Hardware Implementation of Li-Fi Technology for Wireless Data Transmission

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Abstract- Li-Fi is the acronym for wireless-communication systems which uses light as a carrier for data rather than traditional radio Frequencies [1], which is Wi-Fi. The advantage of Li-Fi is it can be used in sensitive areas such as in Aircraft without causing any interference. But, there is one disadvantage that light waves cannot penetrate walls. Its implementation includes use of white LED light bulbs at the Downlink transmitter. By applying a constant current, these devices can be used for illumination. With fast variations of the current, the optical output varies at extremely high speeds, which is used to setup Li-Fi. During operation if the LED is on, a digital 1 is transmitted, if it's off a 0 is transmitted. Switching the LEDs on and off provides better way of transmitting data. Thus, we only require some LEDs and a controller that codes data into those LEDs and by varying the rate at which the LED's flicker [2] on the basis of the data we want to encode. This method can be further enhanced using an array of LEDs for parallel data transmission, or using mixtures of red, green and blue LEDs to alter the light's frequency with each frequency encoding a different data channel. Such advancements promise a theoretical speed of 10 Gbps – meaning one can download a full high-definition film in just 30 seconds

Keyword- Photodiod,ATMega16,LiFi, LM324,VB.net

I. INTRODUCTION

Li-Fi is a new wireless communication technology which enables a wireless data transmission through LED light. Li-Fi is based on a unique ability of solid state lighting systems to create a binary code of 1s and 0s with a LED flickering that is invisible for human eyes. Data can be received by electronic devices with photodiode [2] within area of light visibility. This means that everywhere where LEDs are used, lighting bulbs can bring not only The light but wireless Connection at the same time. With increasing demand for wireless data, lack of radio spectrum and issues with hazardous electromagnetic pollution, Li-Fi appears as a new greener, healthier and cheaper alternative to Wi-Fi. The term was first used in this context by Harald Haas in his TED [1] Global talk on Visible Light Communication. The technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas using a pair of Casio smart phones to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten meters. In October 2011 a number of companies and industry groups formed the Li-Fi Consortium, to promote high-speed optical Wireless systems and to overcome the limited amount of radio based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum. The consortium believes it is possible to achieve more than 10 Gbps, theoretically allowing a high-definition film to be downloaded in 30 seconds. Li-Fi has the advantage of being able to be used in sensitive areas such as in aircraft without causing interference. However, the light waves used cannot penetrate walls [5].Later in 2012, Pure VLC, a firm set up to commercialize Li-Fi, will bring out Li-Fi products for firms installing LED-lighting systems. Moreover Li-Fi makes possible to have a wireless Internet in specific environments (hospitals, Airplanes etc.) where Wi-Fi is not allowed due to interferences or security considerations. Justification and objective of carrying out the research work.

It is based on the transmission of digital data 0's and 1's. The logic is, if the LED is OFF, digital 0 is transmitted and if theLED is ON, digital 1 is transmitted, which can't be detected by human eye. The LED's can be switched ON and OFF very quickly by which we can transmit data with the help of light. Generally white LED bulbs are used for implementing the concept of li-fi which is used for illumination by applying a constant current. However, the light output can be made to vary at extremely high speeds by fast variations of the current. To build up a message we are flashing the LEDs numerous times. In order to obtain data rates in the range of hundreds of mega bytes per seconds we can use array of LEDs which also helps us for parallel data transmission or we can also use combination of three basic colours LEDs red, green, blue to alter the frequency of light.

At one end, all the data on the internet will be streamed to a lamp driver. When the LED is turned ON, the microchip converts the digital data in the form of light. Then the signal is received by a light sensitive device known as photo detector, which will help to convert it back into original data. Then it is given to the device which is connected on it.

The main component of this communication system is a high brightness white LED, Which acts as a communication source and a silicon photodiode which shows good response to visible wavelength region serving as the receiving element? LED can be switched on and off to generate digital strings of 1s and 0s. Data can be encoded in the light to generate a new data stream by varying the flickering rate of the LED. To be clearer, by modulating the LED light with the data signal, the LED illumination can be used as a communication source. As the flickering rate is so fast, the

LED output appears constant to the human eye. A data rate of greater than 100 Mbps is possible by using high speed LEDs with appropriate multiplexing techniques. VLC data rate can be increased by parallel data transmission using LED arrays where each LED transmits a different data stream.There are reasons to prefer LED as the light source in VLC while a lot of other illumination devices like fluorescent lamp, incandescent bulb etc. are available.

