lost their visibility in buildings such as hospitals, blind schools, their own homes and other required places.

1.2. Objective

The main purpose of this project is to make a sustainable and user friendly indoor navigation system for visually blind people around us. As this model uses visible light communication through LED, it provides high speed (100 times faster than Wi-Fi. ie:224 GBPS), uninterrupted and efficient location data to the user and ensures security as well. LED lights emit visible light with location data while an embedded system with a visible light receiver receives the data , demodulates it and informs the actual destination to the visually impaired through an audio device. Moreover, all of us are using LEDs as a light source in our homes so the transmitting LEDs can be easily connected with a microcontroller embedded in the main power supply board of the house. This means that installations are really easy and comfortable for users with the receiving unit on their walking stick. [3] LEDs being efficient and durable can be a cheapest source of data transmission as well as promising residential lighting equipment.

1.3. Motivation

Imagine a world where light becomes data. Through all the research papers available on the internet, we got to know that light(electromagnetic waves) can transmit data way much faster than radio waves. Avoiding penetration through walls, Li-Fi ensures much more security than wifi data transmissions. So, Li-fi in any enclosed room ensures proper connection security as well. Li-Fi (Light Fidelity) is the binary data serving technology that can overcome the drawbacks of Wi-Fi because of its faster data transmission capability, better bandwidth, efficiency and security. Keeping these advantages of Li-Fi technology in mind, we came up with a project called “Li-Fi based home navigation for blind”. Navigation and localization being one of the greatest issues for blind people, motivated us to come up with this idea of a Li-fi based home navigation system that can become an indispensable source of navigation for them with higher rate of location data transmission and extra security.

The potential impact of LiFi-based navigation on the lives of visually impaired people is enormous. It can significantly enhance their mobility, independence, and quality of life by providing them with real-time and accurate location information. Additionally, this technology

has the potential to improve safety and reduce the risk of accidents for people with visual impairments.

To reduce the cost of implementation and installation, we are using conventional two arduino , a LDR and LEDs in place of Li-Fi transmitters and receivers already available in the market at higher prices. For future use we can use laser LED instead of general LEDs for better visibility and transmission rate as the spatial and spectral profile will get narrower and photo-transistor or solar panel instead of LDR for larger access area for receiving the directed messages.

1.4 Programming Languages Used

- C/C++ Programing language using a standard API called Arduino Language

- Arduino function libraries like PCM for audio output at receiver.

1.5 Hardware Requirements

The following hardware components are used in this project:

1.5.1 Arduino UNO

An open source microcontroller board equipped with sets of digital and analog I/O pins that can be interfaced with various boards and circuits.

Figure 1.3 Arduino Uno

Two arduino UNOs are required as a microcontroller. one in the transmitter unit and another in the receiver unit. [5] The actual work of Arduino on the transmitter side is to convert the data fed into it , into the binary pulses which can further be fed into LEDs for data transmission. While, on the receiver side, the data decoded by LDR is fed into the arduino in the form of an electrical pulse, which in turn, converts the data into actual data that can be heard through audio devices.

1.5.2 TIP 120 transistor

It's a darlington NPN power transmitter as shown in figure 1.4, that can provide very high dc gain.

Figure 1.4 TIP120 Transistor

It acts as an audio output amplifier on the receiver side as it is biased properly. It has approximately 5A of high collector current and 1000 gain which is high enough for proper audio output at the receiver. The symbolic representation of this transistor is shown in figure 1.5.

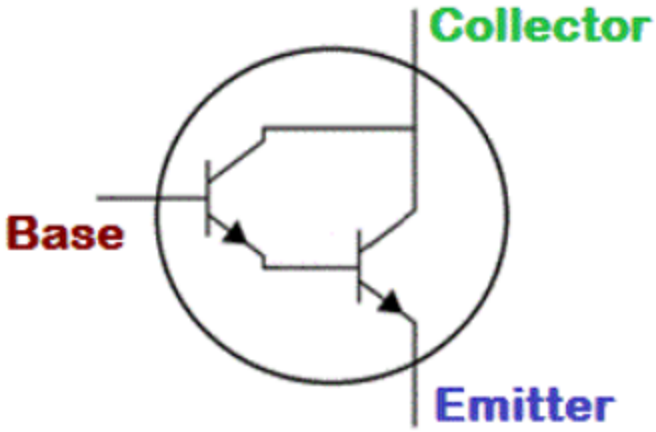


Figure 1.5 Symbolic representation of TIP 120 transistor

1.5.3 LDR(light dependent resistor)

Due to its property of changing its resistance with the change in light intensity, LDR is used to convert the received data in the form of visible light into an interpretable electrical signal and feed into the arduino control unit.The LDR used in this project has hardware representation as shown in Figure 1.6.

Figure 1.6 Light dependent resistor

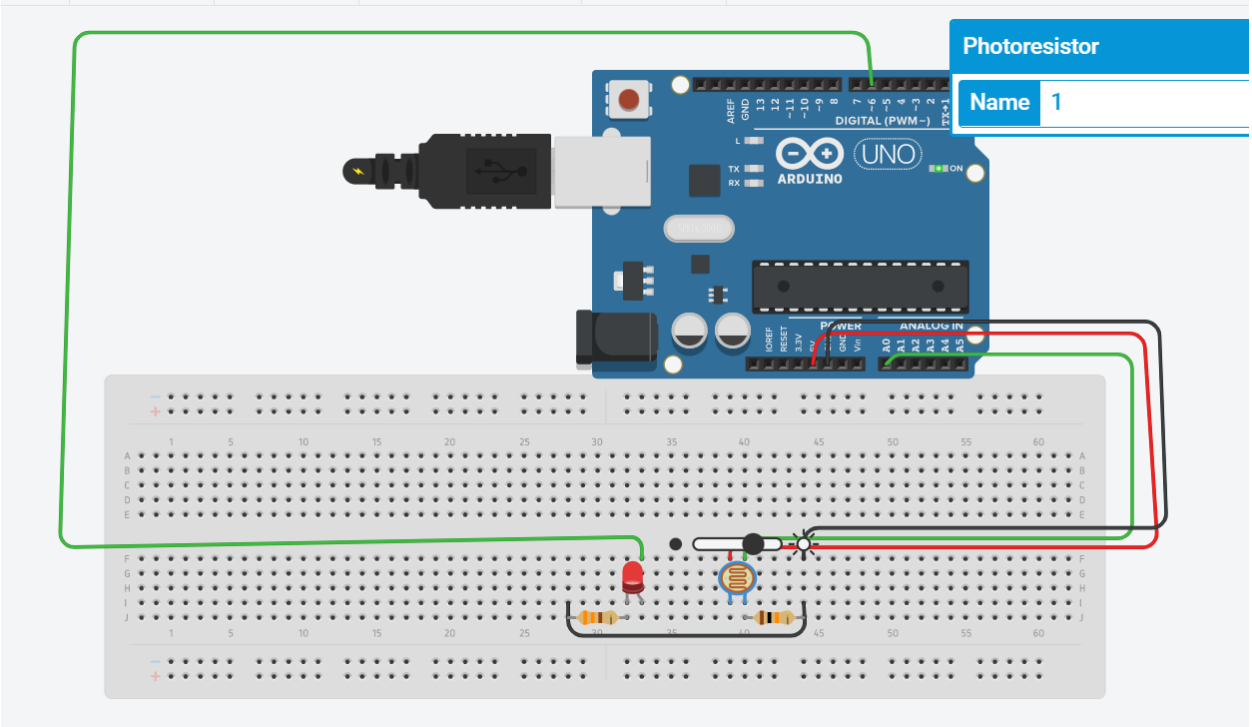


Figure 1.7 LDR(photoresistor) sensor controlling LED brightness

An LDR's resistance, RLDR, can vary from about 100Ω in the sunlight, to over 10MΩ in absolute darkness with this variation of resistance being converted into a voltage variation at V_{OUT} as shown.

The output voltage at the LED terminals vs LDR intensity graph obtained through circuit observation is shown in Figure 1.8.

