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IoT implementation of underwater communication using Li-Fi

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Abstract

Li-Fi is similar to wireless communication which uses the communication medium as light. Nowadays RF interference are getting common due to maximum utility to overcome this problem Li-Fi is introduced in the year 2011. Li-Fi uses LED source to transmit data wirelessly this method is widely called as VLC (visible light communication). IoT technology using light fidelity module plays a vital role in environmental monitoring, underwater disaster management and underwater military applications. Li-Fi communication provides data rate of more than hundreds of Mbps for short ranges and it is an alternative approach to accostic communication in underwater. In Li-Fi, light emitting diode (LED) lamps acts as access points (Aps), and light is used as a medium to carry information bits. At the receiver, a photo diode is employed to collect photons and convert them into a electric current. By using Li-Fi technique, data is transmitted in the light. Photo detector absorbs the light and convert it into electrical signal. The photo detector is placed near the surface of the sea. The information is then passed to cloud storage then it is utilized for various application.

Keywords: Li-Fi (Light Fidelity); VLC (Visible Light Communication); LED (Light Emitting Diode); RF (Radio Frequency); IoT (Information Technology)

1. Introduction

Li-Fi is a visible light communication which is used for high speed communication. The basic ideology behind this technology is that the data can be transmitted through led Light whose intensity varies even faster than the human eye. By using li-fi technique, data is transmitted in the form of light. Photo detector absorbs the light and it converts it into electrical signal. The heart of this technology lies in the intensity and the potential of the light emitting diodes. The transmitted data is uploaded to a cloud and stored for later use. Underwater acoustic communication is a technique of sending and receiving message below water. Compared to terrestrial communication, underwater communication has low data rates because it uses acoustic waves instead of electromagnetic waves. There has been a large demand for high-speed real-time underwater wireless links to load a wide range of underwater applications such as environmental monitoring and pollution control, underwater exploration offshore oilfield exploration, maritime archaeology, scientific data collection, port security, and tactical surveillance among others. Generally, Radio waves propagate at a very long distances through conductive sea water only at extra low frequencies (30-300 Hz), which require a very large antenna and very high transmission power. So radio waves are not suitable for underwater communication. Acoustic communications suffer from a very small available bandwidth less than 100 KHz, very low celerity and large latencies due to the low propagation speed. Li-Fi communication provides data rate of more than hundreds of Mbps for short ranges and it is an alternative approach to acoustic communication in underwater [3].

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2. Methodology

The proposed system comprises of a transmitting section, antenna and satellite and a receiving section with IOT support for underwater communication using Li-Fi. The system can be visualized in short with the below block diagram shown in Fig.31.Here the water channel is the medium through which communication takes place [2].

Figure 1 Block diagram of the system

Transmitting section-The transmitter section primarily consists of a microcontroller equipped with the power supply unit, a Li-Fi transmitter (LED), a 1x5 push button Keypad and a Bluetooth module for better user interface. With the integration of Bluetooth module and keypad, we have developed two modes of operation (i.e.) manual mode and Bluetooth mode. The users can select any one of these modes for operation such that it meets their needs and requirements. The power supply unit is meant for providing the required voltage for the microcontroller unit (12V). The keypad unit is programmed for sending predefined data and in mode selection (i.e.) between manual mode and Bluetooth mode. For manual mode, the messages or data is sent through keypad whereas in Bluetooth mode, the messages and data are sent via Bluetooth through PC or mobile phones. The li-fi transmitter comprises of a white LED packed up in a converging beam case for higher intensity and accuracy. Light is used as source in Li-Fi technology. In the transmitter section, an LED is switched on and off depending upon the arrival of binary data. Through the photo detector in the receiving section, the data will be decoded. The various advantages of Li-Fi are implementation is simple since it uses only LED and photo detector. It provides high security over the data as it can't penetrate through any metallic blocks or walls. Multiple devices can be accessed at any instant and result in no overloading of networks [2].

Buoys, antenna and satellites-A buoy is a floating object that is used to show ships and boats where they can go and to warn them of danger. The photodiodes are placed at the bottom part of the buoys (inside the water, dipped) [7].

