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Visible Light Communication

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Abstract: ***This paper attempts to explain the use of Visible light used to carry out communication and list its advantages over classic radio wave communication. Visible Light Communication (VLC) is basically the transmission of data through illumination where the intensity of light is varied in accordance with the data. VLC offers security, high bandwidth, high data rates and negligible interference acting as a complement to radio frequency communication. The proposed system aims to carry out a successful communication between two or more devices using light as a medium. The input data can be any random data which is converted to binary format, encoded and then transmitted. This signal is then picked by a suitable photodiode and decoded so that the user at the receiver end can read the data. This will open a new pathway to implement IOT in day to day use. It will offer a large bandwidth and safe mediums for transmission and reception of data in contrast to RF-based communication.***
Keywords: Simplex transmission, pulse code modulation, LiFi, VLC, LED, ADC-DAC, Communication, Networking, Photodiode, ON-OFF Keying (OOK)

I. INTRODUCTION

Over the past recent years, there has been an increased demand for wireless data communication. This wireless data communication is carried out on low radio frequency (below 10GHz). Due to increased demand, the provided spectrum has become insufficient. Though the wireless communication industry had considered using Radio Spectrum above 10GHz, there was a major drawback. For higher frequencies(f), the path loss(L) increases in accordance with Friss free space equation ($L \propto f^2$)[1]. Also, the free and undisrupted propagation of high frequencies is difficult in a terrestrial type of communication. A few modifications to this system can help work on high-frequency radio systems but this turns out to be expensive. These issues have motivated the implementation of the concept of visible light communication. This will help operate devices in the visible light spectrum on a much wider bandwidth and higher data rate. The major objective is to implement a trans-receiving system to set up communication between two or more devices. This targets a small area of operation and depends on the line of sight of devices that fall under it.

II. LITERATURE SURVEY

The term 'Light Fidelity' was first introduced in this context by Harald Hass in his TED Global Talk on LiFi [1] where he explained how energy around us has the ability to transmit data i.e. via LEDs. In this talk, he mentions the reasons behind his motivation to find an alternative to RF communication for wireless data transmission.

Harald Hass et. al studied VLC and LiFi and their differences with respect to each other. This paper shows how LiFi has extended its scope while VLC fails to do, by using LEDs for wireless network systems. This paper has been created to try to differentiate between visible light communication (VLC) and light fidelity (LiFi). In actual practice, it will show how LiFi would enhance VLC further by making use of specific light emitting diodes (LED) to create a complete networked system which is wireless. It also contributes to the crucial performance indicators for the 5th generation of cellular systems(5G). Moreover, it covers a range of research areas form LiFi components to hybrid LiFi/Wireless-Fidelity (Wi-Fi) networks. [1]

Alexander Graham Bell is profoundly known as the father of the telephone initially conducted experiments to use VLC as a medium of communication. On 3rd of June of 1880, he and his assistant Charles Tainter succeeded in transmitting the world's 1st wireless telephone message over 213 meters. They developed a model which used the sunlight as a source which was modulated through the vibration of reflecting mirrors and then captured in a parabolic mirror with photoconductive selenium cell at the focal point. [2]

Also, it has been noticed and studied that there has been speedy progressiveness in the solid-state LED which provided a way for VLC. It achieves larger bandwidth and higher data rate as compared to the present RF communication. Currently, LEDs are used on a large scale only for the illumination purpose which can be used for the communication purpose as well, due to the different advantageous characteristics of VLC. [3]

But when it comes to transmission and reception by a device, the line of sight plays a major role in this. Also, the device orientation can affect the data received. If the device does not fall under the light properly then the reception of data cannot give a full efficiency. Tilting of the device, apparent blocking of receiver, varied intensity of light etc. affect the channel gain. [4]

In recent years, attempts were made to transmit simple texts, audio and video data in both uni-directional and bi-directional way. Also, tweaks were in the receiver for better reception of data by using APDs over PIN diodes and also using solar panels for reception of light. Several attempts were made to control the signal to noise ratio in order to extract the encoded data. [5]

Syifaul Fuada and Trio Adiono have executed a short-range audio transfer system using visible light as medium They used a 3watt white phosphor LED in which channel used is the line of sight. In the first step, the audio signal is approaching from the PC and is processed by analog front-end (AFE) transmitter which consists of a preamplifier, summing circuit and buffer. The amplitude of an audio input signal can be adjusted manually by tuning the DC voltage level. In AFE receiver, TIA is used as a current to voltage converter. For setting the signal DC level and positioning adjustment summing amplifier circuit is used. [6]

Attempts were made to apply this concept of VLC in real life. This was carried out to demonstrate audio multicast for location information in order to help the visually challenged people. The working included the transmission of data via light pulses which would then be received and converted to audio data. Different modulation schemes were implemented to carry out the working of this application. Acknowledgment lights in the receiver help multicasting possible and indicate successful transmission. [7]

III. VISIBLE LIGHT COMMUNICATION SYSTEM

An overview of how the VLC system generally works has been given below (Figure 1). This system consists of LEDs, transmitter circuitry, photo-detectors, receiver circuitry, amplifiers, and an output device. The basic representation of the same is given below.

