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Wireless End to End Image Transmission System using Li-Fi Technology

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***Abstract:** The first and most important objective of this project is to convey the image through the utilization of a light-emitting diode (LED). The innovative technique known as visible light communication (VLC) holds enormous promise for the implementation of high-speed, large-capacity, short-range wireless data transmission. It is gaining popularity on account of the growing use of solid-state lighting systems. Additionally, LED lights change frequency at a rate that is substantially faster than what the human eye is able to perceive. This is in addition to the fact that radio waves have a higher repetition rate than LED lights, which results in significantly greater speed than Wi-Fi. This work suggests a real-time image broadcast system prototype. Light-emitting diode (LED) lights are used in the prototype since they are widely available and reasonably priced. The scope of the work encompasses the possibility of making information and communication accessible through the utilization of LED bulbs in a manner that may be implemented in a variety of situations, such as homes, offices, organizations, and corporations. If the LED sources are positioned correctly and concentration effects are increased, it is feasible to obtain a real-time image with a maximum distance of two feet, according to the testing results. In addition to being made to last, the LI-FI (Light Fidelity) light source features a broad variety of digital settings that can be adjusted, and it is simple to operate as a result of its efficient design.*

Keywords: LED, VLC, Wi-Fi, LI-FI

I. INTRODUCTION

"Li-Fi" describes a type of wireless communication system that uses light instead of radio frequencies, unlike Wi-Fi. The ability to use Li-Fi in sensitive areas, such as aircraft, without causing interference is a significant advantage. One of the issues is that the light waves that are being used are unable to penetrate walls [1]. To do this, the Downlink transmitter will, in the majority of instances, make use of white LED lights. Typically, these devices are only used to light up a room when a constant current is supplied to the circuit. By using quick and subtle adjustments to the current, however, it is possible to command the optical output to vary at very high speeds.

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One of the characteristics of optical current that is utilized by Li-Fi technology is mentioned here [2]. The functioning is straightforward to comprehend: a digital 1 signal is sent when the LED is on, and a digital 0 signal is sent when it is off. The simplicity of turning on and off the LEDs creates excellent opportunities for data transfer. LEDs, which are light-emitting diodes, are the sole components that are required, together with a controller that can transmit data to the LEDs. The only thing that has to be done in order to encode data is to alter the rate at which the LEDs flicker [3]. Two more approaches to improve this technique are to use an array of LEDs for simultaneous data transmission or to change the frequency of the light by combining red, green, and blue LEDs, each of which encoding a distinct data channel. These developments appear to point to a theoretical speed of 10 gigabits per second, which would make it possible to download an entire high-definition movie in thirty seconds [4].

II. LITERATURE SURVEY

A recent proposal has been made for an architecture that would combine the advantages of the Wireless Gigabit Alliance (WiGig) and the light-fidelity (LiFi) networks in order to facilitate the transmission of data via wireless networks at extremely high speeds [5]. The service is provided via a LiFi access point, which makes use of a LiFi attocell, which has a restricted coverage area. As a consequence of this, LiFi networks have the potential to enhance their spatial-spectral efficiency by making efficient use of the concept of frequency reuse. The majority voting method, which takes into account the decisions that have been made in the past within the selected subset, is used to determine the decisions that are now being made. A novel load-balancing algorithm has been developed with the intention of simplifying the process while still delivering equivalent levels of feasible data rates and outage probability performances to older systems [6]. Presented in [7], PlaciFi is an all-encompassing framework that is designed to facilitate the efficient placement of three-dimensional access points in heterogeneous LiFi-WiFi networks. When you combine LiFi and WiFi, you are able to take advantage of the benefits that both technologies offer in a variety of different environments. As a direct result of this, new challenges have surfaced while attempting to deploy access points in an effective manner. In order to circumvent these challenges, PlaciFi integrates the three-dimensional positioning of access points into the traditional methods of network planning.