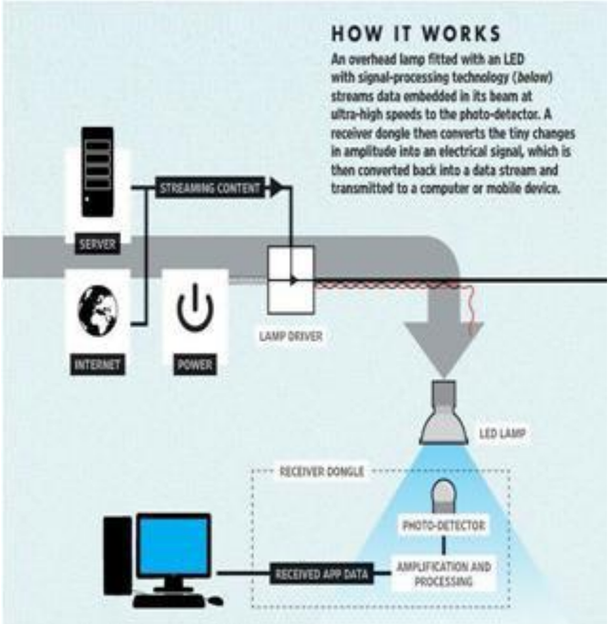

Fig.1: Data transmission using LI-FI

II. METHODOLOGY

Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. This varying property of optical current is used in Li-Fi setup. The LED lamp will hold a microchip that will do the job of processing the data. On one end all data on the data will be streamed to a lamp driver. When LED is ON microchip convert digital data in form of light. On the other end this light is detected by the photo detector. Then this light is amplified and fed to the device. If the LED is ON, transmit a digital 1, if it's OFF you transmit a digit 0.

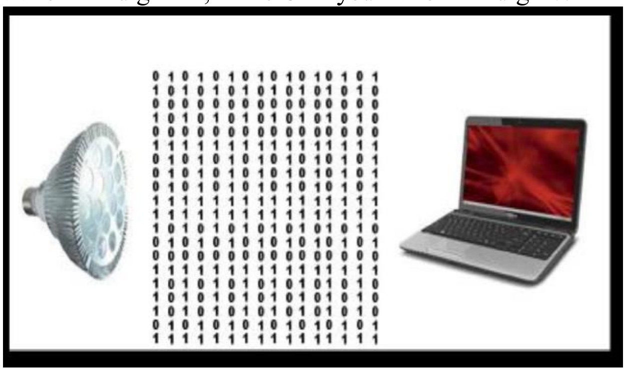

Fig.2: Basic Principle of Li-Fi Technology

The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. All has to do is to vary the rate at which the LED's flicker depending upon the data we want to encode. The flashing of the light actually happens much faster that human eyes cannot detect, so the output appears constant, allowing for a Li-Fi data connection to resemble a simple LED bulb**.** When LED is ON microchip convert digital data in form of light. On the other end this light is detected by the photo detector. Then this light is amplified and fed to the device. The optical signal from LED transmitter is then intensity modulated with Direct Detection and generally On Off Keying modulation scheme is used tosend information. VLC receiver uses a positive-intrinsic-negative (PIN) photodiode. It does not have a high gain such has the photodiode, but it can become an advantage in high noise environments.

LI-FI technology uses semiconductor device LED light bulb that rapidly develops binary signals which can be manipulated to send data by tiny changes in amplitude. Using this innovative technology 10000 to 20000 bits per second of data can be transmitted simultaneously in parallel using a unique signal processing technology and special modulation.

The main components of Li-Fi system are:

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

b) A silicon photodiode reacts as receiver.