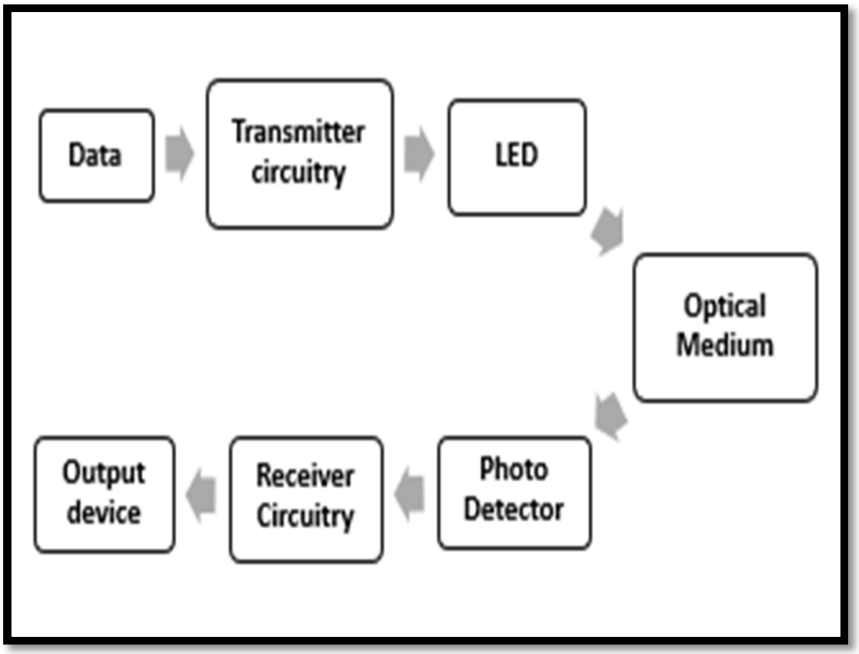

Figure 1: Basic Block Diagram

The Data is taken as input in the transmitter circuitry where encoding takes place. This encoded data is then transmitted by LEDs using intensity modulation. This data is transmitted over an optical medium. At the receiver, the data is detected by photodiode using direct detection method. This data is then decoded and brought back to its original format. The decoded data is amplified and given out to the output device.

IV. ADVANTAGES OVER RADIO WAVE COMMUNICATION

RF communication has been used for various wireless applications over the past two decades. Limitations of variable parameters that makes RF communication superior to other technologies have been gradually increasing. Due to this, there is an urge for VLC. VLC technology has advantages over RF communication based on the following parameters. VLC can achieve a data rate of a few Gbps which other technologies fail to provide. Uses light as a carrier hence several health hazards are limited. VLC offers a Spectrum range which is 10,000 times broader than RF communication. Since licensed bandwidth is not required, the cost of implementation reduces. VLC operates at a frequency of hundreds of Tera Hz.

V. DESIGN

The proposed system works in the following phases:

A. Data Gathering.

The data that is needed to be transmitted is stored for processing purpose.

B. Data Pre - Processing.

In this process, the data is encoded into its equivalent code from analog to digital format. This is done to transfer data through the flickering effect of light.

C. Data Transfer.

This binary format data is then transmitted through LEDs by ON-OFF method (Flickering effect). The flickering is so quick that it cannot be detected by the human eye and thus looks like a normal LED transmitting light.

D. Data Reception.

The Transmitted data is then received by the photodiode. Photodiodes are selected as per specification. In the proposed system, Light Dependent Resistor (LDR) was used. Filters can be used in order to receive a particular wavelength (color).

E. Data Processing.

After the data is received it is processed again to retrieve it into the original format. This is done by a digital to analog converter.

VI. CONCLUSION

The technology proposed in this paper not only addresses the demerits of RF-based wireless technology but also gives user a better platform to try to explore and stretch their limits.

The project intends to transmit data (Text) from source to destination through light. This technology forces the project to work in visible spectrum giving us more bandwidth which RF technology fails to suffice. There are a plethora of advantages(speed, security, low cost etc.) which make this technology more reliable than RF technology. This domain gives the user a brand-new platform to work on their application due to its high specifications.