In this [8] study, the usefulness of light-fidelity (LiFi)-based device-to-device communication in the Internet of Things (IoT) is investigated. In this section, we will discuss every facet of D2D mobility management in LiFi networks that are utilized in the manufacturing industry. Using the semi angle at half illuminance of the AP and the IoT that is D2D broadcasting, you may develop a coverage model for the D2D communication range. This will allow you to determine the coverage model. It has been claimed that the DS-PIM-SIM-OFDM may be enhanced in this regard [9].

The enhancement that was suggested addresses this deficiency and makes DS-PIM-SIM-OFDM significantly more effective across the spectrum. This is the case for a large number of active subcarriers. The suggested approach improves the signal-to-error ratio by 25 percent by utilizing three active subcarriers, a sixteen-QAM modulation, and a three-bit index word. We make use of inexpensive commodity hardware, such as [10] in the IEEE P802.11bb task group, in order to make it possible for WiFi waveforms to be transmitted directly over the optical wireless channel. At the physical layer, the second step is to mix radio signals and LiFi signals by utilizing the MIMO signal processing that is available in WiFi. The prototype of Hy-Fi was put into operation and evaluated in a testbed that was quite low in space. According to the findings of the experiments, our approach is an excellent choice for applications that have severe criteria regarding the packet loss ratio and delay. This is due to the fact that our technique is incredibly resilient to external interference, blockages, and signal fading in both the radio and optical channels. If everything goes according to plan, combining the LiFi and RF channels can increase the link's capacity by a factor of two. This theoretical study [11] looks into the SPAD-based optical waveform converter (OWC) systems that use direct-current-biased optical OFDM signalling in great detail. It achieves this by accounting for signal-dependent shot noise, SPAD nonlinearity, and signal clipping. It has been suggested that an equivalent additive Gaussian noise channel model be utilized in order to characterize the performance of the SPAD-based OFDM system.

In addition to the analytical formulas for the bit error rate and signal-to-noise ratio, closed forms are used to compute the statistical data of the proposed channel model. Comprehensive numerical findings are used to investigate the impact that the nonlinearity of the singular receiver has on the effectiveness of the system. Research into the theoretical performance of an OWC system that is based on SPAD and uses asymmetrically-clipped optical OFDM (ACO-OFDM) is presented in this [12]. The performance of the system is investigated in terms of how the SPAD nonlinearity influences it. A comparison between the two schemes, DCO-OFDM and the one that is now being considered, is also presented. This comparison highlights the significant differences in the trustworthy operation regimes of the two schemes. The influence of LED size on a variety of parameters of communication performance is examined further in this [13][14][15][16][20][21] study, which makes use of a point-to-point OWC system that is one meter in length as its foundation. Among the elements that come under this category are channel gain, relevant ratio, theoretical Shannon capacity, signal-to-noise ratio (SNR), actual data transmission rate, and spectral efficiency (SE).

III. METHODOLOGY

The utilization of light-emitting diode (LED) technology for the purpose of picture transmission is an essential component of the Li-Fi generation of technology. The transmitter and the receiver are the two primary components that make up this system.

A. Transmitter Section

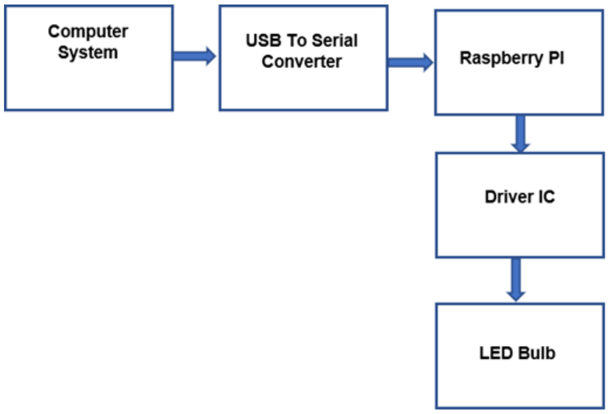

Fig.1. A Module for an Image Transmitter

It is the responsibility of the transmitter module, which is responsible for delivering picture signals or data from the computer system to PICO W for processing, to connect with the USB-to-Serial Converter. It will be converted into a pulse width modulation (PWM) signal by the PICO W, which will then make it usable by the LED driver. The PICO W is capable of producing a pulse width modulation (PWM) signal and displaying it by altering the brightness of an LED that is connected to the power supply (PI). It is possible to monitor the progress of the data transmission using an LCD screen in the meantime.