After sensing the light, the photodiode converts it to electrical signal. This electric signal is transmitted above the sea surface to the antenna. Satellite transmitter is used to communicate with the antenna in the buoy which is controlled by onshore sink. The signal is transmitted from the satellite to antenna of another buoy within whose range the destination ship is located. The electric signal received by antenna is converted to optical signal using LED/LASER connected to motor (for 360 degree rotation) and is passed to the water. This optical signal is sensed by the photodiode of the destination ship [7].

Receiving Section-The receiving section primarily comprises of a photo detector (photodiode) coupled with a PIC microcontroller, a GPRS/GSM - IOT modem. The photo detector is used to detect the arriving signal and the signal is processed at the microcontroller.. The received information is then send to cloud via GPRS/GSM - IOT modem where the information is received and it can be used for further processing analyzing and monitoring purposes [2].

2.1. Block Diagram

Block diagram of transmitter and receiver for text transmission

2.1.1. Transmitter Section

The block diagram shown in the figure 1 represents the operation of transmitter. In transmitter section Switches AC 230V input is given to microcontroller ATMEGA328 which is in the arduino mode processes the signal and the encoded output is given to the amplifier section which amplifies the low voltage level signal to drive an LED. The data is transmitted in the form of light to the receiver.

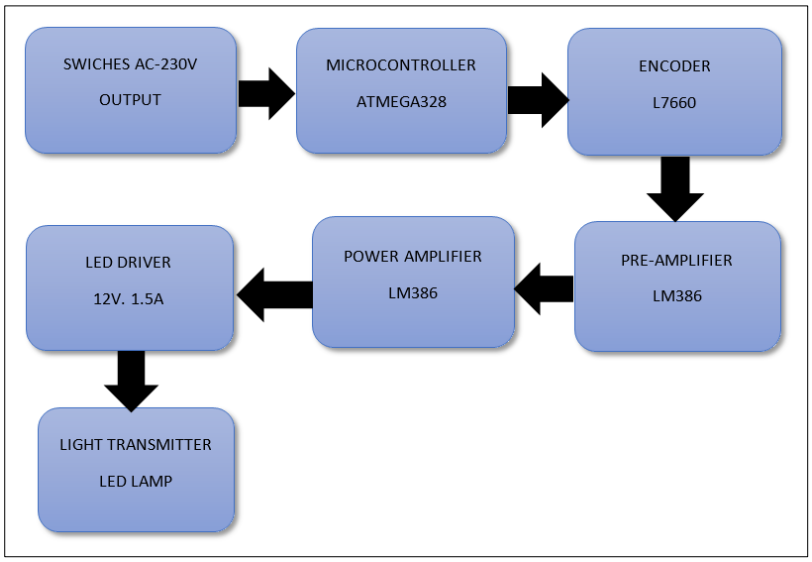

Figure 2 Block diagram of transmitter for text transfer

2.1.2. Receiver Section

The light receiver receives the text in the form of light from the light transmitter and this transmitted signals will be at low voltage range. So it is amplified to the arbitrary voltage level using an amplifier. This amplifier is same type of amplifier whch we use in the transmitter side. The decoded output is fed to the microcontroller and the text is displayed on the LCD and uploaded to the cloud and used for various applications.

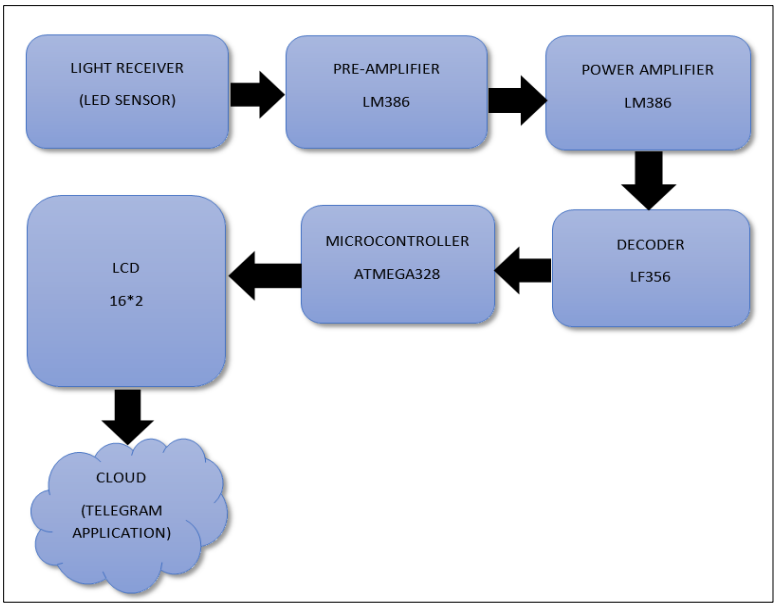

Figure 3 Block diagram of receiver section for text transfer

Block diagram of transmitter and receiver for image transmission

To transfer the image, we use two personal computers with application software. It is programmed to transfer through the Li-Fi transmitter to the receiver the image is then displayed on the other PC. The maximum limit of image is 10*10 pixels.