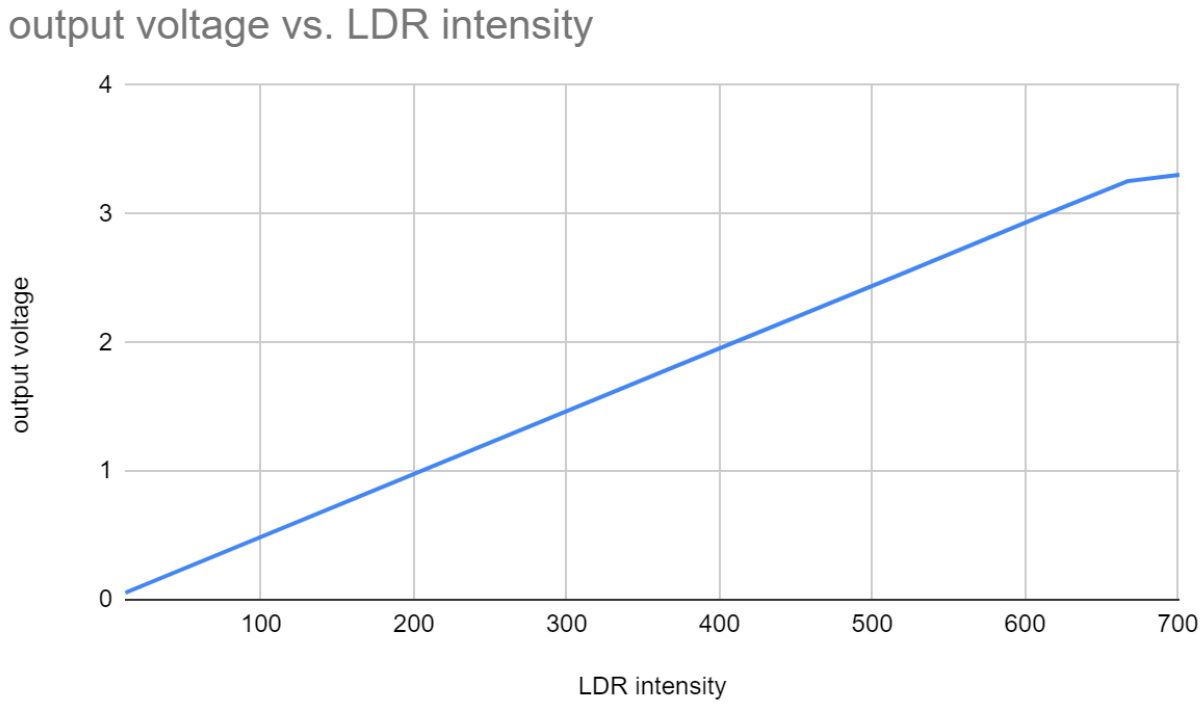


Figure 1.8 Output voltage vs LDR intensity graph

LDR has the property that its resistance decreases with the intensity of light falling on it. The graph of the same is shown in figure 1.9.

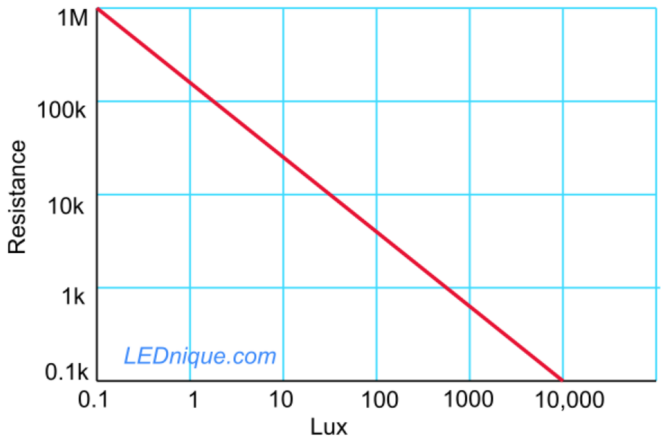


Figure 1.9 LDR(photoresistor) resistance vs light intensity exposed on it

1.5.4 LEDs(5mm)

It has a chip to transfer internet data through the light emitted by it.

Voltage: 3.0v-3.8v

Typical: 3.3v

Current: 20mA

Peak: 75mA

Figure 1.10 LED

A high brightness white LED as shown in Figure 1.10 , is required as a data transmitter through blinking of light at the transmitter side of the model.

1.5.5 Speaker

At the receiver side , Speaker, as shown in figure 1.11, is connected with audio amplifier and arduino for audio output

Figure 1.11 Speaker

1.5.6 jumper wire and bread board

They are used to establish connections between different electronic devices used in this project as shown in Fig. 1.12.

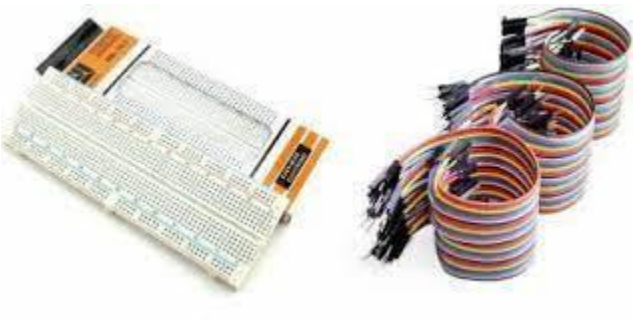


Figure 1.12 Jumper wire and bread board

CHAPTER 2

Feasibility Study, Requirement Analysis, Design and Literature review

2.1 Feasibility Study

Li-Fi - 'Light based Wi-Fi' being one of the revolutionary technologies in terms of data communication, may save the world from the spectrum crunch as well.[8] Here are some pros of Li-Fi technology:

1. high speed and large visible light spectrum.
2. more efficient as compared to another technology due to the use of LEDs.
3. cheaper installations because It can work in the absence of modem,routers,antennas etc.
4. Most importantly, It is a secure mode of transmission as light cannot penetrate through opaque objects.
5. availability of light sources is never a question because of its abundance around us.
6. no RF interference

Pros and cons of any technology goes hand in hand. Here are some cons of Li-Fi technology:

1. Limited range of transmission(10 meters only). That's why it can be used in a closed space only. But sensors could be used to increase this distance.
2. Limited compatibility: Lifi enabled personal devices required
3. opaque barriers can affect the data transmission between sender and receiver.

Due to all those pros stated above, Li-Fi has the capability to replace Wifi or atleast add something to it. With applications ranging from all data of data communication localization and streaming, this technology has experienced gigantic escalation in data rates from 2012 to 2015 [8]. The already established LED infrastructure available around us supports the installation of this technology for the long run.

This project is using this technology for the convenience of blind people in enclosed areas like their homes, hospitals , blind schools etc where the cons of Li-Fi makes no difference to the service provided to them. The aspect of Li-Fi that keeps medical safety and greener technology in check, makes it more viable for development.

2.1.1 Problem Definition

There are 37 million blind persons in the globe, 15 million of whom are from India. Self-navigation is challenging for blind persons. They face difficulties when they encounter an unfamiliar indoor setting. They struggle greatly in crowded areas. People who are visually impaired frequently have difficulties in unfamiliar environments. It makes it easier for blind individuals to move around in enclosed spaces.

Moreover, we are all aware of the Wi-Fi technology that is spread worldwide as the most popular wireless communication technology which is carried out by Radio frequency band limited by blocks of finite bandwidth. With the exponential rise of wireless networks consumers and web servers, there will be a point when all the bands are already allocated to the required consumers , that will ultimately cause RF disturbances and hence, ineffective communications all around the world.

The basic problems listed in all research papers are listed down with their suitable solution in our prototype:

1. A clear line of sight between the LED array and the receiver(LOS): This problem can be solved by using Moveable LED Planes.
2. The system is susceptible to interference from other light sources: This problem can be solved by using filters and moveable LP.

2.1.2 Solution

To overcome these disruptions, visible light communication(VLC) can be used because it uses light, the electromagnetic spectrum, to transmit the required data. This will ultimately lead to a secure data transmission system as Light cannot pass through the walls. It can easily combat the unavoidable RF disturbances and provide effective communication.

Li-Fi (light fidelity) uses VLC that has extremely large bandwidth where the bands cannot be saturated. LED lights emit visible light with location data while an embedded system with a visible light receiver receives the data , demodulates it and informs the actual destination to the visually impaired through an audio device.

As we know that most of us are using LEDs as the light source in our homes, the LED can be fitted at the ceiling of the entrance doors of all the rooms that can send data through a microcontroller embedded at the main electricity board of the house. The receiver unit with an audio device can be embedded in the stick of the visually impaired person at home. This idea makes installation of this proposed navigation device easier and makes data transmission safer and faster

2.1.2.1 Movable LP

With[1] the moveable LP method, a LED can revolve at a specific angle to change the coverage area in accordance with the location requirements for the receiver. As seen in figure 2.1, an LED is rotated at a specific angle to regulate the coverage area of a transmitter. Angle of incidence is the angle with regard to the receiver axis, whereas angle of irradiance is the angle with reference to the transmitter perpendicular axis. In order to get the desired normalised received power, the light intensity on PD can be regulated by employing a specific angle of irradiance, which also allows us to control the range between both the transmitter and the receiver.

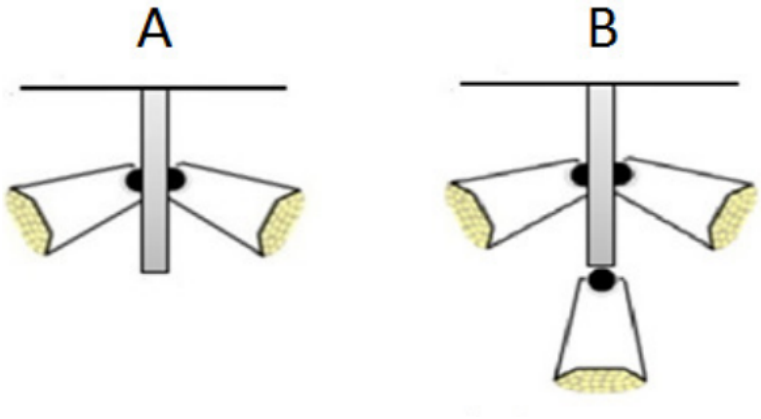


Fig 2.1 Moveable LP

2.1.1.2 Using filters

Filters are able to obstruct noxious sources of light in the environment. This can be done by utilising filters that, while blocking out some other frequencies, only let the particular frequency of light utilised for LiFi transmission pass through[9].

These filters can be created from a variety of substances, including glass, plastic, or films, and they can effectively absorb or reflect light depending on its wavelength.

