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ORIGINAL RESEARCH PAPER

Li-Fi technology based long range free-space communication data transmit system evaluation

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ABSTRACT

The most flexible and reliable technological system is Wi-Fi, which is made possible by a wireless connection that transmits data using radio frequencies. Wi-Fi networks, however, encounter numerous issues related to power supply, availability, efficiency, and security as a result of the various access points. While relational waves describe the medical device, Wi-Fi radios produce radio waves that are very dangerous for patients. This document offers line-of-sight communication between the transmitter and receiver using LED technology. Li-Fi technology is a method that transmits audio data using LED light, which is faster and more efficient than Wi-Fi. Since it is practically ubiquitous, light can be used for communication as well. A cutting-edge technology called optical communication includes a subset called light fidelity. By sending out visible light, the Li-Fi device enables wireless intranet communication. This paper is an in-depth study and analysis of Light Fidelity (Li-Fi), a novel technology that transmits data at high speeds over a wide spectrum by using light as a medium of transmission. The research fields that are pertinent to Li-Fi networks are thoroughly analyzed and categorized in this paper: high speed data transmission, receiving, sharing, broadcasting through light in free space optical communication system by Li-Fi technology. In this paper, we followed some methods and developed a unique method to develop this study: VLC, OOK, a Lambertian discharge mechanism, LOS, NLOS, or a CMOS optical receiver. The proposed model tested transmits and receives audio, video, and other data, which is very high-rated and near the 2 GB/s range.

KEYWORDS

light fidelity, free space communication, wireless network, data transmission, optical communication

1. INTRODUCTION

Any type of data can be exchanged via light communication, internet service, or the transmission of audio and video over a certain distance, something that perhaps no one considered in the past. It is a very effective new method. We have tried to make people's journeys easier and easier with this information technology to establish smooth communication using only light as a career in a new way. Our study presents a completely new approach that is a step ahead of what has been previously studied. In this continuation, more excellent research on light supply can be expected in the future. In audio communications, frequencies ranging from 20 to 20,000 Hz are utilized. An "audio transmission system" is a mechanism that routes and processes audio signals. The audio signal was sent through sensors and processed for a single output channel. Although microphones send and interpret audio signals, the light in this article acts as a transmitter, transferring data. Li-Fi means "light fidelity." The term "LiFi" was coined by Harald Haas, a German scientist. This is the internet's next generation, in which data is sent using light as a channel. Li-Fi is a state-of-the-art wireless light-based communication system. Li-Fi is a novel and efficient wireless communication technology that transmits data using light [1]. It is the same light we have in

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our homes and businesses, but with a few modifications, it can transmit data to all of our internet-connected gadgets. Visible Light Communication (VLC) and Li-Fi (light fidelity) technologies are used to convey audio data. Li-Fi is a one-of-a-kind means of quickly and effectively transferring data over short distances. The Li-Fi operational premise is to send data in a standardized manner by utilizing the AM of the sunlight source. This technology can carry data at speeds of more than 10 GB/s, and its functional bandwidth ranges from 400 THz to 800 THz. Laser light waves move in unison, meaning their characteristic peaks are all coordinated or in phase. This explains how laser beams can be incredibly narrow and concentrated in such a small space. Because laser light is focused and does not spread out as much as a spotlight, laser beams can travel incredibly long distances.

During the 2011 Tide Global Talk, Professor Herald Hood introduced the concept of wireless data transmission from any light source, which led to the creation of the term "Li-Fi". He is a pure Li-Fi co-founder and chair of mobile communications at the College of Edinburgh. Data is transmitted over the visible light portion of the electromagnetic spectrum using General Sound VLC, a technology that has been around since the 1880s. From January 2010 to January 2012, funding was provided for the A-Lite study at the Edinburgh Institute of Digital Communication [2]. To drive this technology, Haas expanded this market in 2011 with Technology Entertainment Design (TED) Global Talk, which has benefited the market company. Puru Li-Fi is the parent company of a market-ready OEM company for Li-Fi system products to integrate with the current Programmable Visible Light Communication (PVLC) lighting system.