The block diagram of the Li-Fi transmitter module is shown in Figure 1, which may be seen above. The operation of these modules is broken down into the following component parts:

✓ This refers to the computer system that enables the transmitter to do image processing activities while simultaneously broadcasting the image.

✓ It is possible to convert data signals sent by USB to and from other communication standards thanks to a specific protocol known as a USB adaptor converter. It is usual practice to make use of USB adaptors in order to convert data from USB into data that is typical of serial ports. The USB port on a computer is the spot that is specifically dedicated for the USB connector. Any data transmissions that are sent from the serial device are sent directly to the USB port.

✓ The PICO W, a little computer about the size of a credit card, is the latest iteration of the concept. To transform it into a fully functional computer, all that is required is a microSD card, a power source, a display, a keyboard, and a mouse. No other components are required.

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The installation of the Linux distribution is all that is required. Preinstalled on the device is embedded C, which is the official programming language of the PICO W embedded C integrated development environment (IDE). One of the most notable characteristics of the PICO W is the row of general-purpose input/output (GPIO) pins that runs along the edge of the board and is located next to the yellow video-out connector for the board. Through the use of these pins, the Raspberry Pi is able to communicate with the outside world. One hundred seventeen of the twenty-six pins are general-purpose input/output (GPIO) pins. Power or ground make up the remaining pins, while the remaining pins are just pins.

✓ DC motor can be driven in any direction with the help of the L293D, a common motor driver or motor driver integrated circuit. Two DC motors can be operated concurrently and in opposite directions without interference via the 16-pin integrated circuit L293D. As a result, a single L293D integrated circuit is capable of driving two DC motors. This integrated circuit is a dual-bridge motor driver. The ability of a circuit to allow voltage to flow in both directions. The fact that it is impossible to move a DC motor in either the clockwise or anticlockwise direction without also altering the direction of the voltage is the reason why H-bridge integrated circuits are ideal for the task at hand. Each of the two Enable pins may be found on the L293D. In order to run the motor, pins 1 and 9 must be set to high voltages. Only then can the motor be spun. A high voltage must be applied to pin 1 in order to make use of the left H-bridge to operate the motor. Additionally, in order to create the appropriate H-Bridge, you need to be sure to lift pin 9 to a high position. When either pin 1 or pin 9 reaches a low voltage, the motor included in that component will stop operating. It is comparable to turning on a switch.

✓ The use of an LED bulb allows for the transmission of images at a data rate that is rapidly increasing. An LED bulb is a versatile optical device that can function as both a source of light and a transmitter of images. At the same time, it is relatively inexpensive. In the eyes of the naked eye, the LED light appears to be constant because of the high flashing rate at which it is produced. In order to achieve the requested high data rate, high-speed LEDs are utilized. The operation of light-emitting diodes (LEDs) is dependent on the visible light spectrum, which has an optical carrier range that extends from 400 THz (780 nm) to 800 THz (375 nm). By having a high pulse rate, LEDs are able to communicate data in a short amount of time.

B. Receiver Section

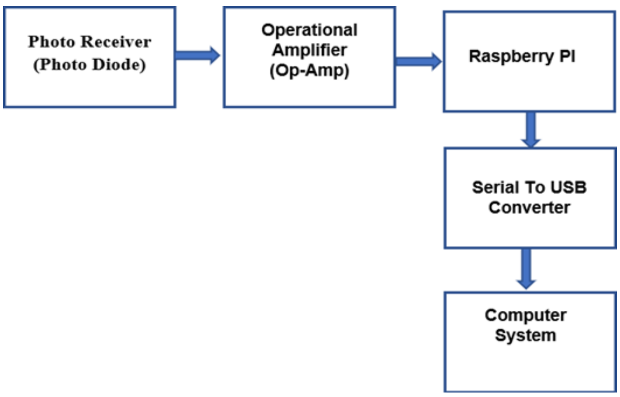

Fig.2. The Module for Receiver Unit

As shown in Figure 2, the block diagram of the Li-Fi Receiver Module is presented below. The photodiode on the LED panel picks up the encoded data signal as soon as it reaches the receiver side. The photoreceiver is then responsible for detecting the digital data, and it is the photoreceiver that decodes the data for the PICO W by utilizing a USB-to-serial converter.