Moreover, filters can be employed to increase the security of LiFi connection by preventing unauthorized parties from intercepting the signal. For instance, a filter that excludes all wavelengths other than a particular one can be used to establish a private channel of communication that is inaccessible to nearby devices.

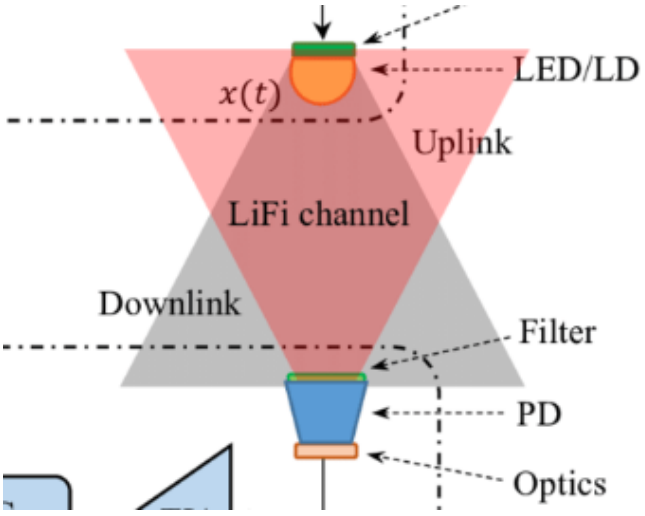


Fig 2.2 Filter in Li-Fi

2.2 Requirement Analysis

1. By observing the current system, the system requirements are derived as part of the requirement analysis process. Through the user interface, a user communicates with the software. For the end user, the software's implementation is of the least relevance [7]. As a result, any programme that is built should maintain the Integrity of the Requirements by having a suitable user interface.
2. The data transmission occurs only when a person has entered the room i.e. receiver(photo diode) comes in range of transmitter (LED).
3. A high brightness white LED is required at the ceiling of every room that should blink at really high speed (invisible to the human eye) to transmit data to the photodetector , sensitive enough to detect and differentiate the light emitted by LEDs and other light sources.
4. We should keep in mind that the range of this Li-Fi system is 10 meters only. That's why the transmitter module and the receiver module must be placed within that range only.

2.3 Design

2.3.1 At Receiver

An audio device connected with a microcontroller and LDR,as a light signal receiver and modulator as shown in figure 2.3 ,can be embedded in the stick of the visually impaired person at home.

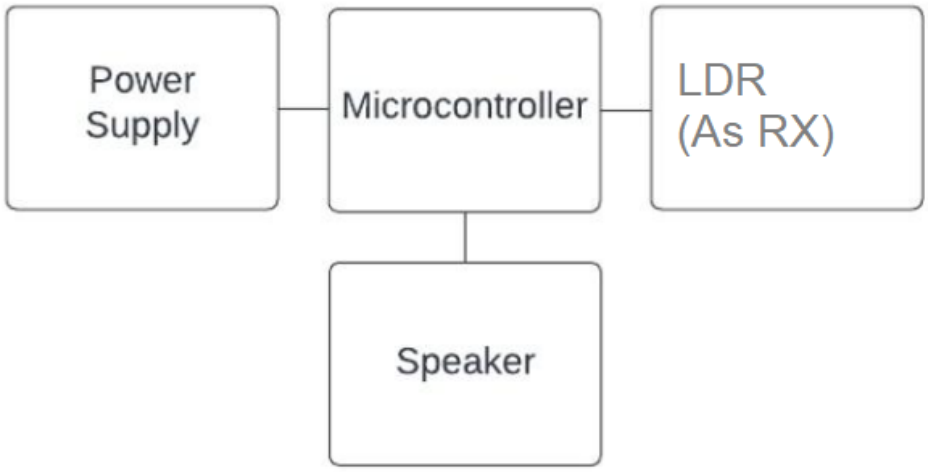


Figure 2.3 Block Diagram at receiver

2.3.2 At Transmitter

The LED can be fitted at the ceiling of the entrance doors of all the rooms as shown in figure 2.4 that can send data through a microcontroller embedded at the main electricity board of the house.

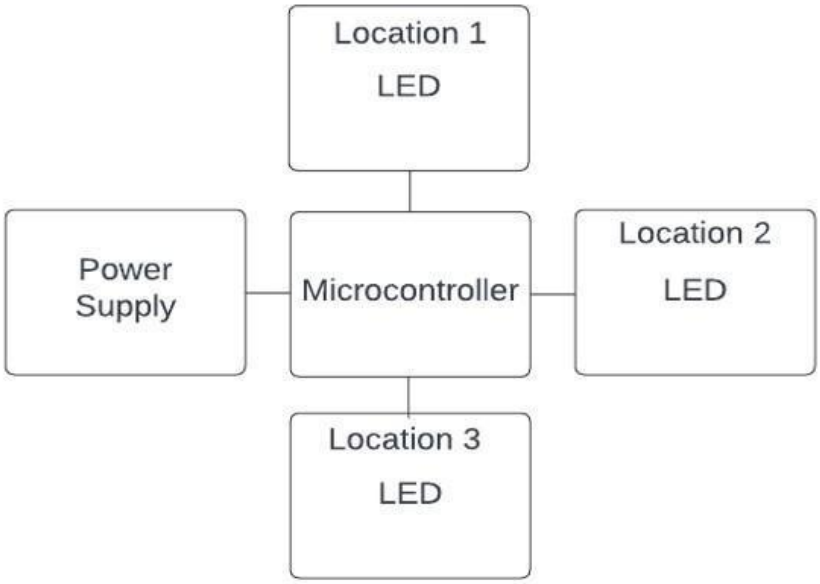


Figure 2.4 Block Diagram at transmitter

2.4 Literature Review

There are various claims showing that Li-Fi will come into the market real soon replacing wifi or atleast adding something really revolutionary into it. With these applications of internet connectivity, Lifi also promises a variety of applications in broadcast medium as well [8].

World is craving for faster internet connectivity, high data rates and more security which makes LiFi a giant technology that is actually required right now. The energy and cost efficient LED ,with a provision of secure wireless connectivity lures the LiFi market for technological advancement. According to the communication testing held by Oxford University, Li-fi is claimed to be a viable option for communication with its data communication speed of 224 Gb/second with a boom of LED light as a source of illumination.

As we know that with the advancement of technologies, particularly industry 4.0 , the number of consumers for wireless internet connectivity is increasing exponentially.[9] According to the recent report of IEEE, this global wireless solution is affecting all the

EMIchallenged (electromagnetic interference) environments like hospitals, aircrafts ,petrochemical plants etc. Li-Fi being unaffected by RF interference becomes a viable communication source here.

Energias Market Research claims that the worldwide market of LiFi will reach USD 80 million in 2023 which is a significant growth indeed. Such fast growth of light fidelity compels many companies to invest more in it.

There are variety of applications of Li-Fi technology

1. **Transportation**: LiFi is adaptable to a variety of uses. Transportation is one that is gaining popularity. The following research application areas were covered in this context: Vehicle-to-Vehicle (V2V) [10], Vehicle-to-Person (V2P) [11], Vehicle-to-Infrastructure (V2I) [12], and Vehicle-to-Network (V2N) [12].

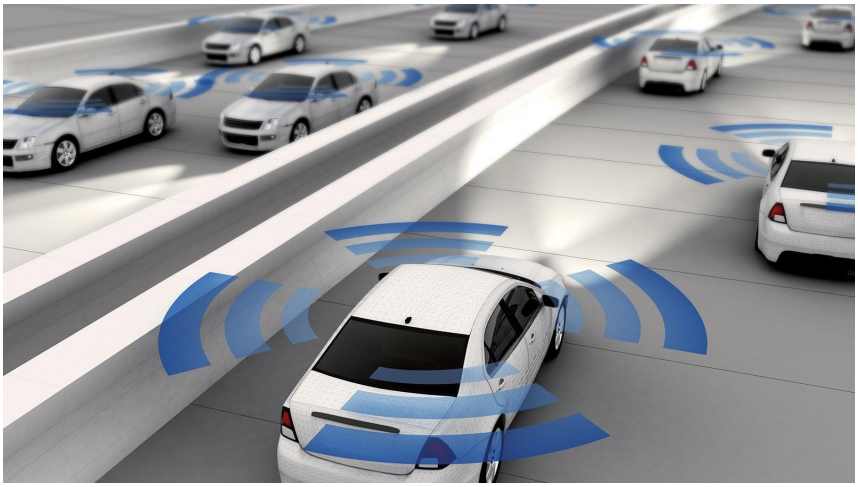


Figure 2.5 Li-fi in transportation

2. **Indoor and Outdoor Lighting**: LiFi hotspots might be distributed by any light source, even streetlights. Artifacts can be connected to the Internet employing appealing VLC features using indoor and outdoor lighting in the workplace, home, healthcare institutions, business locations, airplanes, autos, and streets. As a result, street signs can be utilized as hotspots and converted into a legitimate LiFi

application. Additionally, the same network and sensor technology might be applied to data management and illumination.

Figure 2.6 Li-fi for illumination

3. **Educational System**: Despite being among the newest technologies, LiFi has performed to the same exacting quality as other technologies utilized in a variety of applications, like education. The quickest Internet connectivity is provided by the most cutting-edge Internet access technology [13,14]. Therefore, LiFi can be regarded as the most cutting-edge Internet networking architecture that offers the greatest Internet connection. In corporate and educational settings, it can be a great Wi-Fi substitute. As a result, it may be said to be one of the best frameworks for usage in universities, lecture halls, conference rooms, testing facilities, research institutions, and laboratories [15,16].