Block diagram of transmitter and receiver for audio transmission

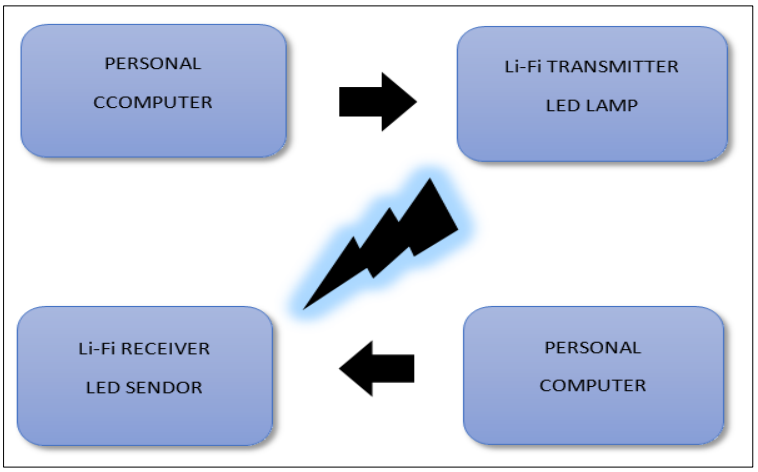

Figure 4 Block diagram of transmitter and receiver for image transfer

2.1.3. Transmitter Section

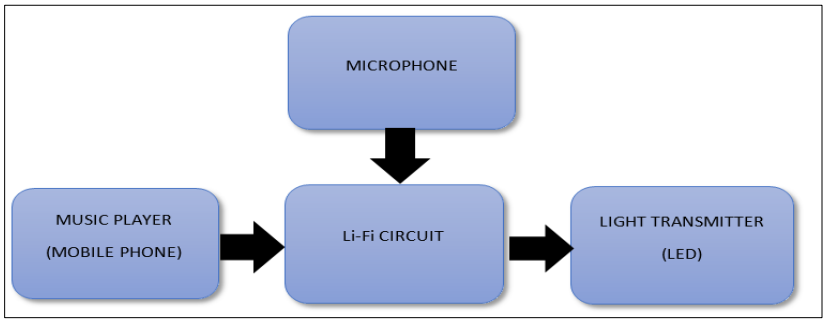

Figure 5 Block diagram of transmitter section for audio transfer

This is the block diagram of transmitter for transmitting audio, here the music player is fed to Li-Fi circuit via microphone using 3.5mm audio jack which is used to connect the device with Li-Fi as input audio signal. The audio signal is transmitted to the receiver in the form of light.

2.1.4. Receiver Section

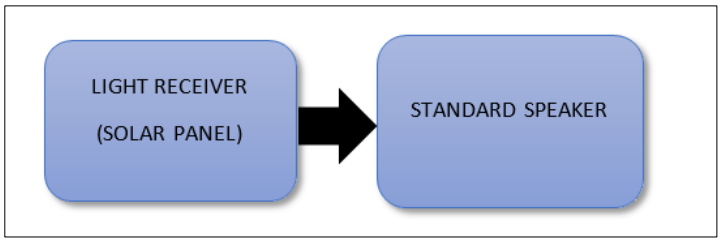

Figure 6 Block diagram of receiver section for audio transfer

This is the block diagram of receiver for receiving the audio signal in the form of light from the light transmitter which receives the audio signal and fed to the speaker.

2.2. Implementation

The implementation steps for device switching, text transfer and image transfer is as follows

The line of sight has to be established for communication to take place between transmitter and receiver. Arduino UNO, Power supply unit, Switches, LCD and the LED lamp of Li-Fi module constitute the transmitter section. Relays, LCD, Node

MCU, LED Lamps, Arduino UNO, Power supply unit, DC Motor, sensor of Li-Fi module constitute the receiver section. TTL is used to connect between the transmitters, receiver laptop with the hardware module.

