LIFI TECHNOLOGY: VISIBLE LIGHT COMMUNICATION AND ITS APPLICATIONS

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Abstract— German physicist Harald Hass had proposed Visible Light Communication (VLC) using a Li-Fi system which provides transmission of data through illumination by sending data through an LED light source. The intensity can be controlled and adjusted such that it appears as normal light to the naked human eye. Hence it is an application for a free, green and sustainable source which can be used for wireless communication at very fast data rates. This report focuses on the many such applications. Due to the low cost LED's we could create numerous applications where the day-to-day light sources have their primary purpose of only emitting light.

Index Terms— Li-Fi, wireless communication, LED, data rates

1. INTRODUCTION

Transfer of data from one place to another is one of the most important day-to-day activities. The current wireless networks that connect us to the internet are very slow when multiple devices are connected. As the number of devices that access the inter-net increases, the fixed bandwidth available makes it more and more difficult to enjoy high data transfer rates and connect to a secure network. But, radio waves are just a small part of the spectrum available for data transfer.

A solution to this problem is by the use of Li-Fi. Li-Fi stands for Light-Fidelity. Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through an LED light bulb (shown in Fig. 1) that varies in intensity faster than the human eye can follow.

Li-Fi is the term some have used to label the fast and cheap wireless communication system, which is the optical version of Wi-Fi. Li-Fi uses visible light instead of Gigahertz radio waves for data transfer.

Fig. 1. Li-Fi bulb [8]

The idea of Li-Fi was introduced by a German physicist, Harald Hass, 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 [9].

Li-Fi can play a major role in relieving the heavy loads which the current wireless systems face since it adds a new and unutilized bandwidth of visible light to the currently available radio waves for data transfer. Thus it offers much larger frequency band (300 THz) compared to that available in RF communications (300GHz). Also, more data coming through the visible spectrum could help alleviate concerns that the electromagnetic waves that come with Wi-Fi could adversely affect our health.

Li-Fi can be the technology for the future where data for laptops, smart phones, and tablets will be transmitted through the light in a room. Security would not be an issue because if you can't see the light, you can't access the data. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

2. WORKING OF LI-FI

The working of a Li-Fi based system is very simple. There is a light emitter on one end, for example, an LED, and a photo detector (light sensor) on the other. The photo detector registers a binary one when the LED is on; and a binary zero if the LED is off. To build up a message, flash the LED numerous times or use

an array of LEDs of perhaps a few different colors, to obtain data rates in the range of hundreds of megabits per second.

The main components of Li-Fi system are as follows:

a) A high brightness white LED which acts as transmission source.

b) A silicon photodiode with good response to visible light as the receiving element.

LEDs can be switched on and off to generate digital strings of different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The LEDs can be used as a sender or source, by modulating the LED light with the data signal. The LED output appears constant to the human eye by virtue of the fast flickering rate of the LED. Communication rate greater than 100 Mbps is possible by using high speed LEDs with the help of various multiplexing techniques. VLC data rate can be increased by parallel data transmission using an array of LEDs where each LED transmits a different data stream.

2.1 BLOCK DIAGRAM

The input data from personal computer (PC) transmitter is first coded into a string of pulse electrical signals by microcontroller unit though the interface circuit. Then, the electrical signals drive LED source directly through a LED driver circuit, with which electronic-to-optical conversion is achieved. Because of the high on-off speed characteristic of LED, people cannot perceive the twinkling phenomena so that both lighting and information transmitting can be realized simultaneously. The generated optical signals carrying original information then delivered into the indoor wireless channel. At the receiver, pin photodiode will detect the optical signal and do the optical to electronic conversion. Then the detected weak electrical signals are delivered into a receive circuit which contains preamplifier for signal amplification to meet the need of the following signal processing. The output data from receive circuit will arrive at the microcontroller device and be decoded into primary signal, and then sent to the PC receiver though the universal serial bus (USB) interface circuit

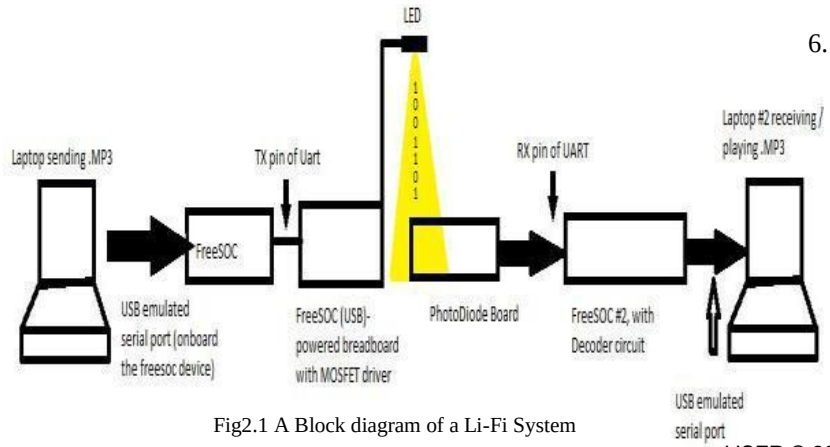

Fig2.1 A Block diagram of a Li-Fi System

3. APPLICATIONS

3.1 Information source lamp

3.1.1 About the Information source lamp

The Idea behind the information source lamp is basically to transmit data about a specific subject and all the information about it. The Information source lamp uses visible light as the transmitting media to send this data to users. For example, when we visit a museum and wish to know information about a specific monument. The information source lamp constantly transmits this information/data using the visible light the user can then just use his/her receiver device (which could also be a cellphone) to receive the information . The other application of the information source lamp in our day to day life scenario could be obtaining information about the products in shops. The users could know information like the expiry date of the product, date of manufacturing and also the cost price of the product, this will however reduce the indulgence of man power.

