ISSN(Online): 2320-9801
ISSN (Print) : 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2016

Indoor Communication through Li-Fi

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ABSTRACT: As human dependence on wireless mode of communication is increasing day by day, it has become necessary to explore new frontiers in this field which can reduce the load on the radio frequency spectrum.Li-Fi technology, an acronym for light fidelity, uses the visible light portion of the electromagnetic spectrum for transmitting data. Light emitting diodes (LED) are generally used for this purpose as they can serve the dual purpose of illumination and data transmission. This paper illustrates the implementation of Indoor Communication through Li-Fi.

KEYWORDS: Li-Fi,LED, visible light communication

I. INTRODUCTION

The radio spectrum is highly congested and the exponentially increasing demand for wireless data is worsening the situation. To improve the situation, more cell towers are being deployed, their number reaching almost 1.4 billion. But clearly, this is not enough [1]. Also, doubling the infrastructure does not necessarily mean double the capacity. Further, research on RF radiation has shown that high levels of radiation have adverse impact on the environment and human health.

Visible light is a natural source of energy and can be used to complement the existing system which uses radio frequency range. The visible spectrum is unlicensed and has wide bandwidth. As a result, a large number of users can be accommodated and each user can utilize a large portion of the bandwidth to transmit their information.

LEDs can be switched on and off at a very high speed. This property of LED is used for data transmission. The on-off motion can be used to represent 1s and 0s of the data [2][4]. White LED bulbs are normally used for lighting purpose by applying a constant current to the LED. In addition to illumination, these LEDs can be used for transmission of data, which minimizes the cost of hardware installation.

II. RELATED WORK

The first reference to conceptual investigation and prototype building of a VLC system comes from the father of the telephone,Alexander Graham Bell.Graham Bell and his assistant succeeded in transmitting the world's first wireless telephone message over a distance of 213 meters. Their design used the sunlight as source.

The idea of using light as means of communication was revived when German Physicist, Harald Hass introduced the term Li-Fi, which he also referred to as — data through illumination. The term Li-Fi was first used by Haas in his TED Global talk on Visible Light Communication. According to Hass, the light, which he referred to as D-Light, can be used to produce data rates higher than 10 megabits per second which is much faster than our average broadband connection.

OFDM based visible light communication has been implemented on an experimental basis[7]. Calculations for SNR and BER have shown a satisfactory performance. On a smaller scale, on off keying has been used as the modulation technique[2][3][4].

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III. ORGANIZATION OF THE REPORT

The rest of the report is organised into the following sections:

- Proposed Solution: It describes the system level block diagram indicating the main hardware and software components.
- Hardware Implementation: It describes the components used in the transmitter and receiver sections and their working in detail.
- Software Implementation: This section describes the framing of data and the basic algorithm used for transmission and reception.
- Results: The data rates achieved are mentioned and screenshots of Graphical User Interface are added.
- Conclusion

IV. PROPOSED SOLUTION

A. *Description of the Proposed Algorithm:*

The project described is mainly focused to provide an option to short range RF communication with high speed data transfer capability. Currently, Bluetooth, Wi-Fi etc. are used for short range communication[2][3]. A system using visible light can be utilized in places such as hospitals, shopping malls, etc. We present a simple transmitter and receiver circuitry along with the use of minimal software which is capable of transferring data at a speed of few kbps.

For our project we aim to design a prototype of indoor communication link (downlink only). The setup consists of 3 receivers and 1:3 transmitter, an office like environment where there can be multiple receptors from a single or multiplexed transmitter hub. Hence communication can be peer-to-peer or broadcast. The transmitter can be installed in current infrastructure with little changes in the actual implementation of our prototype design. The transmitter can decide to send data to all users or a single receiver. The user is equipped with a Graphic User Interface(GUI).

The circuits explained further are for a single transmitter and receiver. The same has been employed for all the sub modules.

