VISIBLE LIGHT COMMUNICATION THROUGH LIGHT EMITTING DIODE IN BIDIRECTIONAL

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Abstract— with the advent of the new technologies in wireless communication, the spectrum available in radio frequency is looming gradually. In electromagnetic spectrum, the visible light frequency is greater than ten thousand times of radio frequency. By using visible frequency, we can communicate data through light emitting diode (LED) as a transmitter and photo detector as a receiver. This has been proposed by a German physicist, Harald Hass which he coined the term as Light Fidelity (LiFi) or Data through illumination. LED has a great advantage it varies its intensity which cannot be human perceptible. LED is used as a medium carrier, on the receiving side the photo detector registers the illumination and converts into electrical energy and further it is converted into binary data to an original message. If the LED is on, the photo detector registers a digital one; otherwise it registers it as digital zero with the combination of clock synchronization and they are in same line of sight. So typically by using some modulation techniques we can use LEDs in wireless communications for transmission of data for safer and brighter future.

IndexTerms- LED, LiFi, Photo detector, Visible Light Communication, Radio Waves, Spectrum

I. INTRODUCTION

From the past three decades after the evolution of the mobile devices the wireless communication has took major challenges. The wireless communication is the fastest growing segment in the communication industry. It was started in the pre-industrial age. Initially people used to transmit the information over line-of-sight distances using smoke signals, flashing of sunlight through mirrors, semaphore flags. The term wireless communication was introduced in the 19th century by Sir J.C. Bose and first demonstration was given by Marconi on long radio waves. The first transmission of radio signals is carried from the Isle of Wight to a tugboat in coastal region which is 18 miles away and radio communication was came into existence. It does not require any physical media such as like cables or wires and it works on the principle of electromagnetic radiation. The Radio communication has a tremendous change over the past few decades initially they used to transmit data by using analog signals, voice signals and now most of the radio signals are digitalizing to binary code. In the electromagnetic spectrum the radio frequency which is available for the communication is decreasing gradually. The visible light has the large available frequency in the spectrum which we can transmit data by using a light emitting diode, and at the receiver side by using a photo detector. The term LiFi is first coined by Prof Harald Hass in TED talk 2011 to unlock the 3rd revolution.

In future the entire communication is loaded with data i.e. data with network, millions of device are going to work under IOT and lot of data is going to be generated every month. We don't have enough data pipes lines to transmit data in this economic growth.

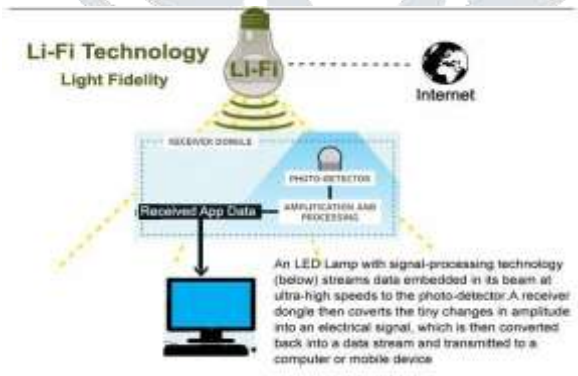
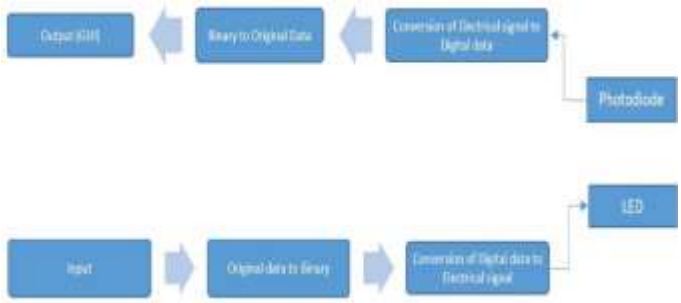


Fig: Pictorial Working of LiFi

As per the Cisco Networks by 2022, 44 zettabytes of data is to be generated and each and every electronic device that are associated with IOT are quiet enough to generate data [1]. So far we are using radio frequencies which are not sufficient in the present scenario. There is different wavelength like visible light; uv rays, x-rays etc., and some of them are hazards to use in this environment. As we are using radio waves which are between 3Hz to 300 GHz for data transmission depending on the usage. And the visible light has enough frequency which is 10 thousand times larger than the radio waves.

II. WORKING OF LIFI

The working principle behind the visible light communication is by using LED we can transfer data that is generated from the source. The source is connected to the semiconductor chip or a microcontroller through a wire and to the LED.