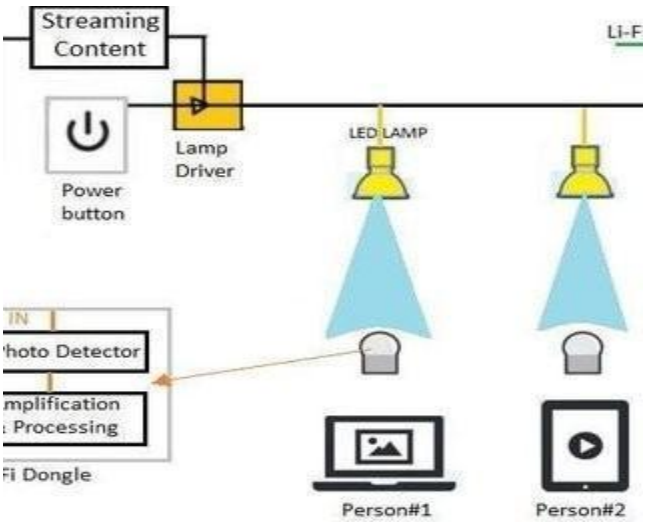


Figure 2.7 Li-Fi for Educational institution

4. **Sound System Communication**:Sound system communications are among the additional LiFi uses. Compared to other applications, sound system applications have received less research. They are discussed, nevertheless, due to how important they are to integrating LiFi. According to [17], different coloured LEDs may convey audio signals and even relay sound at the PWM base [18].Sound systems like those used in concerts, theaters and conference halls depend on wireless communication to transmit voice from sound source to speakers.RF based technologies like bluetooth and wifi are commonly used for this purpose but due to interference, there is audio dropouts and degraded sound quality in such systems. LiFi on the other hand, provides better audio outputs by using LEDs as transmitters and photoresistors or solar cells as receivers.

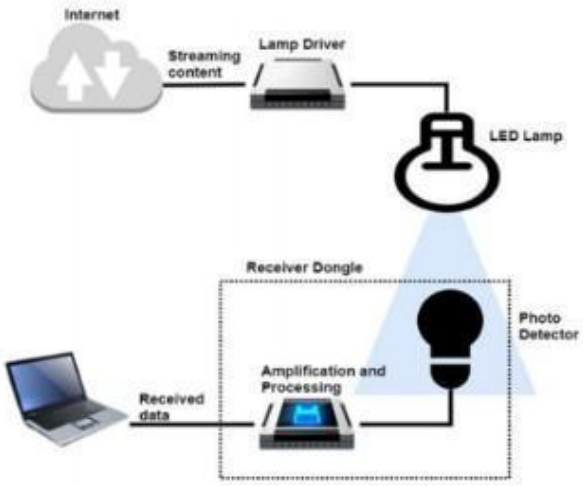


Figure 2.8 LiFi in sound system

5. **Health care facility:** In any medical facility like hospitals, reliable and accurate information is very essential and critical. Lifi with no RF interference,unlike traditional wifi and bluetooth , provides minimal signal loss and interference while detecting any disease. Moreover, spread of infectious disease is very less as Lifi based communication systems do not emit electromagnetic radiation and so, it can be used safely in a close proximity to patients. High speed data transfer with good quality video streaming adds to the ease in real-time monitoring of the patient's condition in a health care system.

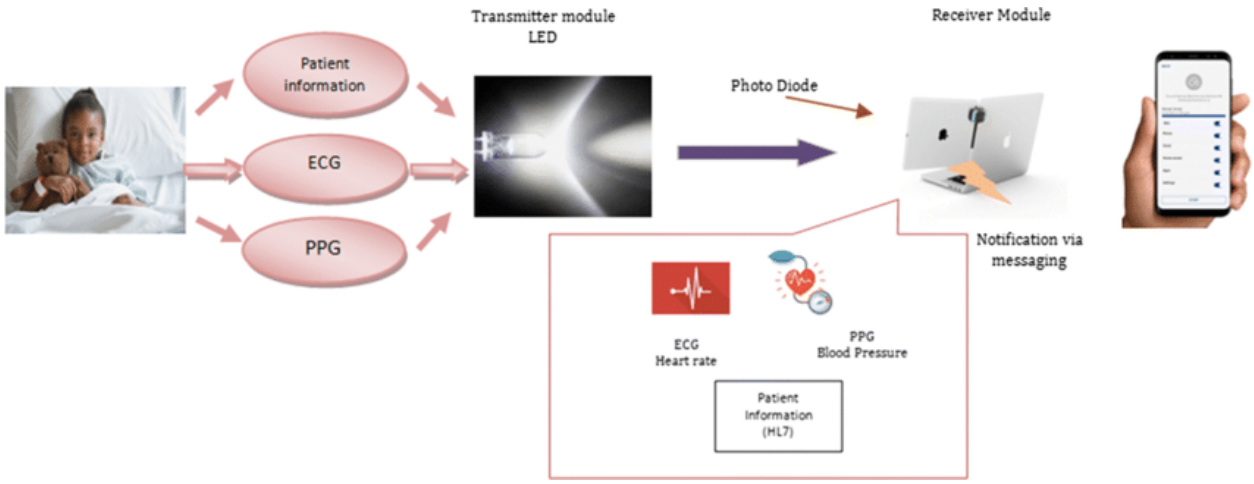


Figure 2.9 LiFi in health care monitoring system

2.4 Related works

We have presented a few relevant research articles and their findings based on Li-Fi technology. Researchers in [2] have proposed an indoor navigation system that utilised LiFi technology for indoor localization. The system consisted of multiple LED transmitters that emitted visible light signals carrying unique identifiers. The receiver device, a smartphone in this case, captured the signals, decoded the identifiers, and utilised them to calculate its position. The system achieved an accuracy of 10 cm, which is sufficient for indoor navigation.

However, the primary drawback of this system is that it required line-of-sight between the transmitter and receiver. As LiFi technology utilises visible light, any obstruction in the path between the transmitter and receiver could disrupt the signal, causing the navigation system to fail. Further, in [3], a LiFi-based home navigation system is again proposed that utilises the Received Signal Strength Indicator (RSSI) of the LiFi signal to calculate the position of the receiver device. The system consisted of multiple LED transmitters that emitted unique signals, and the receiver device captured the signals and calculated the RSSI values. The RSSI values were then utilised to generate a fingerprint of the environment, which was used to calculate the position of the receiver device. However, the accuracy of this system was affected by the

changing environment. As RSSI values are impacted by environmental factors, such as obstacles and interference, the accuracy of the system was reduced in dynamic environments.

Moreover, the use of Kalman filter to improve the accuracy of a LiFi-based indoor navigation system was presented in [4] in which the system consisted of multiple LED transmitters that emitted unique signals, and the receiver device captured the signals and utilised Kalman filtering(also known as Linear quadratic estimation) to calculate the position of the receiver device.

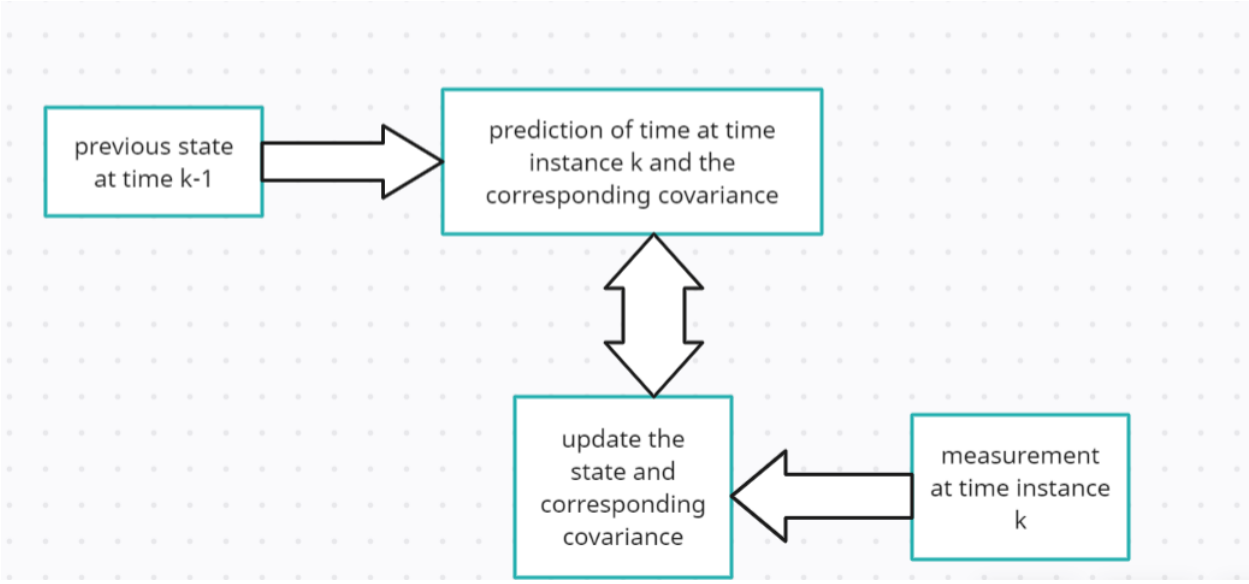


Figure 2.10 Procedure of Kalman filtering technique

However, the use of the Kalman filter required a complex mathematical model to calculate the position of the receiver device. Moreover, Kalman filtering is a mathematical algorithm that utilises statistical models to estimate the state of a system, it requires significant computational resources and expertise to implement.