In this modern era, Wi-Fi communication is very popular, but it has a very common limitation: it can only perform within a very short distance. But Li-Fi communication is a stable communication system, and it can perform at a higher speed. It is very important for modern engineering because it is a very low cost technology, it does not require broadband or internet connections, or wired transmission line from one place to another place. It is a very advanced technology nowadays. Scientists and researchers think that Li-Fi will be a more useful communication system than Wi-Fi by 2030.

In October 2011, businesses and industry associations established the Li-Fi Consortium to significantly enhance optical communications networks and get around radio spectrum restrictions. Li-Fi, which was created by the IEEE 802.15.7 RATA Standard Committee, is not the same as the Universal Database's VLC devices sold by some businesses.

This procedure may also be carried out with computational sensitivity, in which the receivers detect a faint signal from a long distance. Li-Fi is not a brand-new technological breakthrough; infrared light has been used in remote controls since the nineteenth century. The discovery was made in 2011, when the first gigabit-class semiconductor, Li-Fi, was developed. ZeronBD, International Property Measurement Standards (IPMS), and Ibisentelcom support this new development. Li-Fi has a one-of-a-kind chance to broadcast Radio Frequency (RF) technologies. One Wi-Fi building is excellent for widespread wireless coverage; both technologies can be viewed as complementary because one is ideal for high-density wireless data coverage with minimal liability and the other is perfect for that [3]. Li-Fi technology may benefit from factors such as increased bandwidth, distance, data quality, security, dependability, availability of power, transmission, power production, influence on the environment, device-to-device communication, interference, device accounting, market preparedness, and comparison of each transmitter and receiver technology. Li-Fi technology will therefore be superior in the future, as we can infer from this data. Our study's main goals have been presented: To develop and construct a long-range data transmitter structure based on Li-Fi technology, the entire system must be put into action in order to assess its actual impact and validate our efforts to investigate the performance of the system for future reference and upgrade.

- For testing purposes, we implemented a real-world demo study to make sure that Li-Fi technology operates as promised.
- Data transmission and reception throughout the study's implementation were successful.
- The study's operation is coded using MATLAB, Verilog, machine learning, and programmable logic control (PLC).
- Variable coding to adapt to a variety of operations and enhance study results.
- This study successfully verifies that our strategy and method work together.

This article described how light-fidelity technology works and how it can be used to send and receive any kind of data over long distances. Introduction, literature review, methodology, experimental setup, findings, and conclusion comprise the paper's structure. We discussed the history and significance of the wireless technology, which is far superior to Li-Fi technology, in the introduction. For the literature review, we picked some recent research and the history of earlier work by some scholars and researchers. In the methodology, we described our brand-new method for creating the study and how it enhances earlier methods for sending and receiving data quickly over greater distances. We developed our study and put it to the test using our methodology in the experiment and result sections.

The innovation in our research is that we can use this method to do any type of live broadcasting, such as live football matches, cricket, various seminars, live classes, etc. It does not require a traditional internet connection and will be very cost-effective. Our thinkers can merge this provision with the fifth-generation network system to benefit from two advantages. In the future, we will be able to do more research and come up with more surprises, which will be an extension of this research. We believe that our research will make people's work easier and will become popular because it is done in a different way from other research.

Structure of the paper:

- Introduction: We presented the background and importance of the research.

- Literature review: previously published related works were presented.
- Methodology: We described our method or model, as well as other models that assisted us in conducting this research.
- Experiments and results: tested data, outputs, and performance of the proposed model. Comparison with other previous research was made.
- Conclusion: summary of the research and Declaration.