BLOCK DIAGRAM OF LIFI

2.1Light Emitting Diode:

Light emitting diode belongs to the general category of luminescent device where by injecting electrons carriers to holes that produces you light. LED is the best example for electro luminescence device. For a P-N junction diode we inject the electrons to minority carriers. Depending upon the type of semiconductor the recombination can either be dominated by photons or it can be dominated by heat. Gallium arsenide is the material used in making LED. P-N junction diodes came into existence in 1949 but first LED based Gallium arsenide was introduced in 1962. LED is a P-N junction diode that emits light when it is activated.

A suitable voltage is applied to the leads of diode, electrons are able to recombine with holes and pair together. When all holes are filled in valence bond it emits some energy known as photons or we can say further that electrical energy is converted into light energy.

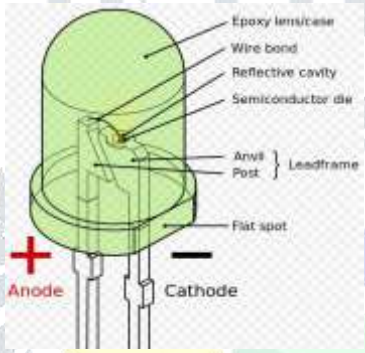


Fig: Description of Light Emitting Diode

2.2PhotoDetector:

A commonly used photo detector is photodiode. A photodiode is a semiconductor device which converts the light into electrical energy when it is exposed to light. PN junction consisting of a P-type semiconductor region on the light receiving side and an N-type semiconductor region on the substrate side. Applying a reverse bias to the PN junction creates a depletion layer between the P-layer and N-layer. When light has more energy than the semiconductor band gap, then energy strikes the region near the junction of the photodiode(to the depletion layer and the area surrounding it).the electrons in the valance band absorb the light and rise up to the conduction band, thus leaving holes in the valance band and generating carriers. The carriers thus generated in the depletion layer separate due to electric field conductivity. So the electrons move to the N-region, and the holes move to the P-region. At this time the number of carriers generated is basically in proportion to the luminance to the light, and a photocurrent flows through the photodiode.

III. METHODOLOGY

The visible light communication through light emitting diode comes under IEEE standards of 802.15.7. This standard describes physical layer and MAC layer of Short Range Wireless Optical Communication using Visible Light. The main key components used for implementing of simple LiFi based system is Arduino Nano of microprocessor ATmega328P which has 8 analog pins, 14 digital pins, 2 voltage pins and Ground. For a node to node communication one of the Arduino Nano is connected to the LED with the help of jumper wires and another Arduino is connected to photodiode and both Arduino boards are connected to pc with the help of cable mini USB-B. Initially the data is converted into binary information with the help of ASCII values and driven into LED.

Circuit Diagram of Transmitter and Receiver:

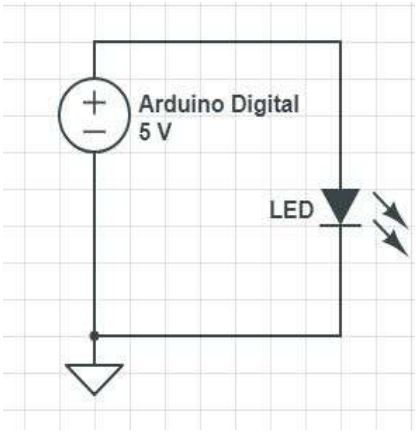


Figure-1

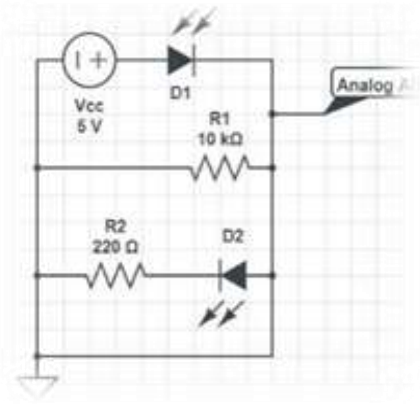


Figure-2

If the LED is in on state (Illumination) then the photo detector on the receiving side registers it as digital one, otherwise the photo detector registers it as digital zero with the combination of clock synchronization. The entire process of communication is carried with the help of light emitting diode in which human cannot discern visually.

In Fig-1 circuit diagram is used for transmitting and Fig-2 is used for Receiver side they are designed with low cost and error control in transmitting data. Resistors R1 and R2 are used to regulate the excess energy that is generated in Receiver.

3.1Modulation Technique:

The simplest form for Data Modulation is represented in series of logical 1's and 0's by switching on and off the carrier. Here 0's is going to have a carrier off (i.e. reducing its amplitude to zero) and carrier in on state (maximum voltage is supplied to illumination). In this process of converting data into binary information is known as on-off keying (OOK). As the name suggest the data is conveyed by turning the LED off and on. We ensure the period of positive pulses and the same as the negative pulses depending on the intensity of light bulb.

The photo detector detects the photons that are released from the LED and it converts into electrical energy and with the help of analog to digital convertor it is converted into binary information. Later it is decoded back into original message and it displays on output console. In which we can transfer data in bidirectional way by connecting both transmitter and receiver to the Arduino.