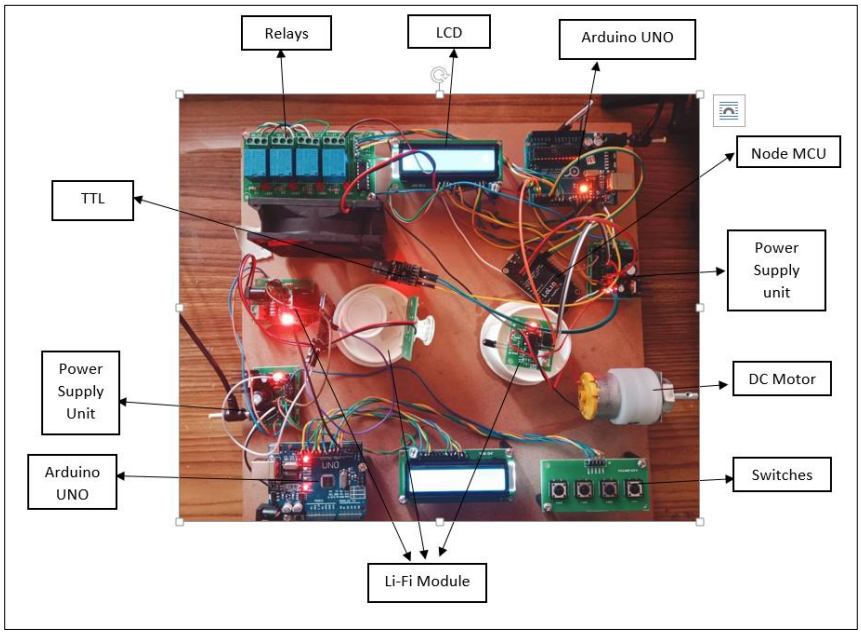

Figure 7 Hardware connection of the implemented model

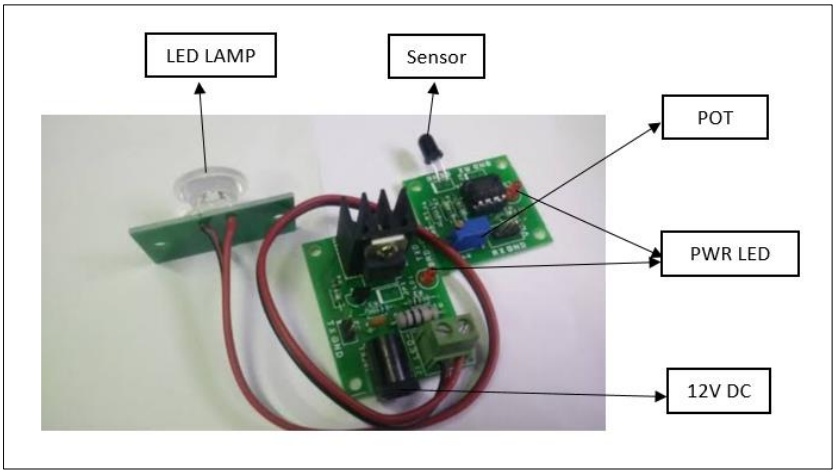

Figure 8 Li-Fi module

2.2.1. Line of sight

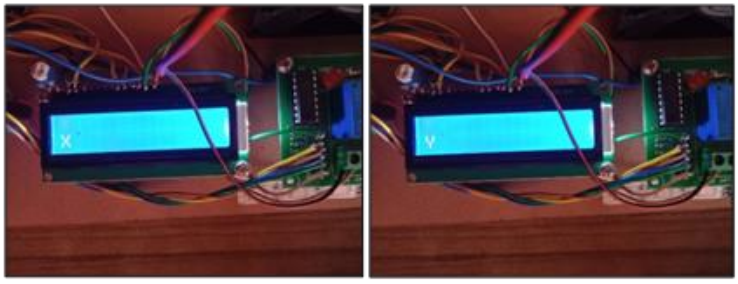

Figure 9 LCD showing 'X' and 'Y' in Line of Sight Communication

2.2.2. Device switching

Once the line of sight communication is established device switching can be done. When switch '1' of transmitter section is pressed 'ON' the LED of the relay glows and fan of receiver section switches 'ON' and is displayed on LCD. When the same switch is turned 'OFF' then the LED of the relay puts 'OFF' and fan also switches 'OFF' and is displayed on LCD. Similarly when switch '2' and '3' is pressed 'ON' the LED of the relay glows and when pressed 'OFF' the LED of the relay puts 'OFF'. When switch '4' is pressed 'ON' the LED of the relay glows and a DC Motor is switched 'ON' and when pressed 'OFF' the LED of the relay puts 'OFF' and DC Motor stops. The information is then uploaded to the cloud, i.e., telegram application is used to store the communicated data.