2. LITERATURE REVIEW

This section is based on a review of the literature. Here is a look at the literature of the past year, including our efforts. Perhaps by reading it, we can overcome the weaknesses of the previous study and improve its effectiveness. The development of Li-Fi technology aims to increase data throughput, power usage, and performance. Li-Fi is a bidirectional network solution that provides a user experience very similar to Wi-Fi. Over time, connectivity requirements will increase dramatically [4]. We need a network with higher spectral capacity to meet these demands. With Li-Fi, we can use a spectrum that is 100,000 times larger than that of radio frequencies. Li-Fi is now capable of delivering unparalleled data and capacity. It is a type of optical radio technology that includes infrared, ultraviolet, and visible light transmission [5]. Li-Fi is distinguished by the fact that the same light energy utilized for lighting might also be used for connectivity [6]. Li-Fi technology is simple but effective. Photons are emitted from a LED bulb when a continuous current flow is applied to it. It appears to be light. With semiconductor technology, LED bulbs allow for very rapid changes in current and light that may be detected by a photodetector. High-speed information may be sent using this technology via a LED light.

In 2012, VLC technology was shown to utilize Li-Fi. In August 2013, single-color LEDs flashed data at rates of over 1.6 GB/s [7, 8]. According to a press release from September 2013, neither the VLC system nor general Wi-Fi had to meet any line-of-sight requirements. In October 2013, firms in China stated that they were developing Li-Fi development kits. The Li-Fi wireless network Beam Custard was unveiled in April 2014 by the Russian company Steincomm. While future speeds of up to 5 GB/s are anticipated, the current module transmits data at a rate of 1.25 GB/s [9]. Sisoft achieved a new record in 2014 by transporting data at 10 GB/s throughout the light spectrum given by LED lights. The latest integrated Li-Fi system's complementary metal–oxide–semiconductor (CMOS) optical receiver employs less sensitive glacier photodiodes. IEEE transitioned to GigMode in July 2015, which improves energy consumption as a photon beam charges an ionophore and boosts receiver sensitivity.

Remote controllers, for example, are examples of low-cost optoelectronic gadgets. Li-Fi uses direct modulation techniques. LED light bulbs can also transmit very high data rates due to their high intensity [5]. The requirement to transfer bandwidth with certain other users is reduced by high bandwidth density, which improves the user experience. Li-Fi has a data density that is a thousand times greater than that of Wi-Fi. As a result, more data per square meter is provided [6]. Li-Fi communication technology can function even in direct sunlight since modified light rays may be recognized. Because the system detects quick variations in light intensity rather than the gradual fluctuating levels created by interruptions induced by sunlight, and because light waves in Li-Fi are substantially modulated, the sun just provides a continuous light that the receiver can simply filter out. Connecting to local network settings, integrated Li-Fi wireless technology for new "smart luminous" technology, including Li-Fi short range and for communities worldwide, is used. VLC technology transfers data from people's minds at the speed of light. Li-Fi is being utilized to provide low-cost, long-lasting, secure, and high-quality work.

VLC does not offer a health risk, but it may harm the human body because it employs microwaves and sustainable and environmentally green technology. However, along with EPP, VLC, and simple wireless plug-and-play technology become the system's benefits and applications. LEDs are more practical than the present fluorescent pipes, and VLC systems work at light speed in direct sunlight. Wi-Fi or other RF interference with system users, electromagnetic interference with visible light, or free, uncontrolled, and outdated THz do not eliminate it. VLC is safe for the human body since it uses ecologically friendly green technology, such as microwaves, which pose no health hazards. The hybrid system is made up of many components.

They layer three structures: the structure of a complex system, a channel model, and modulated schemes. The media access control (MAC) and physical layers are separated in the framework. The Li-Fi VLC was created to construct the PLC [9]. We attempted to complete this study by reading the aforementioned material, and we were able to complete it successfully by avoiding the faults of the previous year's study.

A trichromatic method is explained, and the impact of color combinations on the maximum data rate that may be achieved is examined. A demonstration of rate-adaptive orthogonal-frequency-division-multiplexing-based LED-based communications with more than 10 GB/s data rate is also covered [7].