IV. Results and Discussion

4.1Transmitter:

Arduino IDE provides a graphical user interface for the user to transmit data or to receive the data. The mode of transmission of data is done in serial transmission with 9600 bits per second. For Bulk transferring of data and to control the errors while transferring the data it is arranged into small chunks and into frames of bytes without any loss of data with high speed data rate.

The technology using in LiFi is IrDA (Infrared Data Association) complaint device which is free from radiations and which cannot penetrate through walls. By this classification it provides more privacy when compared with the existing wireless technology. As it has less interface it can pass through high density region and even works at bedrock region in sea for communication.

The Transmission of data is mentioned in the below image with "Welcome to LiFi World".

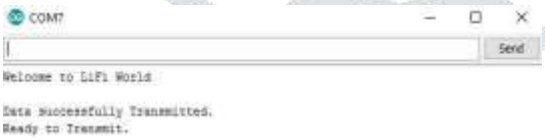


Fig: Input

4.2Receiver:

For receiver side we use PuTTY for serial communication to transmit and recevie data in bi-directional.

Fig: Output

4.3Data Throughput:

In LiFi the data is transferred in binary values, each binary value is nothing but a bit (either it is 0 or 1) and the rate is measured in total amount of data by time take by the data from transmitter to receiver

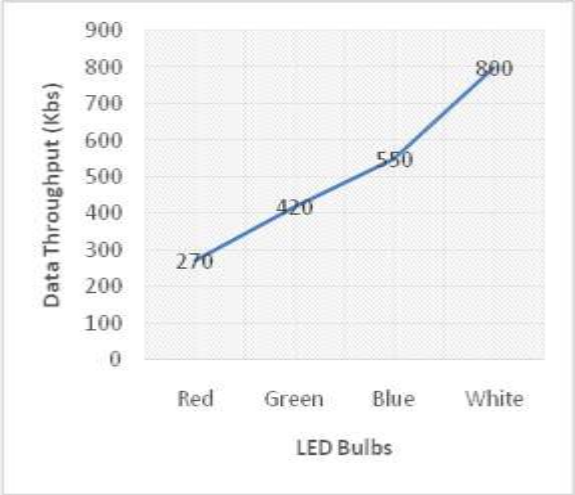


Fig: Graph on Measuring Data Rate

4.4Distance measured in free space (for Designed prototype):

In LiFi the transmission speed and area coverage are depends on the intensity of the light. As I have used four LEDS of different colors the white LED has measured with maximum intensity with low energy consumption. The distance values are mentioned in the below Graph for each differed colored LEDS

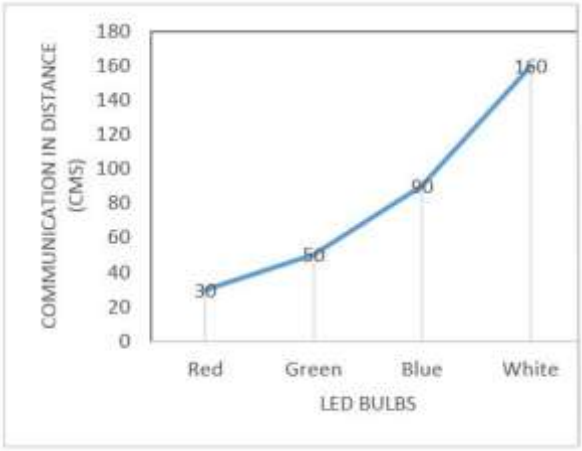


Fig: Graph on Measuring Distance

V. POTENTIAL APPLICATIONS

LiFi system can be used in aircraft cabins for providing multimedia and wireless access and also it helps in reducing the weight of aircraft by avoiding cables to make cabins more flexible.

We have underwater vehicles that stands at the seabed we cannot use Radio frequency in water bodies because of its density by using light we can transmit data.

Underwater divers are vulnerable to their life because they don't have any safety mechanism, they can send data through light for communication.

Lights are building with data for indoor navigation and most of them are useful for tracking Logistics.

We have stadiums as there are thousands of people are using mobiles for communication but there is not enough radio spectrum to receive all the services in the crowded places. We have hundreds of lights in stadium and thousand times more band available in visible spectrum than the radio frequency.

VI. CONCLUSION AND FUTURE SCOPE

There are numerous possibilities that can be explored in the concept of LiFi is currently attracting throughout the world. LiFi is very efficient in energy consumption and provides better security in the indoor communication. The radio waves are clogging day by day it is more difficult to get reliable and high-speed signals. Research is still going on micron sized LED which are able to flicker on and off to work better than a LED. We can replace this LiFi technology practically where WiFi hotspot are installed to transmit data towards safer, cleaner and in a green channel mode through light for friendly environment.

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