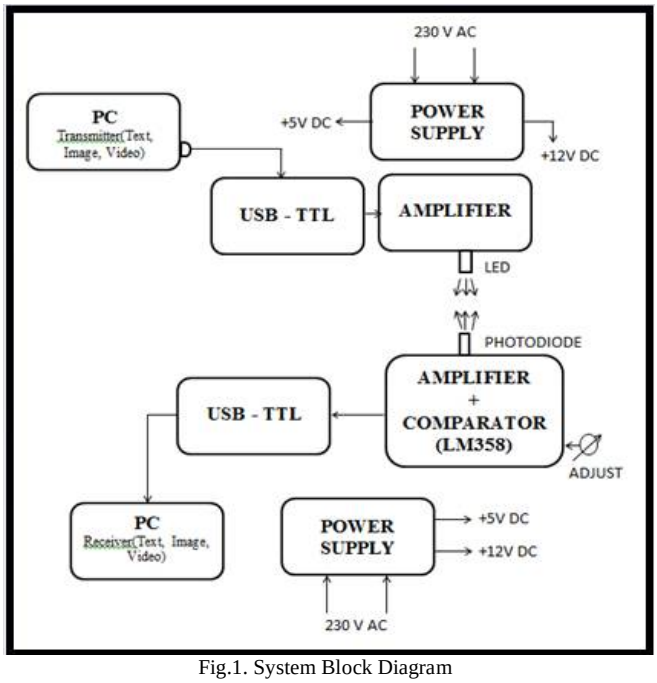

Fig.1. System Block Diagram

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V. HARDWARE IMPLEMENTATION

A. *Transmitter section*

The first part of the transmitter is the power supply circuit.It consists of IN4007, a switch and positive voltage regulator LM7805. At the output, we get +5V which is used to drive the torch.

The USB to TTL module(CP2102) converts the data bits into digital format. But, the output voltage is very low and is not enough for the torch to glow at its full brightness. Hence, we need a current driver circuit to increase the output voltage level. We use high power fast switching NPN transistor 2N3053 for this purpose.The serial data stream continuously switches the transistor hence led. There is one transmitter driving three torches hence data transmitted from each is same.

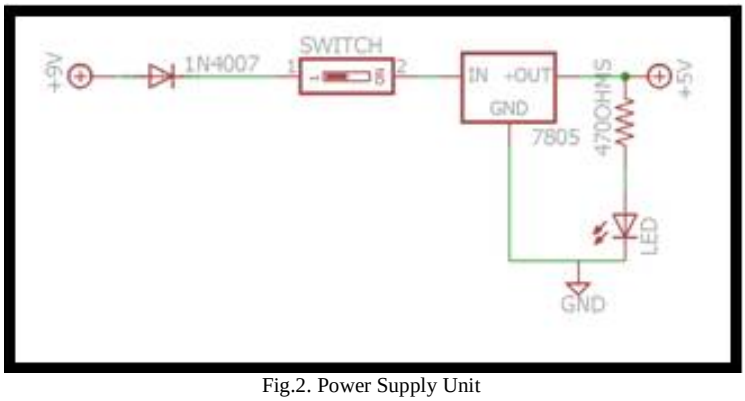

Fig.2. Power Supply Unit

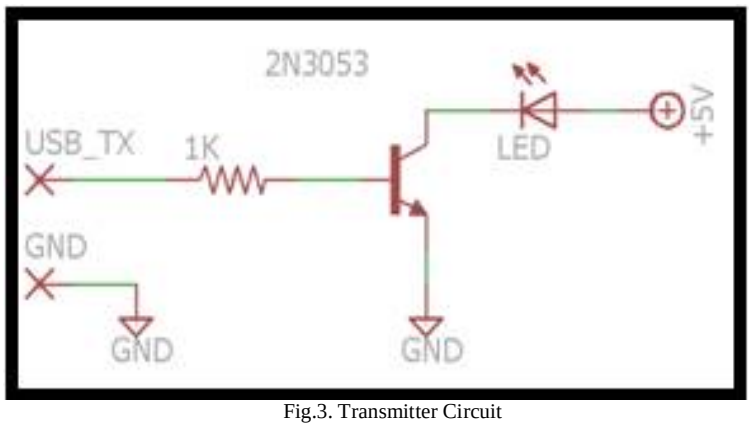

Fig.3. Transmitter Circuit

B. *Receiver section*

The light signal coming from the torch is incident on photodiode BPW34. BPW34 is a silicon PIN photodiode with high sensitivity to visible radiation and is a high speed photo detector. The photodiode converts the light intensity into electrical signal. The sensitivity of BPW34 is set to detect max. light to produce max outpu.t and also according to experimental setup which include the intensity of transmitter led, transmission distance and ambient light interference. The output of the photodiode is a weak signal which is amplified using LM358 Op-amp. Thus the amplified signal (corresponding to the bytes received) is fed to the CP2102 module and the transmitted file is reconstructed at the receiver side using the software developed.