Orthogonal frequency division multiplexing (OFDM) modulation is supported, along with time synchronization. Additionally, to provide a system that is more suitable for use in commercial products, it supports TCP and ICMP. The user can access the Internet using various web browsers with very quick response. The system has undergone functional testing that allows for real-time transmission and Internet connectivity. Because of this, a baseband processor can send data at a rate of up to 1 Mbps over an FPGA at 125 MHz [9].

The VLCIoT system has a very low bit error rate (BER), and its maximum data rate is 115.2 kbps. This gadget can be used effectively over distances of up to 7 m indoors, where it is intended to be used. In this study, a figure of merit (FoM) that considers important aspects for IoT applications is proposed and can be used effectively over distances of up to 7 m indoors, where it is intended to be used. In this study, a Figure of Merit (FoM) that considers important aspects for IoT applications is proposed. In-depth comparisons are made between VLCIoT and other VLC platforms that are suitable for IoT applications [10].

This technology works through the Free Space Optics (FSO) Structure; it is a straight-transmitting technology that can be affected by any obstruction. But it can work great if there is no obstruction. One of the ongoing difficulties in remote correspondences is to have the option to give a practical high velocity information connect in applications, there RF based innovation cannot be utilized. It is not reasonable. For instance, in profoundly populated indoor conditions and the last mile access organization, where the last end-clients, utilizing the Radio Frequency based remote advances, do encounter lower information rates and inferior quality administrations because of the range clog [11].

3. METHODOLOGY

This research relied on specific criteria and settings to construct its connected articles, from the beginning stages of the search procedure to the final stages of the production of this work. A critical component of every inquiry is the usage of proper keywords to discover possible research areas. The phrase "Li-Fi" is one of the most common search phrases for previous research on Li-Fi technology. We followed some methods and developed a unique method to develop this study. which is VLC, On-Off Keying (OOK), Lambertian discharge mechanism, Line-Of-Sight (LOS), Non-Line-Of-Sight (NLOS) propagation, and a CMOS optical receiver. This phrase has appeared in all Li-Fi studies, including Haas' work and other relevant articles [12].

As a result, it is concluded that this keyword is sufficient and acceptable to cover crucial areas in this evaluation. The papers considered for the study were all written in English. Review studies, which offer a literature review and are also valuable sources of knowledge, or journal research papers, which present original research, are employed. All work in this review has been produced within the ten-year time frame since 2011, when Li-Fi was first made public. Li-Fi offers a wide range of applications. As a result, including them all in a single document will be tough. Instead, focusing on a few areas of Li-Fi research and emphasizing them will provide fascinating findings. As a result, the closing paragraph in this section will concentrate on the methods of inclusion and exclusion utilized in this study [8]. All of the research involved Li-Fi-related simulation studies. We picked this study because we wanted to provide simulation-based studies on Li-Fi. Only a few countries and industries have adopted Li-Fi as a communication system, and it is still not widely used worldwide. Presenting all relevant numerical simulations would therefore encourage researchers and developers to test Li-Fi before it is legally implemented. Due to methodological limitations, all Other World Computing (OWC) papers that do not contain Li-Fi-based systems as part of their communication and equipment analyses have been eliminated [13–15].

The procedure for this study is as follows:

- Develop an idea for the design and construction of a long-range data transmission system based on Li-Fi technology;
- Design a block diagram and schematic to determine which components we need to build;
- Assemble all the components and program the microcontroller to control the entire system;
- Assemble all the components on a printed circuit board and solder them. Finally, put all the components on the board and test the system.

In our study, we developed a long-range data transmission system based on Li-Fi technology [16, 17]. The current from the AC source enters the DC output circuit through an adapter. This circuit included an audio amplifier, a lithium-ion battery, a laser light, a tiny solar panel, and a speaker (Fig. 1). Li-Fi is a free-space wireless communication system that uses light to convey data and location between devices. The laser light, DC power supply, and Li-Fi audio amplifier are all connected to a 3.5 mm port, which will be connected to the audio source on the transmitter side. We have a solar panel, a lithium-ion battery-powered audio amplifier, and a speaker on the receiving side. At the time of connection of the 3.5 mm port to the audio source on the transmitter side, the laser or LED will illuminate, but there is no variation in the intensity of light at the time the audio source is turned off.