2.2.3. Text transfer

Text transfer to happen, two laptop's one at the transmitter and the other at the receiver are used. Flash magic software installed at the transmitter side and Arduino IDE software installed at the receiver side.

A TTL is used to connect the laptop with the Li-Fi module hardware module. With the line of sight established the text can be transferred in real time between the transmitter and receiver.

2.2.4. Image transfer

The Arduino IDE is installed in both laptops at the transmitter and receiver ends. Both transmitter code and receiver code should be running simultaneously in both laptops for image transfer to happen. The reconstructed image is shown in receiver side laptop screen.

2.2.5. Audio transfer

Earphone has to be connected to a mobile phone with music player along with 9V power supply. An LED is connected along the power supply and the LED light is flashed on a solar panel. The audio playing in the mobile phone is heard through a speaker.

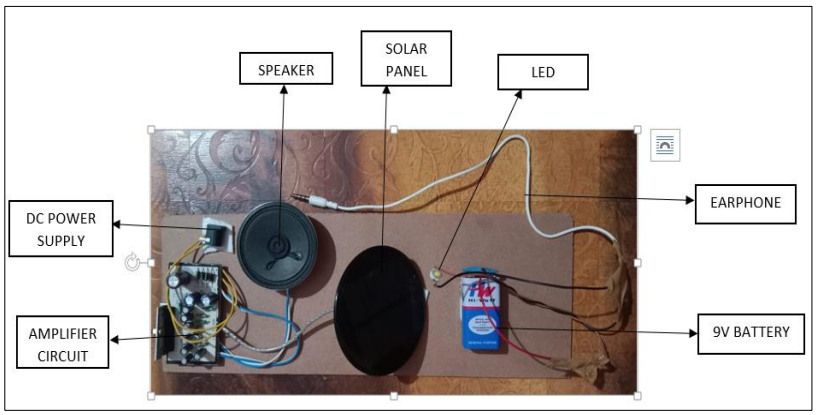

Figure 10 Audio Transfer module

3. Results and discussion

The following are the outcomes in real time and is shown below accordingly.

3.1. Device switching

When switch '2' is 'ON' as shown on LCD, the LED bulb of relay glows and a different colour LED is also used to show that device '2' is 'ON'. As a additional LED, a fan or a motor also can be used. When the switch is turned 'OFF' it is displayed on the 'LCD' and the 'LED' also turns 'OFF'.