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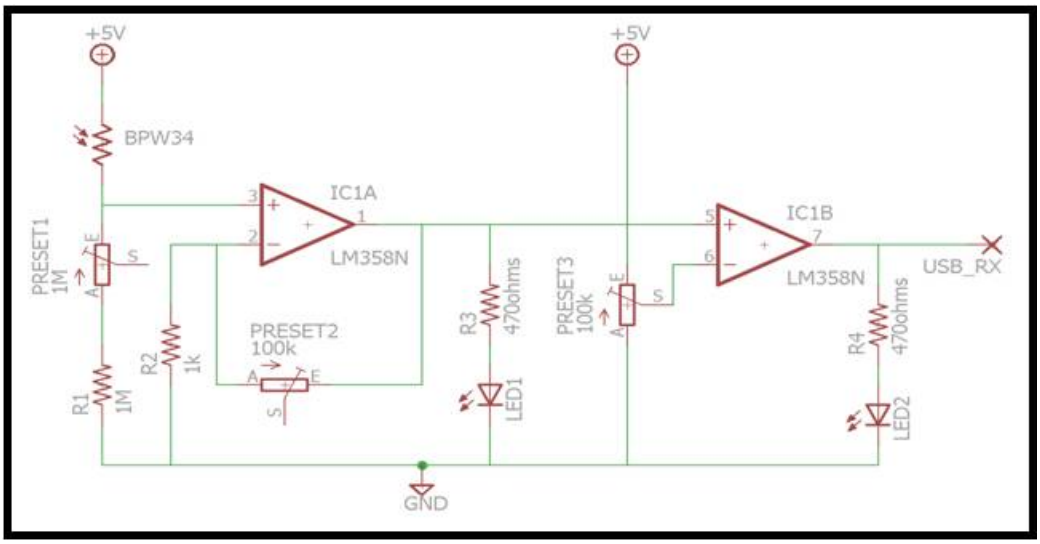

Fig.4. Receiver circuit

VI. SOFTWARE IMPLEMENTATION

The software being used in the project is Visual Basic.Net 2008 and Visual Studio 6.0 [5]. The software frames the data into packets and is also used for providing a Graphical User Interface.