VII. FUTURE SCOPE

At initial stages, there had been only simplex form of communication using light but now advancement has been made to carry out a full duplex type of communication. Moreover, with mere modifications, multiple unique data signals can be transmitted on without mixing of data. Similarly, the range of the system can be increased with the help of focusing lens at both the ends thus maintaining the reception quality. Improvement in data rate can be achieved by using high-speed switching devices and various modulation technique. Also, parallel transmission of data using different arrays (each array consisting of different color Led) at the transmitter, tuning different photodetectors at the receiver with different wavelength can increase transmission speed. This technology can be applied into numerous applications like underwater communication, low-speed internet at a very high rate in airplanes, smart traffic management and in RF sensitive areas.

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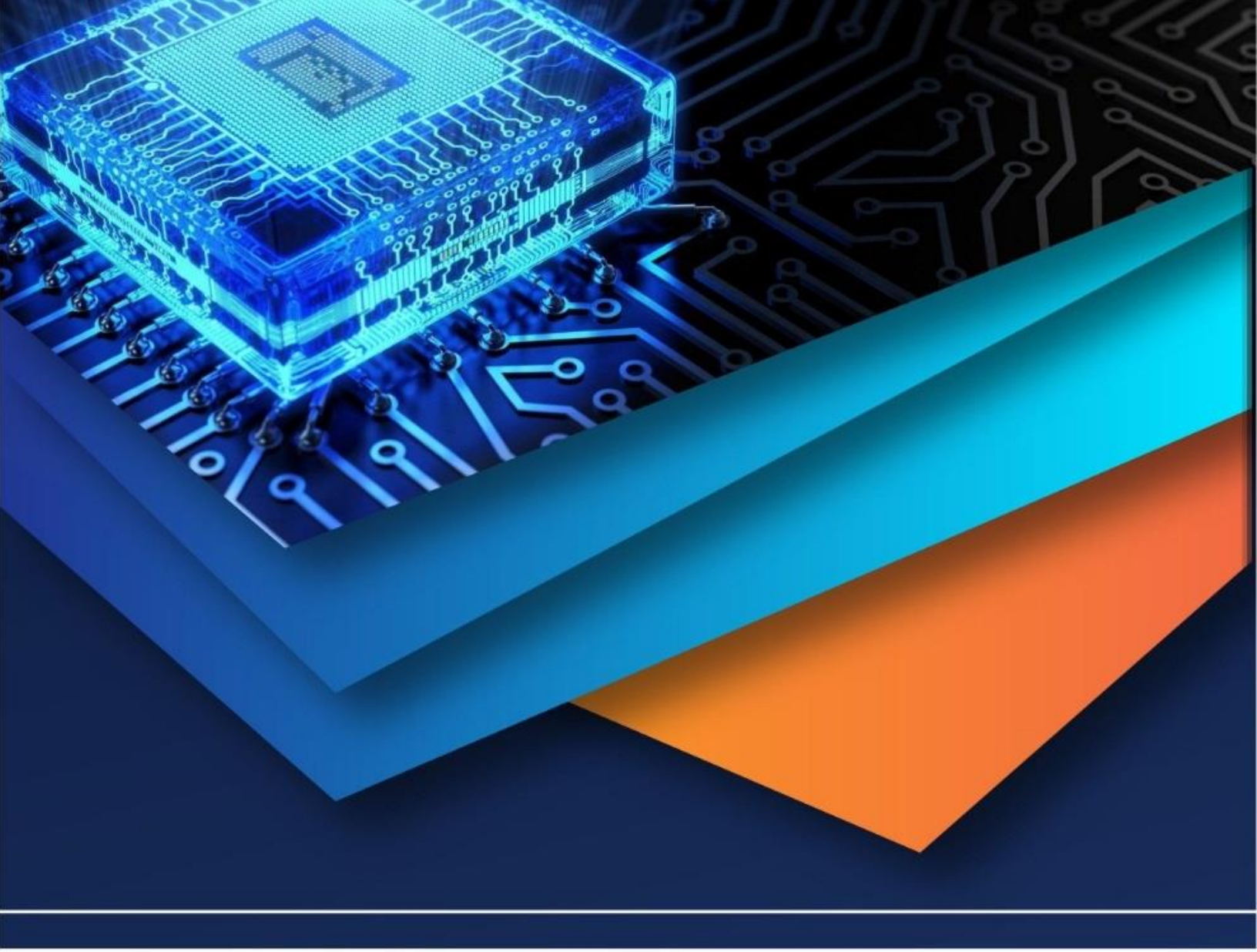

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