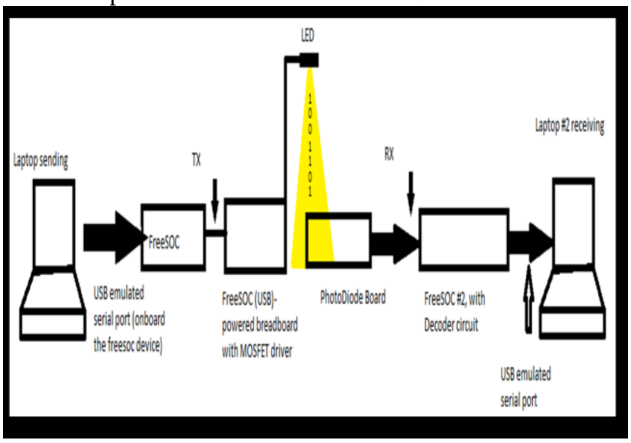

Fig.3 Data transmission and Receiving

can be turned on and off to generate digital strings of different combination of 0s and 1s. The LEDs can be used as a source or sender, by modulating the light with the data signal. The LED output appears same to the human eye by virtue of the fast flickering rate of the Bulb. Data transmission rate greater than 100 Mbps can be possible by using high speed LEDs with the help of various multiplexing techniques. Visible Light Communication data rate can be increased by s ending parallel data transmission using a multiple of LEDs where each LED sends a different data stream.

The Li-Fi emitter system consists of 4 primary parts:

a) Bulb

b) Power amplifier circuit (PA)

c) Printed circuit board (PCB)

d) Enclosure

Important factors we should consider while designing Li-Fi as following:

1. Presence of Light
2. Line of Sight (Los)
3. For better performance use fluorescent light & LED

A. Why VLC?

The radio waves are costly and very less safe. The use of Infrared can be done with power which is low for eye safety. Gamma rays cannot be used as they are dangerous. UV rays can be used at places where humans are not found otherwise they can be harmful. Now visible light is safe to use that is no harmful effects and it also have a larger bandwidth. Visible Light Communication (VLC) is a medium, that use light which is visible that is 400 THz – 800 THz of range, as optical carrier for data transmission and illumination. [6]

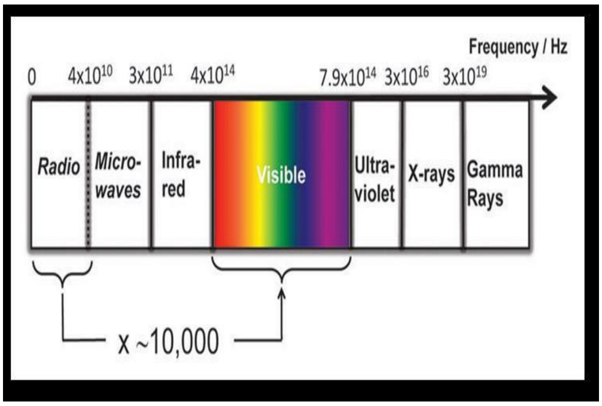

Fig.4: Spectrum Range

B. VLC Transmitter

It includes a high brightness white LED and a driving circuit. Flickering rate of LED bulb is very high which is not visible to human eye. This flickering of bulb is used for data transmission- if LED is ON, it transmits digital '1' and if OFF, it transmits digital '0'. The driving circuit is used to modulate the digital data over the dimming control signals of LED by passing Drive Current into the LED with appropriate DC bias [3]. The optical signal from LED transmitter is then intensity modulated (IM) with Direct Detection (DD) and generally On- Off Keying (OOK) modulation scheme is used to send information.

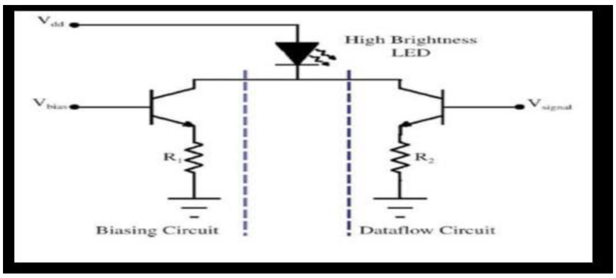

Fig 5:- Simple Emitter Prototype

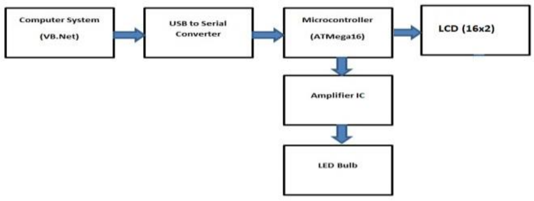

Fig.6: Flow Chart of Transmitter Side

C. VLC Receiver

It includes silicon photo diode which shows good response to visible wavelength, optical concentrator and filter and an amplifier. The optical concentrator is used to compensate for high spatial attenuation due to the beam divergence from the LEDs to illuminate large area [4]. The VLC system is vulnerable to the sunlight and other illuminations, and therefore, it is important to employ appropriate optical filter to reject unwanted DC noise components in the recovered data signal. VLC receiver uses a positive-intrinsic-negative (PIN) photodiode. It does not have a high gain such has the avalanche photodiode (APD), but it can become an advantage in high noise environments, where the APD tends to saturate. The PIN is also cheaper and has a larger active area.