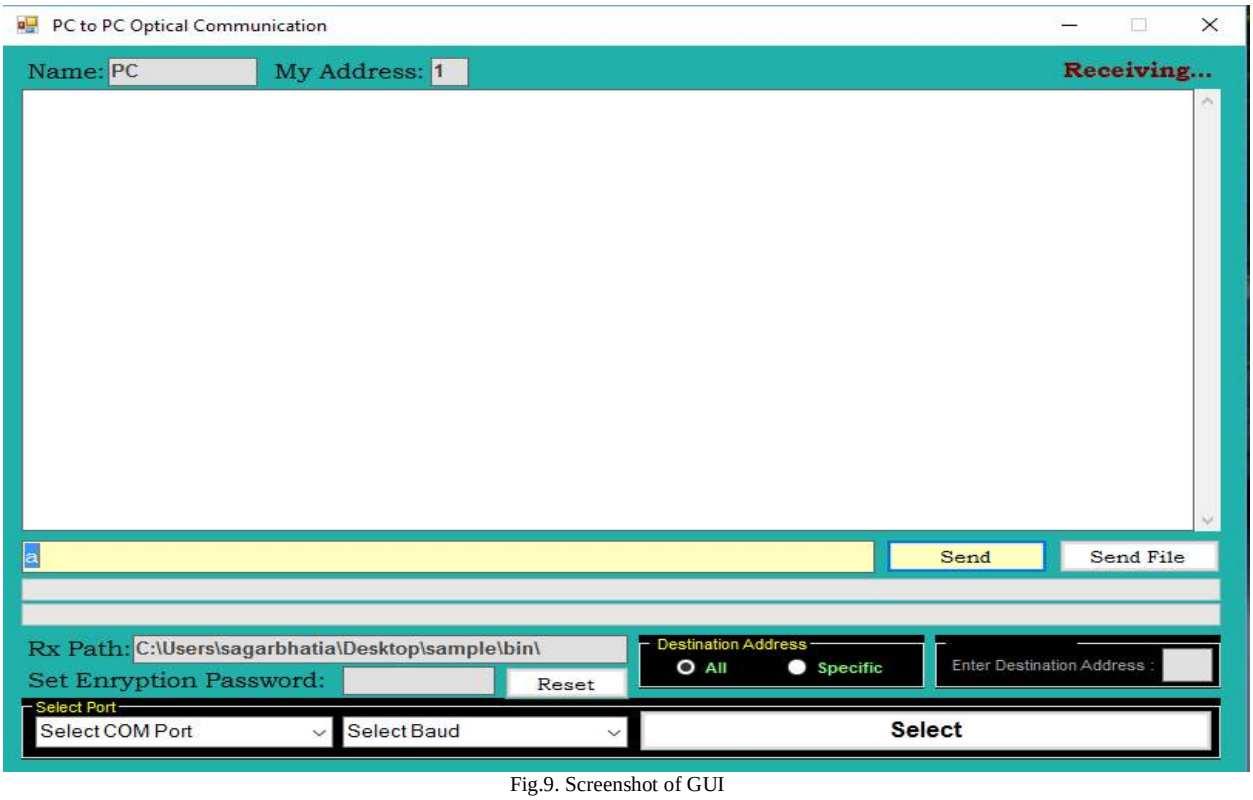

Fig.9. Screenshot of GUI

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A. *Data Framing*

Initially, when there is no data to be sent, the output bit is set high and the torch is continuously on. When we transmit data, the LED blinks according to the zeroes and ones of the message being sent. But this blinking is so fast that it is undetectable to human eyes.

Since our project can be used to send message or a file, two different methods of framing are used for the two cases:

1. For Message:

Chr(30)	Destination address	Source address	Message bytes	Chr(2)

Fig.5. Frame Format for message

2. For File:

Chr(30)	Destination address	Source address	Chr(1)	File Length	Chr(2)	File Name	Chr(2)	File Bytes	Chr(1)

Fig.6. Frame Format for File Transfer

Characters 1,2 and 30 are non-printable characters.So, they do not cause any change in data and act as start and stop bits.