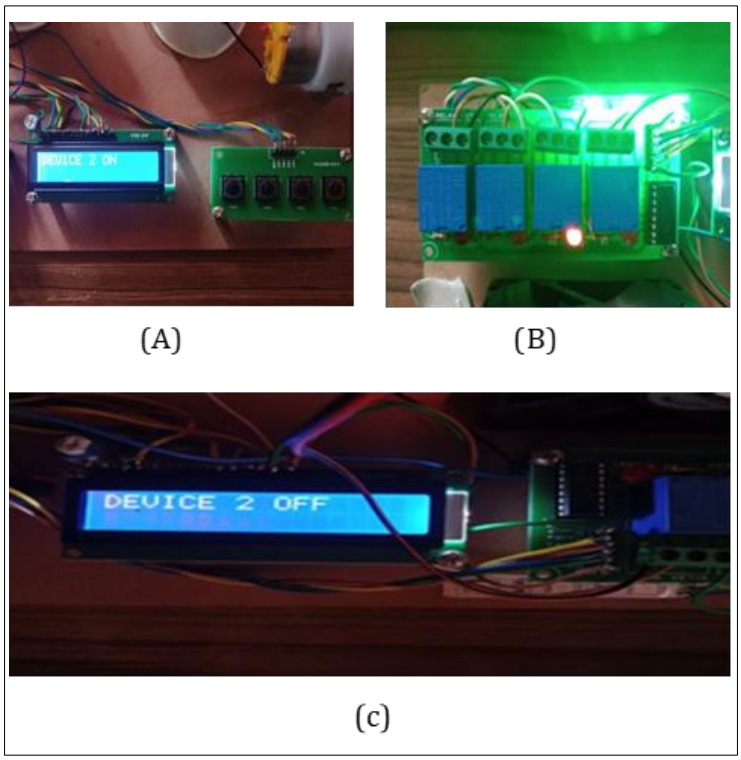

Figure 11 (a), (b), (c) Device Switching output

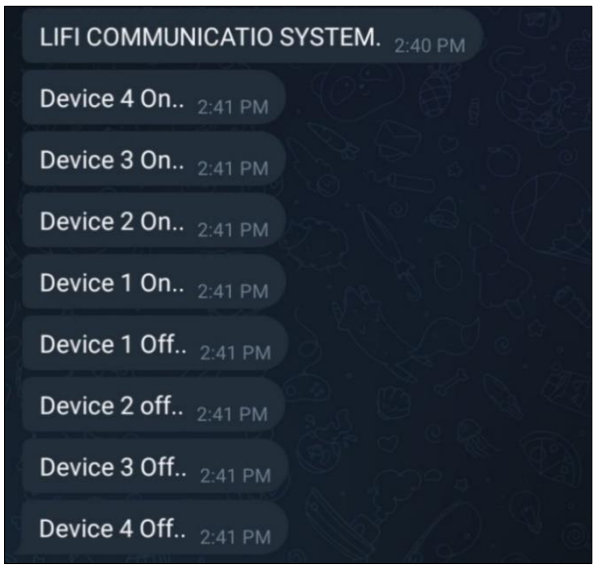

Figure 12 Information Uploaded to cloud(Telegram)

3.2. Text transfer

The text transfer is done in real time. The message sent by the transmitter is displayed on the screen of laptop in the receiver section.

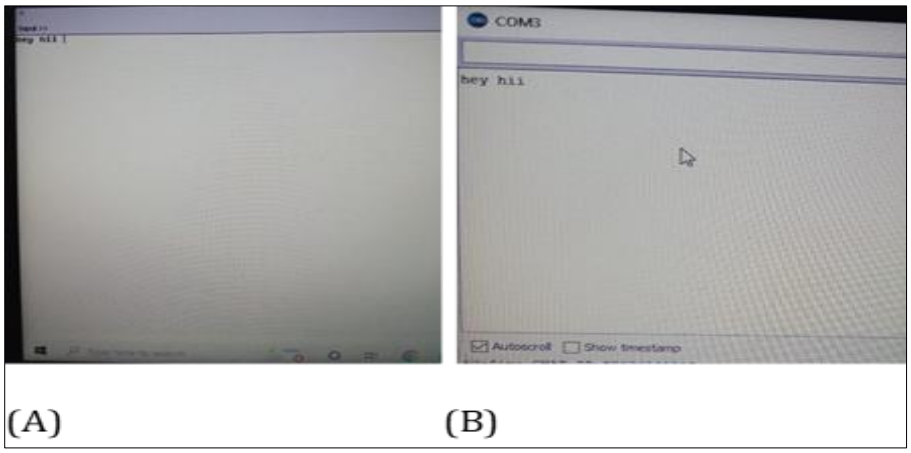

Figure 13 (A) Input message sent at the transmitter (B) Output message read at the receiver

3.3. Image transfer

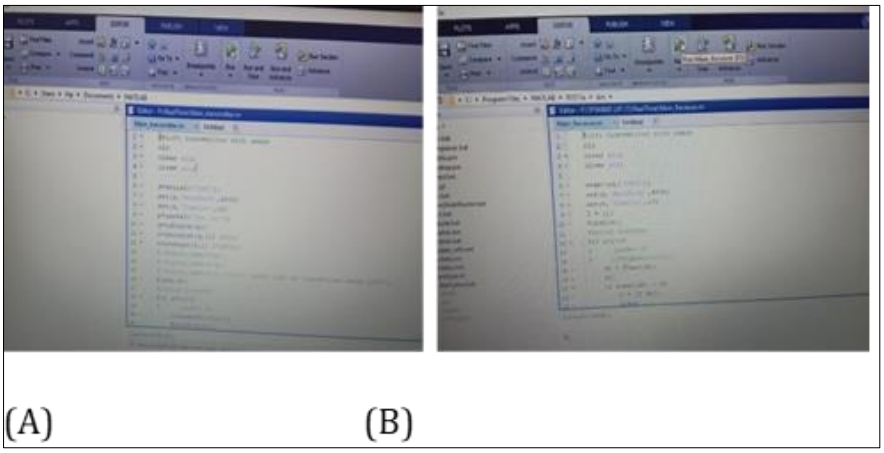

Figure 14 (A), (B) Screenshot Code running simultaneously at transmitter end and receiver respectively

