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Li – Fi Technology, Implementations and Applications

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Abstract - *LED (Light Emitting Diodes) are the diodes that always plays an important role in every day activity of every human. The most amazing fact about LEDs are that they are not only capable of Lighting the surroundings but can also be used for data transmission purpose. There comes the Li-Fi that utilizes both capabilities of an LED. Li-Fi stands for Light Fidelity and it uses LEDs intensity variation for transmission of data. This variation is frequent enough that the naked human eyes can't detect it. The most important benefit of Li -Fi technology is that it can possibly eliminate all the bottleneck problem of the existing Wi-Fi Infrastructure. Exploiting the existing capabilities of a LED, we can actually transfer the data from one device to another device with speed of Light and with much efficient. The transmitted data will have very less error correction requirement. This paper focuses on developing a Li-Fi based system and analyzes its performance with respect to existing technology. The paper also the study on advantages as well as disadvantages of using Li-Fi in transferring data from one computer to another computer. The use of this technology can reduce many problems of currently used data transfer technology.*

Key Words: **Li – Fi technology, Wi – Fi Technology, Visual Light Communication (VLC), Wireless Data Transmission**

1.INTRODUCTION

In current era, every day, we exchange information over the internet via various media. Imagining a human life without internet is absurd. Exchange of information in digital form has revolutionized the world by opening the doors for every human to the greater extent. The only thing we can't compromised is the speed of transmission of data. We as a human has always desired for more. Existing Data Transmission Infrastructure is old and slow.

A solution that can be introduced to solve this problem is by using Li – Fi Technology. Li – Fi (Light Fidelity) technology exploits the capabilities of an LED (Light Emitting Diode) to serve the purpose of data transmission with greater reliability, security and accuracy. In the year 2011, Professor Harold Haas, University of Edinburg, UK proposed the idea of Light Fidelity as "Data through illumination" where we use Visual Light for achieve the data transmission [1]. Visual Light can produce the transmission of rate of more than 10 Megabytes per second which is marginally faster than existing Broadband Data Transmission Technology.

Li – Fi Can be understood as the optical form the Wi – Fi. It actually refers to the 5G Visual Light Communication System where we use LED as a transmission medium to achieve the High Speed Communication among the devices just like the Wi – Fi. The utilization of Visual Spectra provides us the capability to transmit the data with speed of light but at the same time, brings its all limitations to it that it can't penetrate an opaque object like wall. But in the positive way it can utilized as the privacy and security tool or feature for the transmission.

The working principle of Li – Fi Technology is very simple. Whenever the LED is ON, digital 1 is transmitted and whenever the LED is OFF, digital 0 is transmitted [2]. Unlike Wi – Fi where electricity is required to keep turned on the router, Li – Fi utilizes the already under consumption electricity that is lightning bulb, hence decreases the electricity cost.

2. CONSTRUCTING Li – Fi

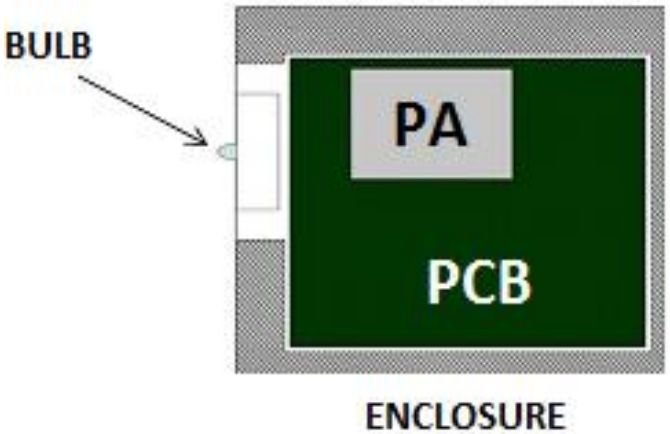

Fig-1: Li – Fi Transmitter Structure

VLC (Visible Light Communication) is the type of communication technique that uses the Visual Light having frequency between 400 THz (780 nm) – 800 THz (375 nm) as a carrier for the Data Transmission and Illumination. The Core Components of this VLC are as follows:

a. A LED Bulb (Transmitter)
b. A Photodiode (Receiver)

LED has a special characteristic that it remains stable to the frequent fluctuations of voltage. Using this stabilizing property of LED Bulbs, they can be switched ON or OFF frequently therefore permitting us to send the signal via Visual Light. The traditional Cellular Network and Wi – Fi Technologies are using Radio Waves for data transmission, which eventually end up with the signal congestion and speed restrictions. This problem of the congestion and speed limitations can be overcome by Li - Fi Technology. This also leads to create the market for the VLC (Visual Light Communication).