When researchers perform the sound, you will also notice that light intensity varies regularly. When the volume is increased, the intensities of LEDs and lasers vary more quickly. The photovoltaic system is so sensitive that even small variations in the intensity result in a variation in voltage at the panel's output. As a result, when light from the LEDs falls on the panel, voltages fluctuate depending on the intensity of the light. The photovoltaic voltages are instead sent into the amp Li-Fier (it is a speaker), which amplifies the signal and produces audio output through the speaker attached to the amp Li-Fier [14, 15, 18, 19]. As long as the solar cell is in contact with the LEDs, output will be produced. Working procedure part by part is given in Figs 2 and 3.

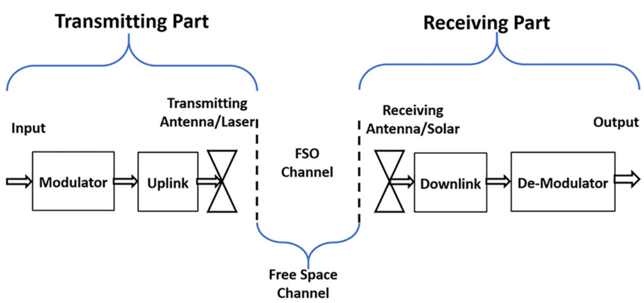

Fig. 1. Free space optics (FSO) structure

4. EXPERIMENT AND SIMULATION

4.1. Experiments

This study focused on two areas: hardware and software. We used the Optical System (OptySim) to design the operational circuit diagrams. The most apparent component of any information system is the hardware. An audio amplifier, a lithium-ion battery, a laser light, mini-solve software, and a speaker comprise the hardware. "Software" refers to the entire collection of procedures, techniques, and programs necessary for a computer system to function. The program aids in the design of circuits. For schematic capture, we utilize Proteus software. The hardware and software are described in depth below. Proteus 8.9 is the software. The hardware components are the PAM8403 Audio Amplifier Li-Fi Module, Mini Photovoltaic Panel, Communication Module, Laser Light, Adapter DC Power Supply, and Speaker [20].

An electrical amplifier known as an audio power amp (or power amp) boosts weak electronic signals, such as those from a radio reception or a musical instrument pickup, to a volume that can drive loudspeakers or headphones. Many different types of audio equipment, such as sound reinforcement, broadcasting, and domestic sound systems, as well as audio instrument amps and Li-Fiers such as guitar amps, are all examples of products that fall into this category