Here are some of the related works on Li-Fi:

1. Lifi Based Blind Indoor Navigation System for Visually Impaired People:[1]In order to provide accurate guidance for visually impaired people, they developed and tested an indoor navigation system utilizing LightFidelity technology, which employs LED lights.

They are using GSM modules and GPS to provide correct location information to the user using an audio output.

2. Transmission of data, audio and text signal using Li-fi technology:[4]With the use of a light source located on the transmitter side, they were able to broadcast text, temperature, and speech data to the reception side. The speaker produces a proper audible sound,the temperature sensor accurately measures the temperature, and lcd displays the text as intended.

3. Implementation of a data transmission system using Li-Fi technology: [5]In this project they have created a data transmission system using a Li-Fi transmitter and Receiver already available in the market. The sample data (text) sent was observed, and the speed, effectiveness, security, and capacity of the system were analyzed and found to be top notch. This was achieved by designing a user (Receiver PC) interface using JAVA programming. As a result, the system would eventually become a necessity for communication.

4. The deployment of robots in neighborhood pharmacies in the UK is still quite infrequent. Robots could take over high volumes of dispensing at neighborhood pharmacies or dispensing "hubs," freeing up pharmacists to create and provide patient-centered services. Li-Fi can make it possible for robots in pharmacies to interact with staff members and other IT systems, transport medications, restock shelves, and many other tasks.

5. Li-Fi is currently being tested in classes at The Hegel-Gymnasium in Stuttgart to teach a variety of disciplines, from everything to information technology. In the Stuttgart school's Li-Fi prototype installation by Fraunhofer, lightwaves from LED luminaires wirelessly transport data to boxes that are connected to laptops through Ethernet. Similar to pureLiFi, Fraunhofer wants to transfer the box's electronics onto a dongle. The chips will eventually be found inside laptops, cell phones, and tablets.

6. Application of Li-Fi technology in the transmission of the sound at the base of the PWM.[18]: In this project the data is transmitted as an audio through a mobile phone and pulse width modulation is used to transmit this data through blinking LEDs. Photodiodes are used to receive the data and transform it into desirable electric signals. The transmission speed is 87KHz.

7. Vehicle-to-Vehicle Visible Light Communications in the Presence of Denial of Service Attacks[10]: Vehicle to Vehicle communication link is established using VLC communication and noise elimination is done using DoS scheme ie: either using a saturated channel or making the original channel undistinguished from noise signal. This Vehicle to vehicle communication allows drivers to send information like speed,location and direction of travel.

8. Li-Fi Based Smart Traffic Network[13]: For safety and security of travellers and precise dynamic traffic flow, the traffic light system is equipped with LiFi transmitters and the vehicles with LiFi receivers hence reducing travelling time and traffic congestions.

   Along with this facility, a smart parking system is established that informs the drivers about the available parking spots nearby. This project improves the efficiency of the traffic system and provides safety to transportation while also reducing energy consumption and costs.

CHAPTER 3

Implementation

Li-Fi transmitter and receiver have been designed in line with the circuit diagram shown in Fig. 2 and tested in order to determine whether positioning using the lighting panel is feasible. Microcontrollers and LEDs make up the transmitter unit, while LDR and speaker in the receiver unit enable the microcontroller to interpret the signals it received from the speaker and photodiode.

High-intensity LEDs that serve as a communication source. The wall or ceiling is fitted with the transmitter device. LEDs in the transmitter are being used to send the modulated information. A receiving element is an LDR(Light dependent resistor). The receiver device demodulates the binary data which has been encoded and responds to the user by speaker. The LDR in the receiver unit gathers data from the LED by changing its resistance with the change in intensity of light emitted by a particular LED attached to the transmitter.The information includes location, and whenever the receiver module enters the range of the transmitter area, a message with the corresponding location is sent to the receiver. This message is stored in the microcontroller & processed further to start the voice guidance and vibrator motor navigation systems, which can help people with visual impairments navigate in enclosed spaces.

3.1 Flowchart

The working procedure described above can also be explained using the flowchart in the figure 3.1:

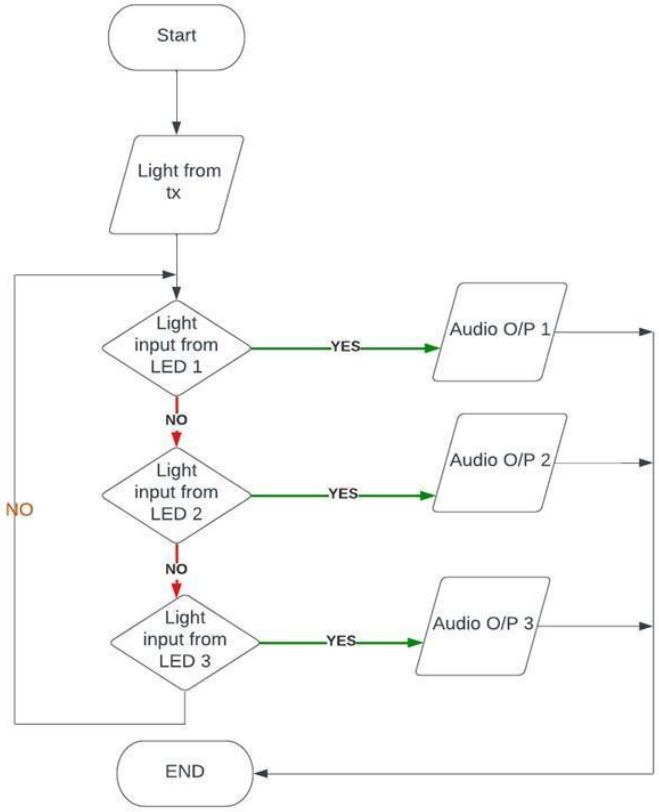


Figure 3.1 Flowchart

Each LED pin at arduino has different data stored in it which is produced through audio output when LDR at receiver comes in Line of Sight of the transmitter ie: LED.

3.2 Working Procedure

Step 1: Receiver i.e. LDR comes in the range of transmitter i.e. LED, the location data is transferred to the receiver through VLC

Step 2: Once these signals are received and demodulated, they can now be converted into a continuous stream of binary data that contains audio.

Step 3: The processed audio information that contains positional information of the user is sent to the receiver using a speaker embedded in the receiver unit.

The circuit diagram of transmitter on the left and receiver on the right side is given in figure 3.2:

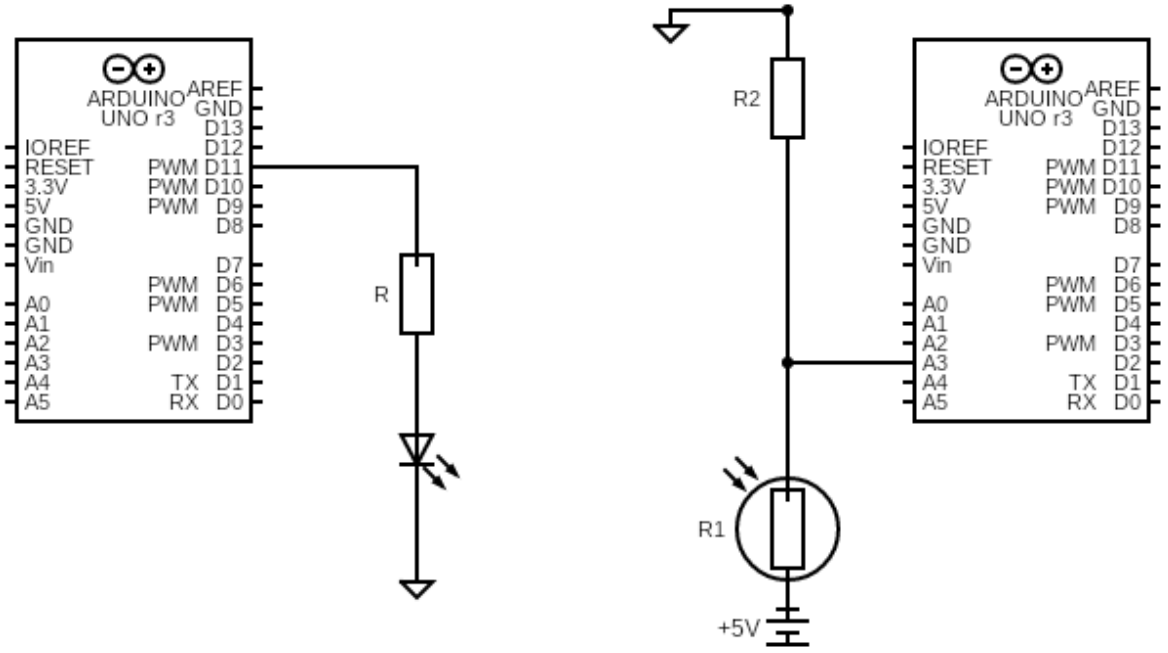


Figure 3.2 Circuit diagram

Formula used for potential divider circuit at the receiver: V=R2/(R1+R2)

Transmitter unit has a transmitting LED with a resistor of 220 ohm to control the flow of current and avoid the burn in the LED attached.