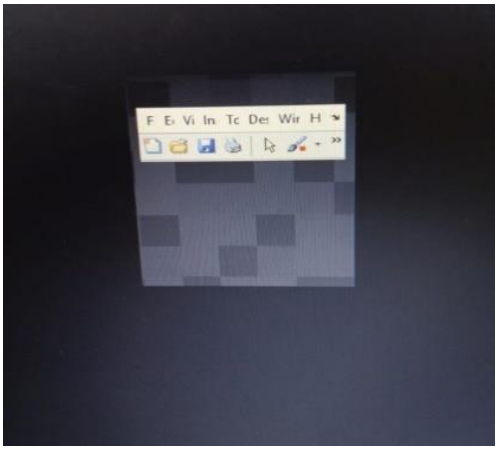

Figure 15 Image reconstructed at the receiver end

The image transfer technique requires to run the program simultaneously in the background in the transmitter and receiver end. The image is reconstructed at the receiver end.

3.3.1. Advantages

- Green information technology

Green information technology means that unlike radio waves and other communication waves affect on the birds , human body's etc. Li-Fi never gives such side effects on any living thing.

- Free From Frequency Bandwidth Problem

Li-fi is an communication media in the form of light, so no matter about the frequency bandwidth problem. It does not require the any bandwidth spectrum i.e. we don't need to pay any amount for communication and licence.

- Increase Communication Safety

Due to visual light communication, the node or any terminal attach to our network is visible to the host of network.

- Multi User Communication

Li-Fi supports the broadcasting of network, it helps to share multiple thing at a single instance called broadcasting.

- Lightings Points Used as Hotspot

Any lightings device is performed as a hotspot it means that the light device like car lights, ceiling lights, street lamps etc

3.4. Disadvantages

- It can cover a short range upto only 200m. Long distance transmission may lead to loss of information.
- The receiver and transmitter should be placed in line of sight, if not placed the information is not transmitted.

3.4.1. Application

- Underwater Applications

Underwater ROVs (Remotely Operated Vehicles) operate from large cables that supply their power and allow them to receive signals from their pilots above.

- Disaster management

Li-Fi can be used as a powerful means of communication in times of disaster such as earthquake in underwater or hurricanes. The average people may not know the protocols during such disaster.

4. Conclusion

Currently, the Acoustic waves are used for the purpose of underwater communication. Now we are implementing Li-Fi as an IoT for underwater communication. When the photodetector receives the signal, it sends it to sink. Later the results can be exported to the cloud. We have received the details via mobile application. The possibilities are numerous and can be explored further. If his technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, highspeed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

Future scope

As Light is everywhere and loose to use, there's a remarkable scope for the use and evolution of Li-Fi generation. If this technology becomes mature, each Li-fi bulb can be used to transmit wi-fi data. As the Li-Fi era will become famous, it will result in a cleaner, greener, more secure communications and feature a vibrant destiny and surroundings. The idea of Li-Fi is deriving many humans as its far free and faster means of information transfer. If it evolves faster, human beings will use this generation increasingly more. A higher end camera and laser can be used to achieve better efficiency

and higher transmission speed. A camera and a laser can be used at both receiver and transmission end to establish two way communication. This project can be used in Robotics control. This project can be used in Heavy machinery controls in varies industries. By using Li-Fi we can have energy saving parallelism. With growing number of people and their many devices access wireless internet, on one way data transfer at high speed and at cheap cost. In future we can have LED array beside a motorway helping to light the road, displaying the latest traffic updates and transmitting internet information to wirelessly to passengers Laptops, Notebooks and Smart phones. This is the kind of extra ordinary, energy saving parallelism that is believed to deliver by this pioneering technology.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

There are no conflicts of interest in connection with this paper, since the paper is implemented and results are original in nature.

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