The Transmitter section consists of the Following components:

i. Power Supply
ii. USB cables to power the Arduino boards
iii. Microcontroller (Arduino Uno)
iv. MOSFET Amplifier (N-channel 1RFZ44)
v. LED Module

3.1.2 Working:

1. The Transmitting arduino board is pre-loaded with the information of that is to be transmitted.
2. After the power supply on the transmitting side is turned on the arduino board continuously starts emitting the data to be transmitted.
3. LED array flickers in several nanoseconds according to the bit stream.
4. On the receiver side the photo diode (module) is used to receive the data.
5. The Data is then transferred to the screen of the receiver device using the USB cable.
6. The Information received is available to the user.

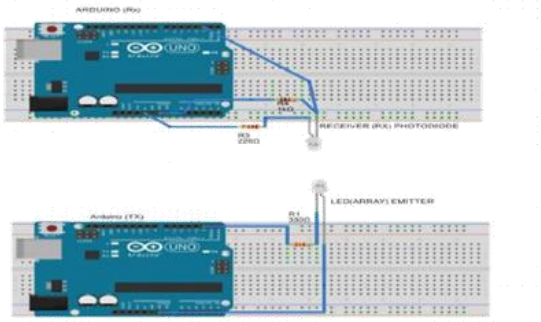

Fig 3.1 Information source lamp

Fig 3.2 Li-Fi Lamp

3.2 Full Duplex live chatting

3.2.1 About the Full duplex live chatting

In telecommunication Duplex communication means that both ends of the communication can send and receive signals at the same time. Full duplex communication is the same thing. Half duplex is also bidirectional communication but signals can flow in one direction at a time.

The example of a full duplex communication system is the Telephone system or we could say the mobile phones.

In our duplex live chatting system both parties can communicate/chat with each other simultaneously. The setup has achieved as mentioned above by using two transceivers on both the ends of the communication system. The transceivers consists of Arduino UNO, resistors of value 220 Ω, 330Ω, 1kΩ and two pairs of photodiodes and transmitter LED arrays respectively. Mobile phones, laptops, personal computers and several devices can be interfaced with these transceiver modules to serve the purpose of live chat-ting. In this system the textual data is purely getting transmitted using visible light and no other wired media.

This application can be used for high speed chatting and data transfer using visible light. The setup can be further expanded to a bigger communication network where multiple devices can chat with each other.