Receiver unit has a potential divider circuit using LDR and potentiometer that measures the voltage across R2 with the change in resistance of LDR R1. The idea of this setup is that the more the intensity of light incident on the LDR , more is the voltage across R2 as resistance of LDR decreases with the increase in intensity of light incident on it.

3.3 Implemented circuit

Hardware implementation of the project is done using the hardware components mentioned in chapter 2 and the connection is done accordingly. Figure 3.3 shows the hardware implementation of integrated LiFi receiver and transmitter on the same breadboard. This circuit was used for test transmission of data and similarly the number of receivers were increased according to the rooms in a house.

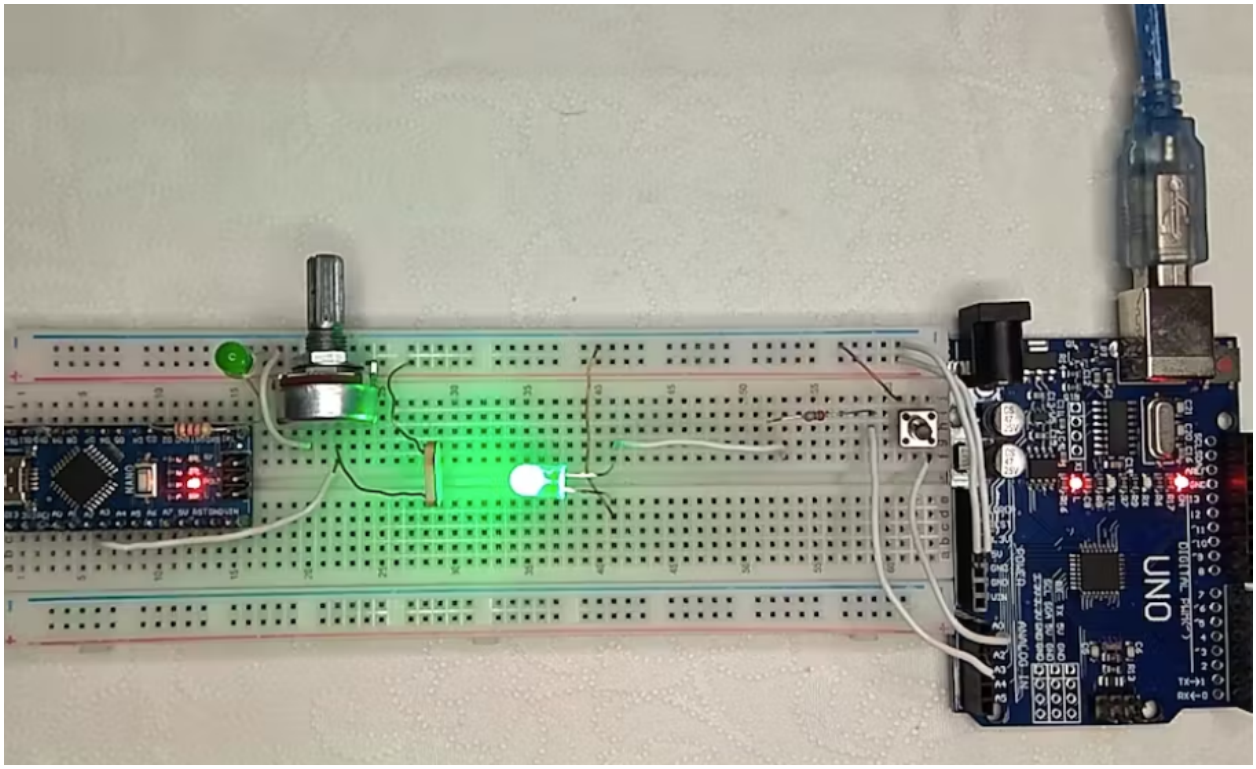


Figure 3.3 Integrated LiFi transmitter and receiver

There are two units:

a}Receiver unit

This unit consists of LDR in a potential divider circuit and speaker connected to arduino UNO as shown in the hardware setup diagram in figure 3.4

b}Transmitter unit

Transmitter unit has a transmitting LED with a resistor of 220 ohm to control the flow of current and avoid the burn in the LED attached as shown in figure 3.5.

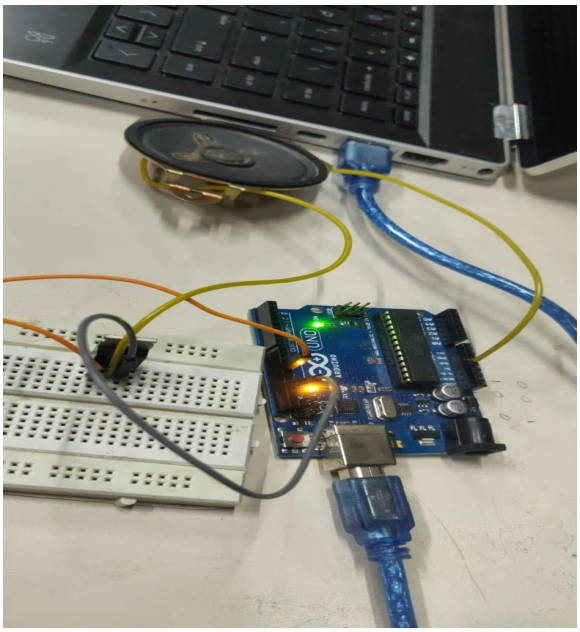


Figure 3.4 Receiver unit circuit

Figure 3.5 Transmitter unit circuit

The only drawback is the low memory of the Arduino UNO, which only allows us to play an audio of about 4-5 seconds due to its limited memory. However, we have played two mp3 audio with Arduino uno without any modules in this project. All we need is a speaker and, if one is available, an audio amplifier. Here, I'm using a transistor TIP42 for audio amplification.

We are using a PCM library that helps to play a low bitrate audio sample using an Arduino board through a standard loudspeaker.These samples are immediately encoded as a number array in the Arduino project.

3.4 Software Implementation

Software files required in this project:

1. PCM Library for arduino to play a low bitrate audio sample through an audio output.
2. Audacity software that is used to convert an mp3 audio file into a 16 bit PCM 8 Hz file.

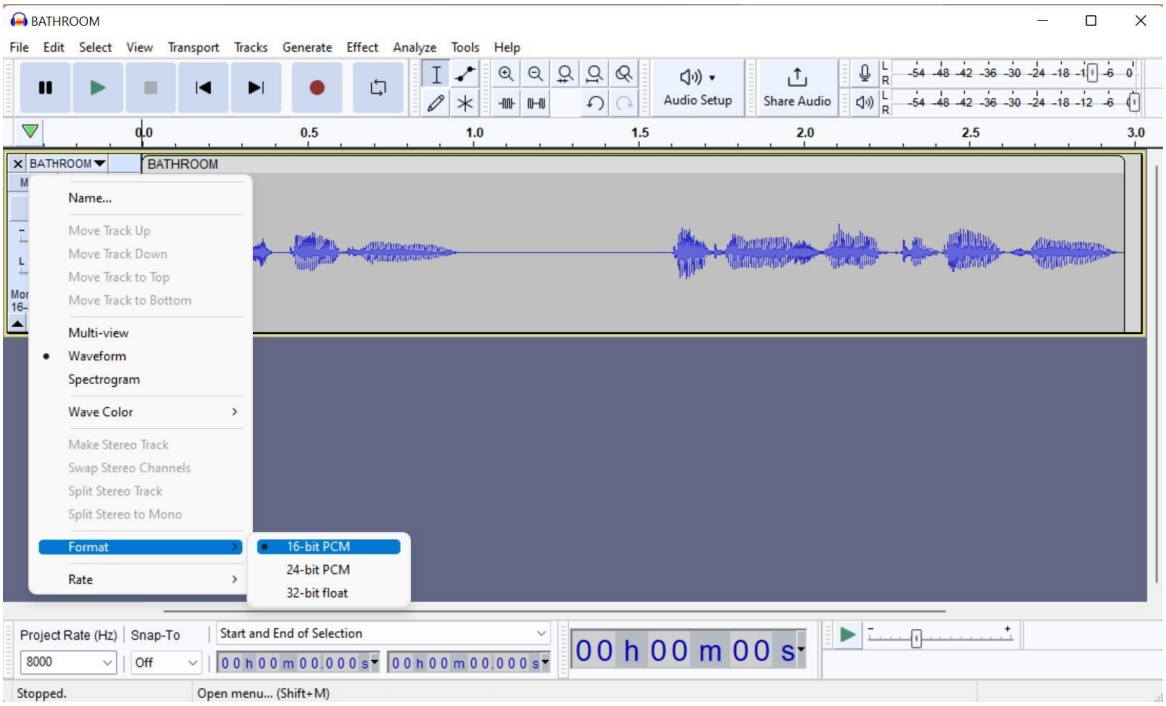
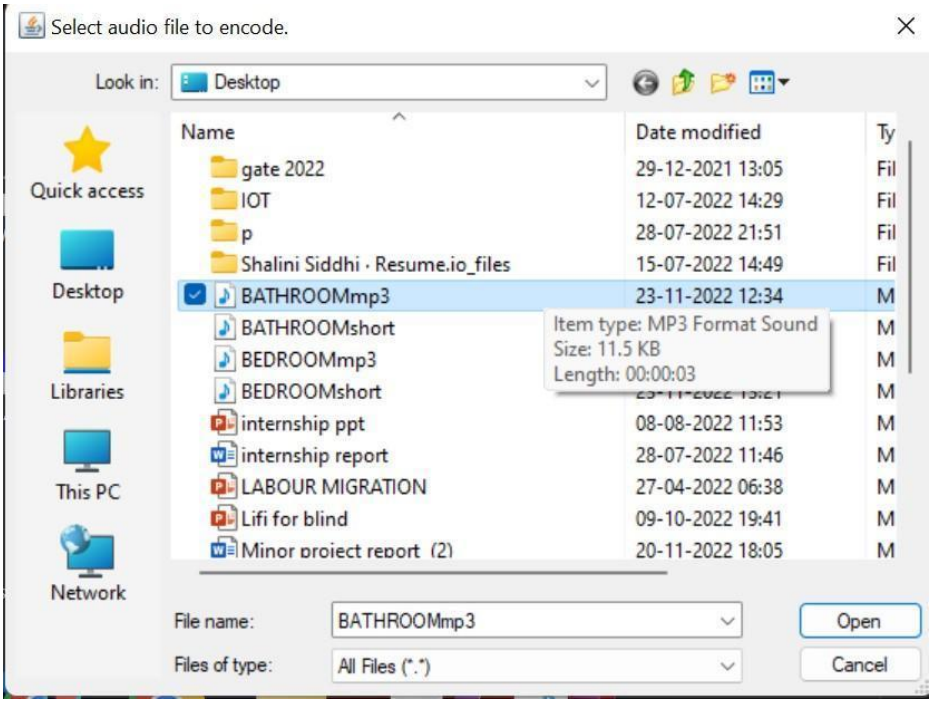