VII. SENDING AND RECEIVING ALGORITHMS

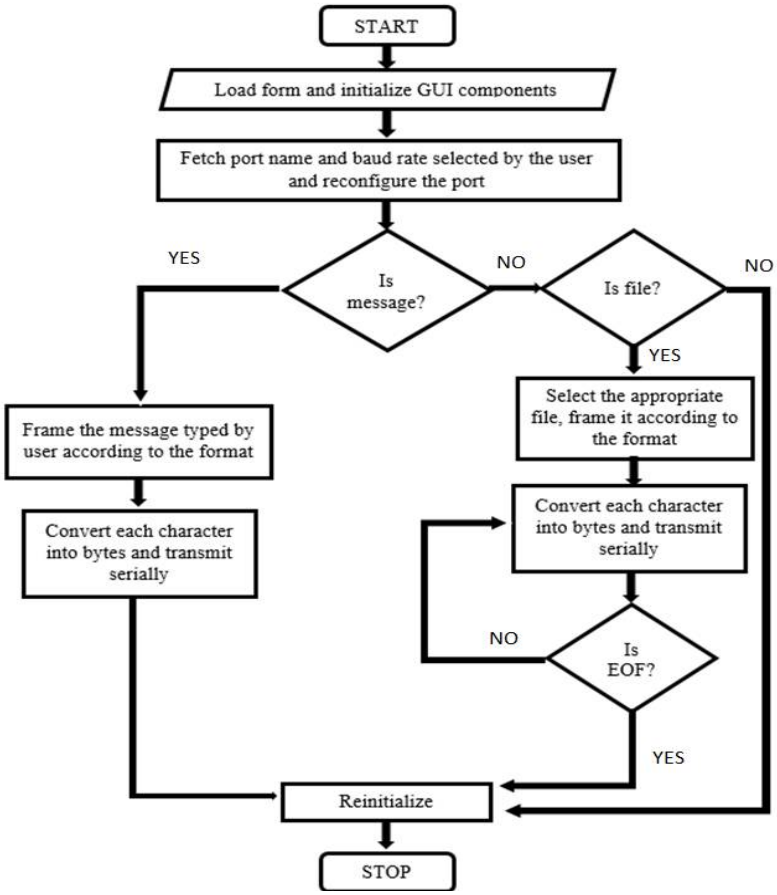

Fig.7. Sending Algorithm

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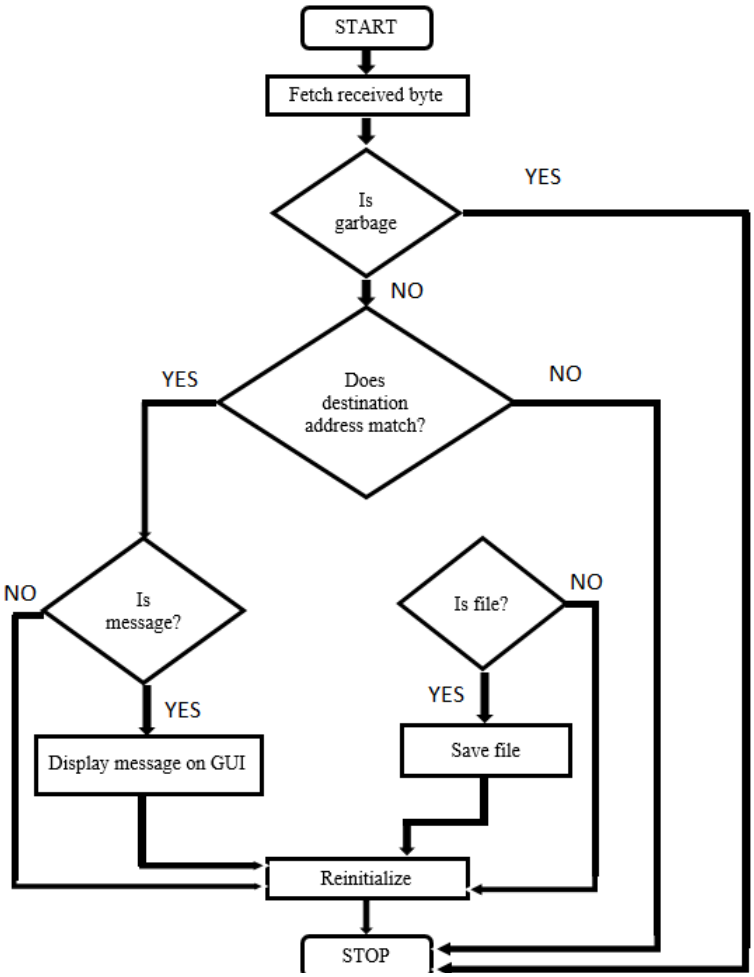

Fig.8. Receiving Algorithm

VIII. RESULTS

The maximum distance of successful data transfer was found to be 1m. The downlink speed of transmission was found to be 8kbps.Short message,text file as well as image file was successfully transmitted over this distance. A 44 KB image file was transmitted in 45 seconds. In this case,the time taken was slightly more. As the distance between the transmitter and receiver was reduced, data transfer took place at a higher speed.For a separation of about 50 cm, the speed increased to 9 kbps.

IX. CONCLUSION AND FUTURE WORK

In this paper, data transmission in an indoor environment using visible light was presented.Till now, LEDs were mostly used for lighting purposes. This project gives a new dimension to them as data transmitter. It is observed that as the distance increases the time taken for file transfer increases. Also, as the size of the file becomes larger, time taken increases.

Currently, no modulation technique has been employed in the prototype, which increases the chances of data being corrupted and affected by ambient light. With further improvements in the project, data rates and distance of transmission can be increased by using suitable modulation techniques such as ASK or OFDM.Also, the current model is only for downlink transmission.By introducing some changes, the system can be made full duplex.

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