✓ The photodiode is a type of light detector that, depending on the mode of operation it employs, is capable of converting light into both current and voltage. To generate electricity, a photodiode uses a PN-junction diode to convert light into a current. This allows the photodiode to generate power. It is possible to explain it using the phrases "light detector" and "photo detector" whenever necessary. Due to the fact that this diode is extremely sensitive to light, it is able to transform visible light into an electrical current with a minimal amount of difficulty.

✓ An operational amplifier (Op-Amp) is a type of high-gain electronic voltage amplifier that works with direct current (DC). It usually has a single-ended output and a differential input that is connected to a DC. An operational amplifier, often known as an Op-Amp, is a type of integrated circuit that has a very high gain and uses an external voltage to amplify the input signal. Equipment that improves the performance of operational tasks. Increasing the power of a weak input signal is the primary function of an amplifier, which is designed to accomplish this. The LM324 operational amplifier integrated circuit has the capability to perform comparator operations. Designed to run from a single power source throughout a wide voltage range, this low-power quad operational amplifier offers good stability and bandwidth.

IV. RESULT AND DISCUSSION

For the purpose of ensuring the safety of image transfer, Li-Fi technology has emerged as a vital instrument because it eliminates the possibility of data loss[17][18][19]. It is possible to convert the image to base64 format before sending it through an LED system in a serial fashion. This information is sent to the receiver after it has been converted from base64 to image format.

V. CONCLUSION

By simply illuminating the area, Li-Fi will one day make it possible for data to be transmitted from electronic devices such as laptops, cell phones, and tablets. Researchers are developing micron-sized LEDs that are capable of flickering on and off. These LEDs work at a rate that is more than a thousand times faster than larger LEDs. We have more room to deal with them as a result of their small size and high data transfer rates. Alternatively, we can install extra LEDs in order to further optimize the communication channel. In the event that his invention is able to be adopted and every light bulb is capable of functioning as a Wi-Fi hotspot for the purpose of transferring wireless data, we will be able to make progress toward a future that is cleaner, greener, safer, and lighter.

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At the moment, there is a great deal of excitement surrounding the concept of Li-Fi. In addition to bringing the internet to locations such as airplanes and hospitals, where it is prohibited to utilize standard radio-based connectivity, this has the potential to solve issues such as the limited availability of radio-frequency bandwidth. One disadvantage, however, is that in order for it to function, it needs to be in direct visual contact.

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AUTHORS PROFILE

Abishek S -B.E (ECE). Currently I am a student in St. Joseph's Institute of Technology, Chennai. I have a strong foundation in the principles of electronics and communication, I also have a keen interest in exploring cutting-edge technologies that push the boundaries of conventional wireless communication. My expertise lies in the field of wireless communication systems particularly in the emerging technology of Light Fidelity (Li-Fi). My work focuses on the development and optimization of wireless end-to-end image transmission systems using Li-Fi, a revolutionary technology that leverages visible light for high-speed data transfer. My research aims to enhance the efficiency, reliability, and speed of data transmission, offering potential solutions to the limitations faced by traditional Wi-Fi systems.

Habeeb Rahman J, I am a Bachelor of Engineering student specializing in Electronics and Communication at St. Joseph's Institute of Technology, Chennai. My academic journey has been deeply rooted in exploring embedded systems, digital signal processing, and wireless communication technologies. Through various projects and coursework, I have developed a strong foundation in these areas, aiming to contribute innovative solutions to the field. I am an expert in wireless communication systems, with a strong interest in Light Fidelity (Li-Fi) technology.

My efforts are directed towards the development and optimization of wireless end-to-end image transmission systems that utilize Li-Fi, a technology that employs visible light for rapid data transfer. The goal of my research is to improve the efficiency, reliability, and speed of data transmission, addressing the limitations of conventional Wi-Fi systems.