Figure 3.6 Audacity software settings

3. An encoder software :Use the EncodeAudio programme to transform the downsampled audio file into numerical values



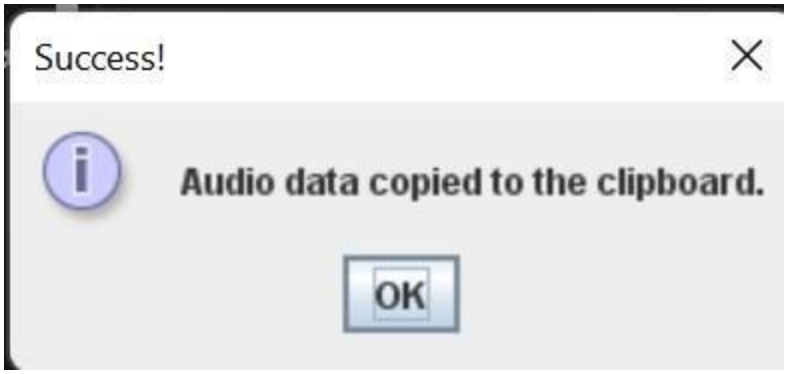


Figure 3.7 encoderAudio

software For example:

126, 125, 124, 123, 122, 121, 120, 119, 118, 118, 117, 117, 117, 118, 119, 120, 121, 123, 124,

126, 128, 130, 131, 133, 135, 137, 139, 141, 142, 143, 144, 145, 145, 145, 144, 143, 142, 140,

138, 135, 133, 130, 127, 124, 121, 118, 115, 112, 110, 108, 106, 105, 104, 104, 104, 105, 106, 108, 110, 112

We have recorded two audios

1]bathroommp3

2]bedroommp3

and converted them into mp3 and encoded them according to the steps mentioned above. The resulting encoded data was then pasted into the actual arduino code for receiver that will play the required audio according to the data received by the transmitter.

The range of transmission was successful till 7-8 meters with a really high rate of transmission. The communication was secure because the light could not penetrate through the obstacles.

Now comes the coding part where we wrote two arduino codes for the arduino installed as a transmitter at the electricity board and for the arduino placed at the receiver's stick.

That’s how our project was successfully implemented.

1]Transmitter unit:[For one room]

The LED attached to the arduino through digital pin no 11 blinks at a desired rate to transmit data stored in it.

The communication protocol in order to send the data is as follows:

Example:

Data-0b11011001

synchronizing signal- Sent along with the data in order to sample it correctly according to the specified time period. The data is read corresponding to the rising edge of the synchronizing signal.

In the beginning the receiver is at idle state when there is no transmission. And when it recognizes the falling edge before the actual data bits, it knows that the data transmission has begun.

At the end of the transmission of data bits there is a rising edge[high voltage] in order to confirm that the data transmission is finally done.

For the transmission of one bit at a time, bitwise operations are performed inside the code.

c=0x01

a] bitwise AND- & (data&c)

b]left shift - << (c<<1)

data- 11011001 data-11011001

c - 00000001 c- 00000010

& -00000001 &-00000000……and so on.

Figure 3.8 and 3.9 shows the software implementation of the proposed project on Tinkercad, a circuit simulation application. The connections are established using all the components mentioned in chapter 2 of this report. The coding part is done on the same application using the same logics as mentioned in the above section. The blinking of LED at desired rate transmitted the room information to the receiver ie: LDR and the output was shown on the serial monitor of the receiver's arduino UNO.

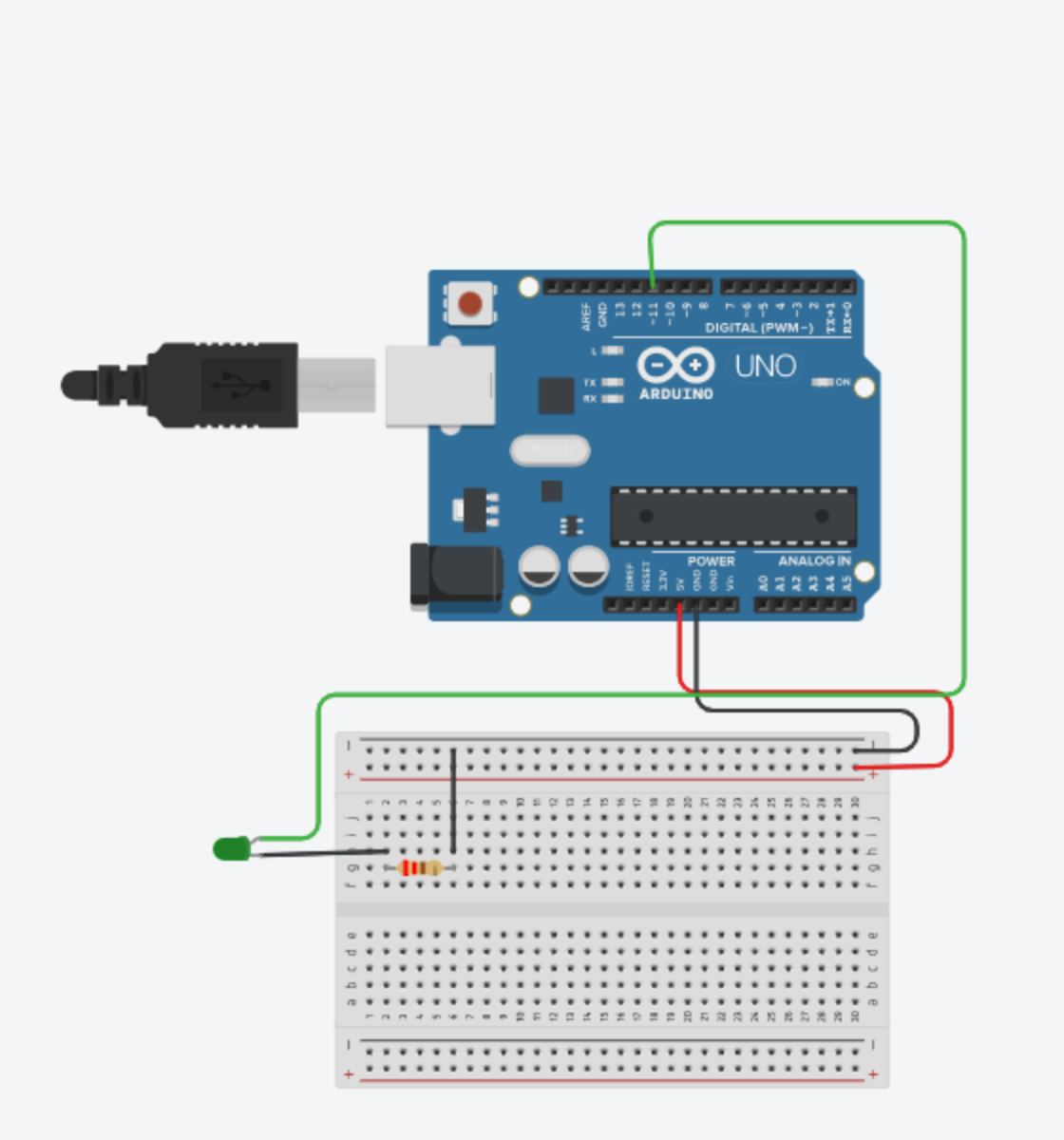


Figure 3.8 Blinking LED at transmitter side

2] Receiver unit

LDR will change its resistance according to the light incident on it and will accordingly change the voltage value hence converting the light signal into understandable electrical signal for further audio processing.