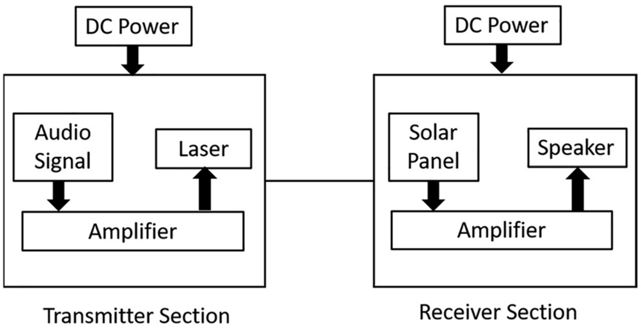

Fig. 2. Block diagram of Li-Fi technology based long range data-transmit system

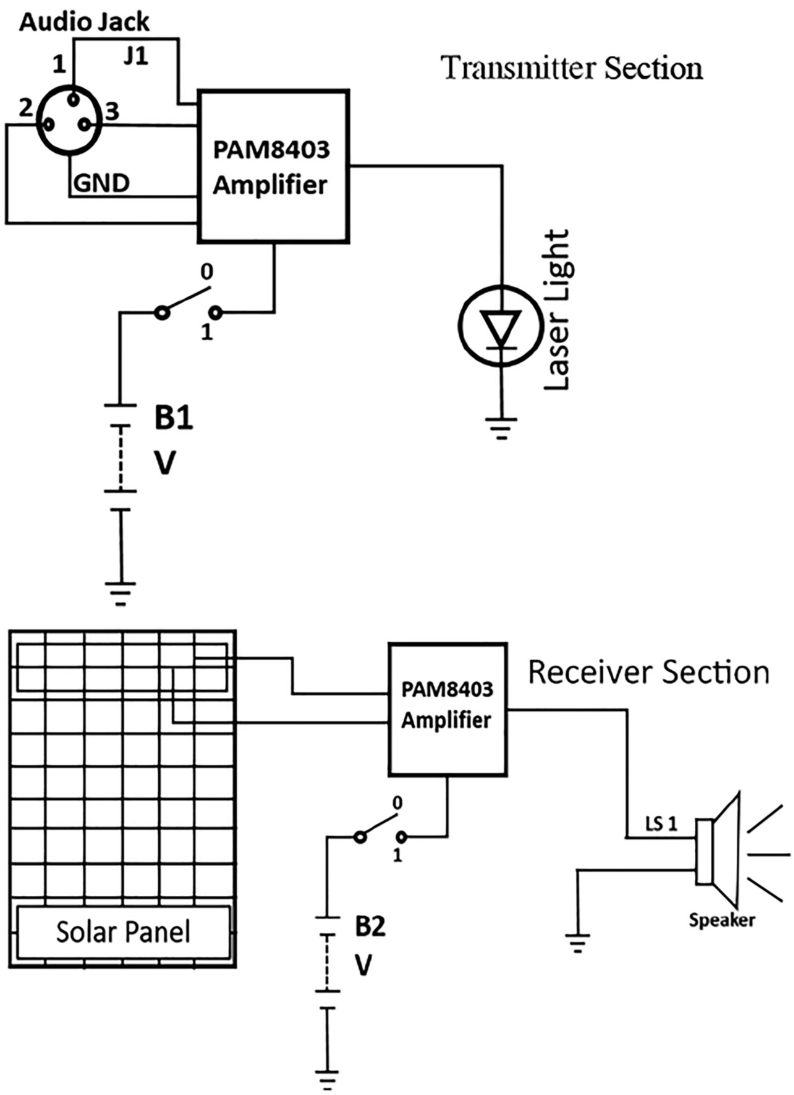

Fig. 3. Li-Fi transmitter and receiver diagram

and contain audio power amplifiers and Li-Fiers. It is the last electrical stage before the signal is routed to the loudspeakers in a conventional multichannel audio chain. The experimental diagrams of transmitter and receiver are shown in Figs 2 and 3. The amplifier is a Li-Fi board that can drive two 3 and 3W LEDs and is powered by a typical 5V input. Anyone looking for a Class-D stereo audio amp with lithium-ion batteries that fits on a small board should definitely consider this option. With this amplifier, users can output high-quality audio from stereo input [21]. It also has a unique function because it is able to drive speakers straight from its output. as seen in the study prototype photographs below.

The operating voltage of an amp's power supply ranges from 2.5 to 5 volts DC. With a four-channel load at 5 V DC, dual-channel stereo with a high maximum output (3 W + 3 W) at 10% THD Maximum Gain: 24 dB, Architecture without Filters Low EMI and low quiescent current. Temperature range: −30 to +80 °C short-circuit protection, thermal shutdown, and up to 90% low capacity in the primary power amp Li-Fi IC, as seen in Fig. 3.