The LED flickers at very high speed. Its high enough that the data is transmitted and human eye can't even come to know about it. It appears constant glowing to human eye. Various Multiplexing techniques can be used to achieve a communication rate or transmission speed of more than 100 Megabytes per second. Parallel Transmission of data can be achieved by the array of LEDs where each LED will be transmitting a different stream of data. The Li – Fi Transmitter or emitter consists of 4 basic parts as follows:

a. Bulb
b. Radio Frequency Power Amplifier (RF PA) Circuit
c. PCB (Printed Circuit Board)
d. Enclosure

The PCB will be used for mounting and connecting the other electronic components and provide us the control over the input and output of the lamps. Micro-controller is used for managing different functioning of the lamp. A RF (Radio Frequency) Signal is generated by the Power Amplifier (PA) and is guided into the Electric Field to the bulb. The Electric Field has very high energy stored in it which vaporizes the contents of the bulb to a plasma state. This plasma is generated using controlled signal and thus can be controlled by varying input Electric Field intensity value. This plasma state of the component of bulb generates intense Light. All these components or sub-assemblies are enclosed inside the Aluminum container. Fig-1 depicts the structure of the circuit of Li - Fi Transmitter.

3. WORKING OF Li - Fi

Li – Fi Technology utilizes the principles of VLC (Visual Light Communication). Here, the working logic is very simple, if the Bulb is turned ON then Digital 1 is transmitted otherwise if Bulb is turned OFF then Digital 0. The LED can be turned ON and OFF very frequently causing a flickering signal that is used for transmitting signal across devices. In a Li – Fi model one end consist of the light emitter (LED) and on the other end that's receiver's end, we should have light detector (Photodiode). The Photodiode gains a binary 1 when LED is ON and Binary 0 if it is OFF. To have a data rate of hundreds of megabytes per seconds, different colored LEDs are used.

Fig-2 is the block diagram which shows the signal flow of the Basic Li – Fi Technological Model.

Encoding and Decoding the data involve in communication while transmitting/ receiving it, is one of the most important step that need to be follow to accomplish an error free transmission. Therefore, we can use various Encoding/Decoding techniques like 4B/5B, NRZ, Manchester, Differential Manchester, etc. with dedicated quantization bit. To accomplish this, we just need a microcontroller and a transceiver. By this we can theoretically achieve the speed of 10 Gigabytes per second.

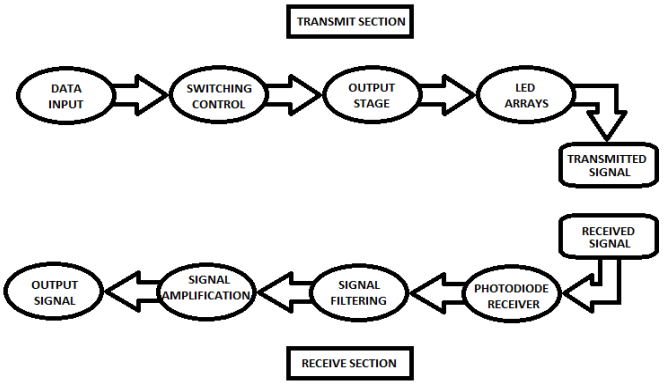

Fig-2: Block Diagram of Signal Flow in Li – Fi

Just like the Encoding and Decoding, Modulation and Demodulation techniques are also very important for the signal that is involved in communication. Since, there exist various modulation techniques, each one of them has their own advantages and disadvantages of using them. Some of the most frequent and common used Modulation techniques are listed below that can be proved to effective when used for Li – Fi Signal Modulation:

a. PPM (Pulse Position Modulation): It is a modulation in which the message is encoded by transmitting single pulse in a required time period. It is basically most effective when used in OCS (Optical Communication System).
b. PWM (Pulse Width Modulation): It is defined as a technique to encode a data into a pulse signal, it's main feature is to allow the control of power supply to the device to inertial load to the motors. In PWM more than one bit of data can be conveyed in a single pulse.
c. OFDM (Orthogonal Frequency Division Multiplexing): It is used as a digital multi carrier for encoding digital data on multiple carrier frequency. There is a large number of closely spaced sub carrier and each is modulated with a conventional modulated scheme at a low symbol rate.
d. SIM-OFDM (Sub carrier Index Modulation OFDM): It is a modulation which uses sub carrier to transfer

information to the receiver, it splits the serial bit stream into two sub streams.

e. OOK (ON OFF Keying): It is the simplest form of amplitude shift keying modulation and represents digital data as the presence or absence of carrier wave. At its simplest form the presence of carrier is reported as Binary 1 and absence is denoted as Binary 0. It is easy to generate and decode signal using OOK but it is very optimal towards illumination control and data throughput.

4. ADVANTAGES

a. Light has 10000 times wider bandwidth than radio frequency so the capacity of data transfer will be better than that of Wi-Fi.
b. Instead of using radio wave, Li-Fi uses visible light for communication.
c. Data transmission through Li-Fi is very cheap as LED uses very less amount of energy.
d. Security of a Li-Fi network is much better because the light cannot penetrate the walls so no one can misuse the network.
e. The shortage issue of radio frequency bandwidth may be solved by using Li-Fi.
f. Using Li-Fi each street lamp can be used as a free data access point.
g. Underwater Wi-Fi does not work at all, here Li-Fi can be used for data transmission.

5. DISADVANTAGES

Although there are lot of advantages of Li-Fi there are many challenges that we have to face and overcome.

a. The main problem with Li-Fi is how the receiver will transfer the data back to the transmitter.
b. Li-Fi works on direct line of sight.
c. The network topology is point to point.
d. Li-Fi has a limited range of communication.
e. Light waves cannot penetrate the walls and can be easily blocked.

6. APPLICATIONS

Applications of Li-Fi can be used were Wi-Fi doesn't work, since Li-Fi uses visible light the applications are safe to use in many regions such as hospitals nuclear power plants, etc. here are some regions were Li-Fi can be used and improve the conditions of world in a drastic way.

a. Medical society- We cannot use Wi-Fi in hospitals and other medical institute because of the radio waves being used in data transfer but Li-FI can be a better and safer option in hospitals. Using Li-Fi one can also operate robotic surgeries without causing any harm to the patients.
b. Educational system- Li-Fi can be used in educational institute for better and faster internet, by using LED bulbs everyone can use same speed of network.
c. Underwater application- underwater remotely operated vehicles uses lager cables for suppling power and to send and receive data for operations, but the cables used are not long enough and make the operation limited to a point. Here Li-Fi can be used to make the exploration much more. Li-Fi can also be used in many underwater military operations were Wi-Fi fails.
d. Radioactive and other power plants- Wi-Fi cannot be used in power plants because of the radio waves and increases the cost of speed and other temperature modulations systems. Li-Fi could offer safe, abundant connectivity for all areas of the locations. This can save money as compared to the currently implemented solutions. Also, the pressure on a power plant could be lessened.

6. CONCLUSION

Li - Fi is an emerging and vast technology, a lot of research can lead us to the betterment of the world. If this technology becomes justifiably marketed, then every bulb can be used analogous to a Wi-Fi hotspot to transmit data wirelessly. As the amount of available bandwidth is limited, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. The LI-FI technology can solve this crisis. Moreover, it will allow inter access in places such as operation theaters and aircrafts where internet access is usually not allowed. The concept of Li - Fi gives the solution to many issues like shortage of radio-frequency bandwidth and boot out the disadvantages of Wi-Fi. Hence the future applications of Li-Fi can be predicted to solve the problems of human life style and make it more simple.

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