The communication protocol followed to read the data received by LDR are as follows:

We will sample the received data in the same way we did in the transmitter unit and then we will take a variable to store the data using bitwise OR(|) operator and left shift operator (<<) to get the LDR value bit by bit.

example:

rx data:11011001

ret :00000000

| :11011001

In this way accurate and reliable data can be transferred and received through this system.

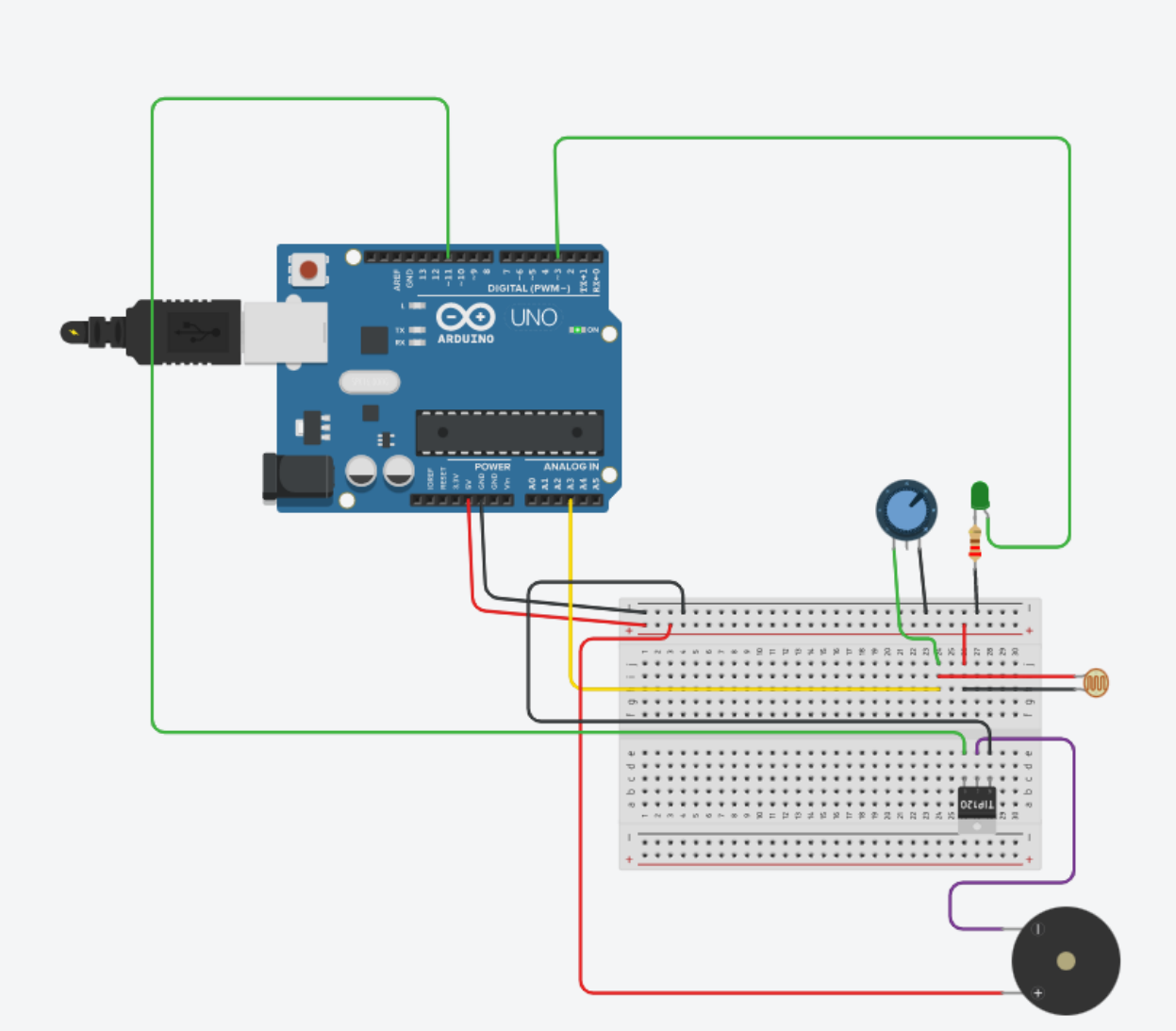


Figure 3.9 Potential divider circuit with LDR and speaker at transmitter side

CHAPTER-4

Results

Through this project, we implemented a reliable Li-Fi based home navigation system specifically for visually challenged people and reduced various challenges that this system could face by using cost effective components that can easily adapt in already surviving infrastructure. This project has various other applications that makes it more viable for the future market. High data rate, security and abundance of light sources make it a suitable option for wireless communication.

Using LED instead of other light sources and arduino instead of other available modules makes it cost effective. The expected range of Li-Fi was 10 meters, our system can work for 7-8 meters depending upon the intensity of LED and presence of minute obstacles.

Following is the result we are getting at the serial monitor of the receiver unit after the successful connection of both the transmitter and receiver circuit on software simulation of our project as shown in figure 4.1.

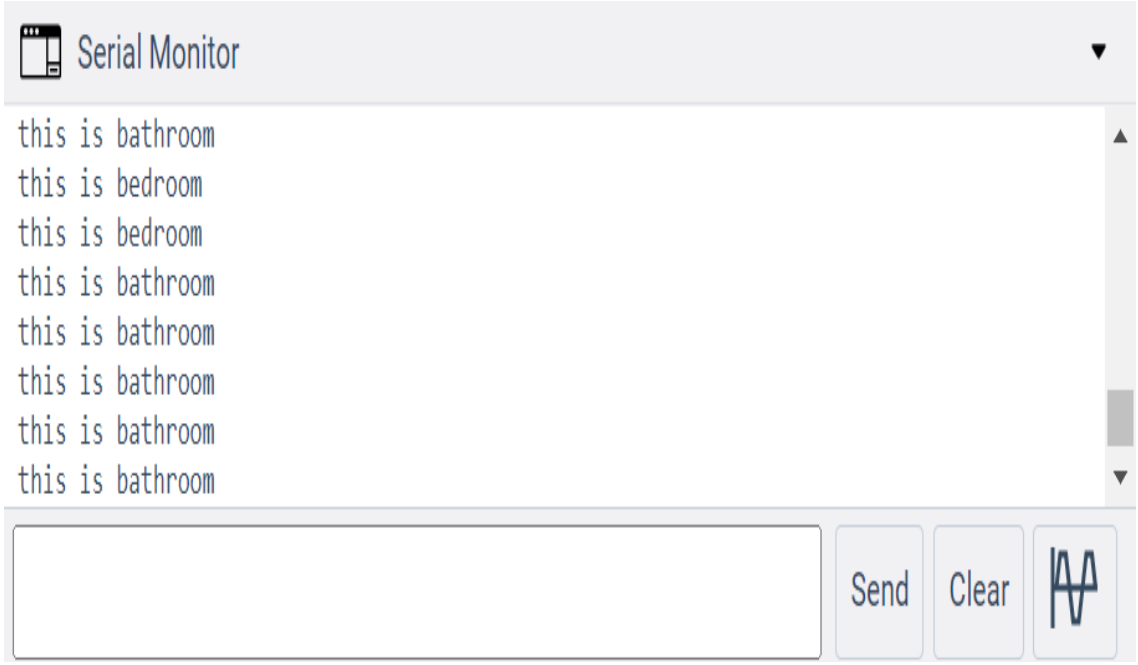


Figure 4.1 Serial monitor at receiver side

The voice output through speaker matches with the data fetched in the respective LEDs through arduino code when the LDR in the receiver unit comes in the line of sight of the particular LEDs installed at the transmitter side.

TIP120 transistor provided high enough collector current gain to amplify the output voice and play it through the speaker hence, the location voice was clearly audible when receiver came in line of sight of the transmitter LEDs.

The system worked well in a dark as well as normal lighted environment provided that the transmitter and the receiver is in line of sight of the transmitter. Selectivity and sensitivity of the system was fine enough to make the system reliable for future use by blind people.

CHAPTER-5

Conclusion

In this project, through hardware implementation, we concluded that this Lifi based home navigation system can be very beneficial for blind people living alone in a home integrated with data transferring LEDs distributed all over the required places at home for proper navigation with extra security. This system can be more powerful and accurate in future if we use laser LED in place of general LEDs at home and solar panel as a receiver in place of LDR because of better speed and spatial efficiency of both these components.

This technology is still in its early development stage and many projects are coming up which states that accepting LiFi in future can be very beneficial for the wireless transmissions due to its high speed and low cost of implementation.

Our project ,on the other hand, is using this technology for blind people at homes, hospitals or schools for security and safety purposes. Robbery, accidents and many more cases can be reduced by using this technology for blind people out there because of its promising security, less interference and high speed as compared to Wifi already used in the market, hence providing accurate and reliable indoor positioning information to the blind user with the same technology.

Moreover, the ease of implementation is ensured as almost every home has pre-installed LEDs and power supply boards for LiFi based control unit integration. Additionally, this system can be integrated with smart home devices like automatic door locking, temperature control with various voice assistants for seamless user experience.

The actual cost of implementing this project in a house with one room is about Rs 600-700 if the LEDs are already installed in the room through the main power board.

As the LEDs are installed on the entrance ceiling with filters, the clear LoS problem is almost reduced to a considerable extent. This system can work fine for the range of 4-5 metres between transmitter and receiver and the sensitivity of the system can be increased by using powerful Laser LED and solar panels.

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