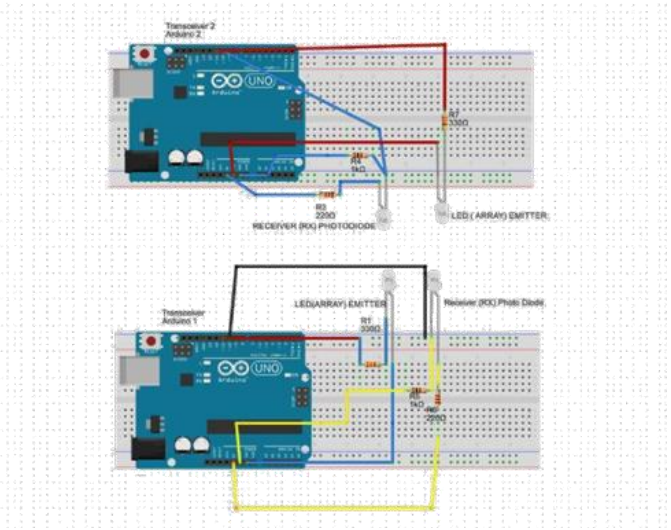

Fig 3.3 Duplex Chatting

Fig 3.4 Live Chatting

3.2.2 Outputs of Duplex Chatting:

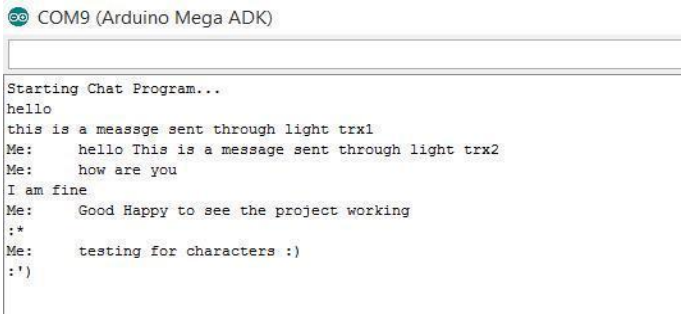

Fig 3.5 Light TRX 1

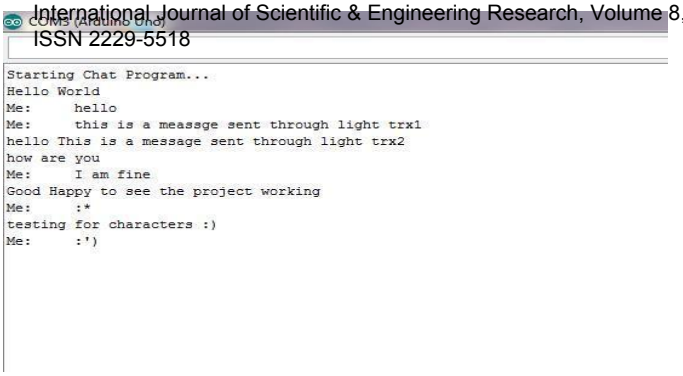

Fig 3.5 Light TRX 2

3.3 Li-Fi Music player

3.3.1 About the music player

The idea behind the music player is to transmit the music via light. A lamp which is modified is connected to the audio jack of the computer.

The Li-Fi Music player consists of an audio jack that is used to receive the audio signals from the source / computer. A transmitter. LED array, constant DC source which used to light the transmitter LED array, solar Cell to receive the audio signals and a speaker to play the received audio signal. In a Li-Fi music player music is converted to varying light intensity and then transmitted wirelessly using an LED array and a solar cell whose output it seen by a speaker. The tip of the speaker jack is connected to positive of the solar cell and negative is connected to the body. The output of the Li-Fi music player varies with the change in the intensity of the light source which transmits the audio signals and when the path of the visible light is blocked the output sound at the speaker is not heard. An audio signal is a representation of sound, typically as an electrical voltage. Audio signals have frequencies in the audio frequency range of roughly 20 to 20,000 Hz (the limits of human hearing). The audio signal received from the audio jack varies the LED array (transmitter) and these variations are sensed by the solar cell.

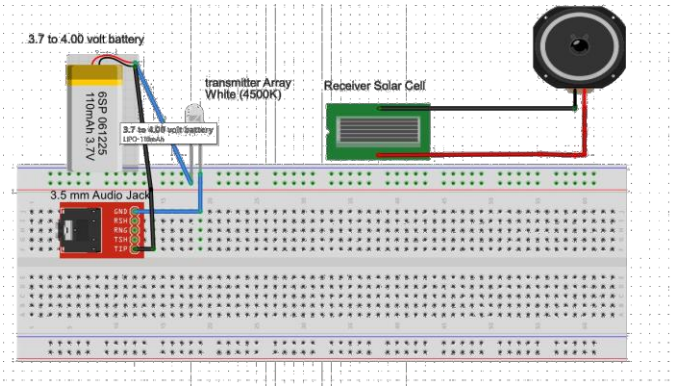

Fig 3.7 Li-Fi Music Player

Fig 3.8 Music Player

4. CONCLUSION

Hence we have demonstrated how to use visible light as a medium to transmit data such as music and text. By replacing our huge hardware modules with programmable Arduino boards we have reduced the size of our setup and made it more versatile. It has become more practical to implement and use in daily life. Visible Light Communication is a cleaner, greener, cheaper and safer way of communicating. By using simple signal processing hardware attached to LED bulbs we can use the already available infrastructure to supplement our data consumption. Li-Fi based systems which rely on data communication using visible light are the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.

5. REFRENCES

[1] Jyoti Rani, Prerna Chauhan, Ritika Tripathi, ―Li-Fi (Light Fidelity)- The future technology In Wireless communication‖, International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7

[2] Richard Gilliard, Luxim Corporation, ―The lifi® lamp high efficiency high brightness light emitting plasma with long life and excellent color quality‖.

[3] Richard P. Gilliard, Marc DeVincentis, AbdeslamHafidi, Daniel O'Hare, and Gregg Hollingsworth, ―Operation of the LiFi Light Emitting Plasma in Resonant Cavity‖.

[4] http://articles.economictimes.indiatimes.com/2013-01-14/news/36331676_1_data-transmission-traffic-signals-visible-light-spectrum

[5] http://www.extremetech.com/extreme/147339-micro-led-lifi-where-every-light-source-in-the-world-is-also-tv-and-provides-gigabit-internet-access

[6] http://www.dvice.com/archives/2012/08/lifi-ten-ways-i.php

[7] http://www.good.is/posts/forget-wifi-it-s-lifi-internet-through-lightbulbs

[8] http://www.lifi.com/pdfs/techbriefhowlifiworks.pdf

[9] http://www.ispreview.co.uk/index.php/2013/01/tiny-led-lights-set-to-deliver-wifi-style-internet-communications.html

[10] http://www.newscientist.com/article/mg21128225.400-will-lifi-be-the-new-wifi.html

[11] http://groupivsemi.com/working-lifi-could-be-available-soon/