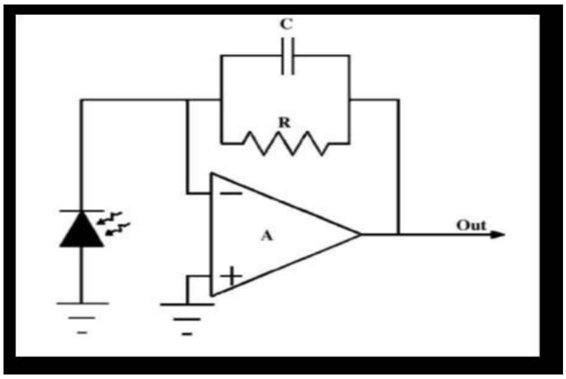

Fig.7: Simple Receiver prototype

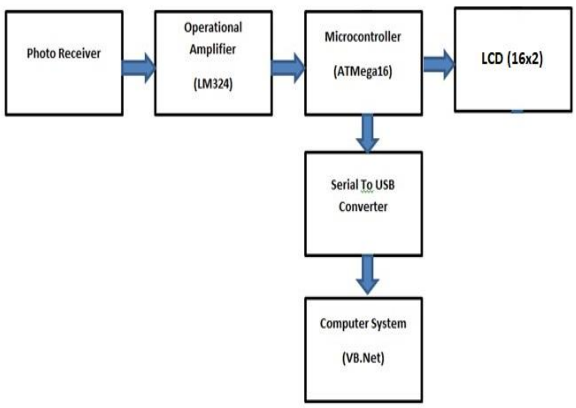

Fig 8:- Flowchart of receiver side

The Printed circuit board controls the electrical inputs and outputs of the bulb and houses the microcontroller used to manage different bulb functions. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb 's centre; this controlled plasma generates a source of light. There are various advantages of this system which includes more brightness, highest colour quality and high luminous power of the emitter – in the range of 150 lumens per watt or more. The structure is mainly robust without typical degradation and failure mechanisms associated with tungsten electrodes andglass to metal seals, resulting in useful Bulb life of 30,000+ hours. In addition, the unique combination of high temperature plasma and digitally controlled solid state electronics results in an economically produced family of Bulb scalable in packages from 3,000 to over 100,000 lumens.

III. DESIGN AND IMPLEMENTATION

The idea behind Li-fi is implemented by using white LED light bulbs at the downlink Transmitter. For illumination, a constant current is applied to LEDs. The optical output can be made to vary at very high speeds, by fast variations of the input current. It works as, when the LED is on then the logic "1" is transmitted and when the LED is off then the logic 0 is given. LED's flickering occurs at a very fast rate and which is not visible to the human eye. In this method much advancement could be possible by use of an array of LEDs for parallel data transmission.

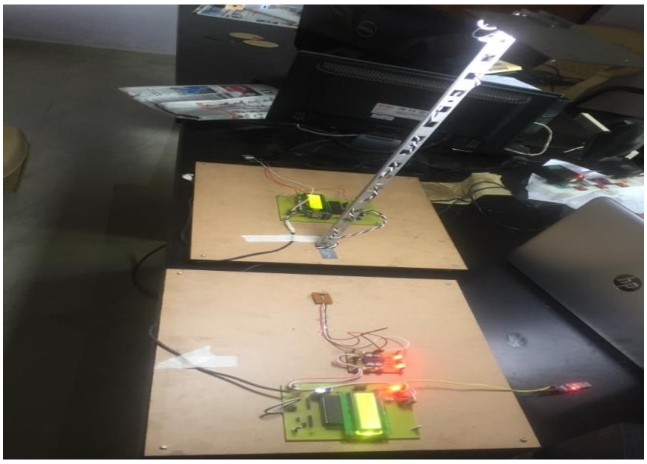

Fig.9: Li-Fi real time analysis

Fig. 9 shows the real time analysis of light fidelity model. Basically the model is divided into two parts. It contains the transmitter side as well as the receiver side. In the working model LED bulb work as a carrier which transmits the data from one device to another device. The communication can be done in three ways, i.e. there are 3 types of communication that the Li-Fi model can perform which are

- hardware to hardware
- software to software
- hardware to software

Fig. 10 shows the transmitter side of the working model. The transmitter circuit consists of a PCB that controls electrical input. The component AT mega 16 microcontroller used to manage different LED functions. Also it consists of LED with 6 watts which changes its brightness with respect to signals. L293D motor driver which regulates the current and the battery of 12V is attached.

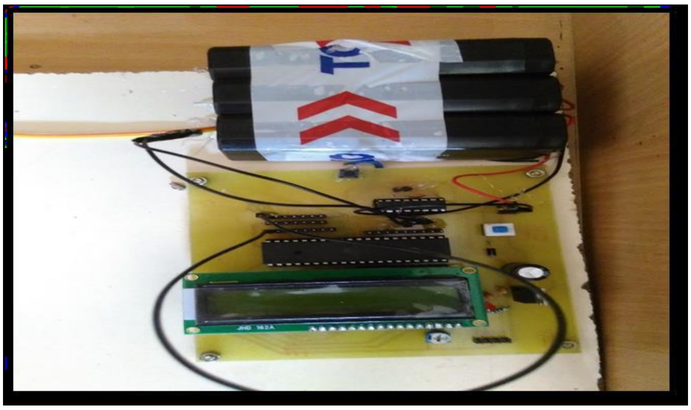

Fig.10: Transmitter side

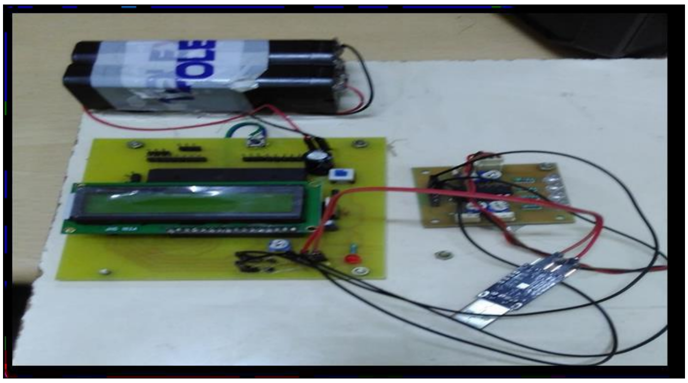

Fig.11: Receiver side

Fig. 11 describes the working of receiver side. The receiver side consists is photodiode which receives the data transmitted by the LED bulb from transmitter side. The photodiode is paired with an amplifier.

IV. RESULTS

A. 1Li-Fi Transmitter

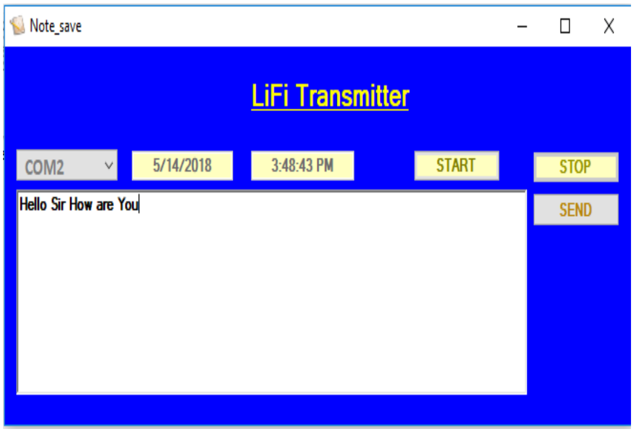

Fig.12: Screen Shot of Li-Fi Transmitter

B. Li-Fi Receiver

Fig.13:- Screen Shot of Li-Fi Receiver

V. CONCLUSION

Thus we have implemented the data transmission with the help of Visible light communication using LED bulb and photodiode. By using Li-Fi technology information can be transmitted and received at very high rates with simply turning on and off of the LEDs. Here LED bulb is used for transmitting the data and photodiode is used to receive that data. We observed that as the intensity of the light i.e. intensity of LED bulb increases the data rate also increases. The sending and receiving of data is totally depending on the light. If the light is not present we cannot communicate between two devices. The main purpose behind implementation of light fidelity is to transmits the data with the higher range and with higher band width. Also to reduce the use of radio waves which are harmful for us. The light fidelity is not replacement to the Wi-Fi but it is compliment for wireless communication to use it more effectively. 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.

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