We made a module to test our proposed model. Where we used an IC, the module is made up of a few other components, such as capacitors and resistors. The amp board is a dual-channel Li-Fi amp board with a total output power of 6 W. One channel, which is for the audio input jack, is labeled "L" for left. The ground channel's input audio jack is a "T", the right channel's input audio jack is an "R", and the power supply is 5V. L indicated left-channel positive and negative output, and R indicated right-channel positive and negative output. The amplifier includes built-in short-circuit protection, which is crucial for trouble-free operation because each big Li-Fi system requires it [22, 23]. Since the Amp Li-Fier IC does not require a heat sink, it is an excellent choice for bespoke speaker applications. It can also drive 4 or 8 speakers directly. You must use a good speaker with a maximum output power of 3 W. Since this is a Li-Fi board with a stereo amplifier, the input section includes two inputs, L and R, separated by a common ground. It generates 3 W + 3 W audio output from any audio input that requires lithium-ion battery amplification. At 5V DC input and 4 Ω load output, this amplified Li-Fi module has a peak gain of 24 dB and a total harmonic distortion (THD) of 10%. Without a heatsink, it runs smoothly, which frees up space on the board. Regardless of the heatsink, it might also provide thermal protection, which is an important function for a low-wattage Li-Fier module. LCD monitors and TV study or speaker output Notebook laptops' lithium-ion batteries improve speaker output. Portable speakers, portable DVD players, and game machines can all be used. Any wireless amplified study with a compact footprint and 5V output A solar panel is made up of many electrically connected photovoltaic modules that are mounted on a structural support [24]. Solar cells that have been prepackaged and linked together form a photovoltaic module.

The solar panel can be utilized in commercial and domestic applications as part of a bigger solar power delivery and generation system. Each module is rated for its DC output power under conventional test settings, which generally varies from 100 to 320 W under International Electrotechnical Commission (IEC) specifications. The size of a module is dictated by its efficiency for a given maximum power: a 230-W module with an efficiency of 8% requires twice as much area as a 230-W module with an efficiency of 16%. Due to a single solar panel's capacity limitations, the majority of systems use multiple solar panels [25–27]. A photovoltaic system is made up of a panel or array of solar cells, a transformer, and, on rare occasions, a battery, a solar tracker, and communication cables. Photovoltaic solar modules only generate power when the sun shines. LED positioning and simulation outputs are shown in Figs 4 and 5. They do not store energy; hence, to assure the flow of power when the sun is not shining, a portion of the electricity produced must be stored.

The most apparent answer is to employ batteries, which store electrical power naturally. Batteries are series-connected sets of rechargeable batteries (devices that convert electrical energy from chemical energy). Batteries are made up of two electrodes submerged in an electrolyte solution, which, when connected by a circuit, generate an electric current. The current is generated by reversible chemical reactions within the cell between the two electrodes and the electrolyte. Supplementary or extra batteries are rechargeable batteries. Electric energy is stored as chemical energy in the cells while the battery is charged. When the battery is drained, the chemical energy contained in it is released and transformed into electrical energy [28–33]. A robust outer poly frame encloses and safeguards high-quality, specially designed solar modules and polycrystalline solar cells. The highest output power is 0.66 W, the highest operating voltage is 6 V, and the highest charging current is 110 mA. The minimum output power is 0.55 W, the operating voltage is 5.5 V, and the charging current is 100 mA. The installation of or integration of small epoxy solar panels into a product is simple. There are no frameworks or specific adjustments required for construction. Installation requires only a minimal amount of room. Comparable amorphous thin-film solar cells only produce half as much electricity as these ones. They do not need any additional frames or modifications and are ready to use right away. Simply solder or crimp the copper tape to make connections. Trays are made of thin, incredibly strong, and weather-resistant substrates, or they can be custom-designed, injection-molded trays that are laser-cut, wrapped in UV and weather-resistant materials, and made for the good or service in question. Possibilities include making your own solar-powered models or toys as well as small crafts, science experiments, electrical applications, charging small DC batteries, and electrical applications [26]. Laser light waves travel together, with their peaks in alignment, or phase. This explains why laser beams can be focused in such a small space and are so brilliantly focused and narrow. Due to the laser's continued concentration and lack of dispersion relative to a flashlight, laser beams can cover very long distances. A laser is a device that produces light by amplifying it optically through the electromagnetic radiation that it is stimulated to emit.

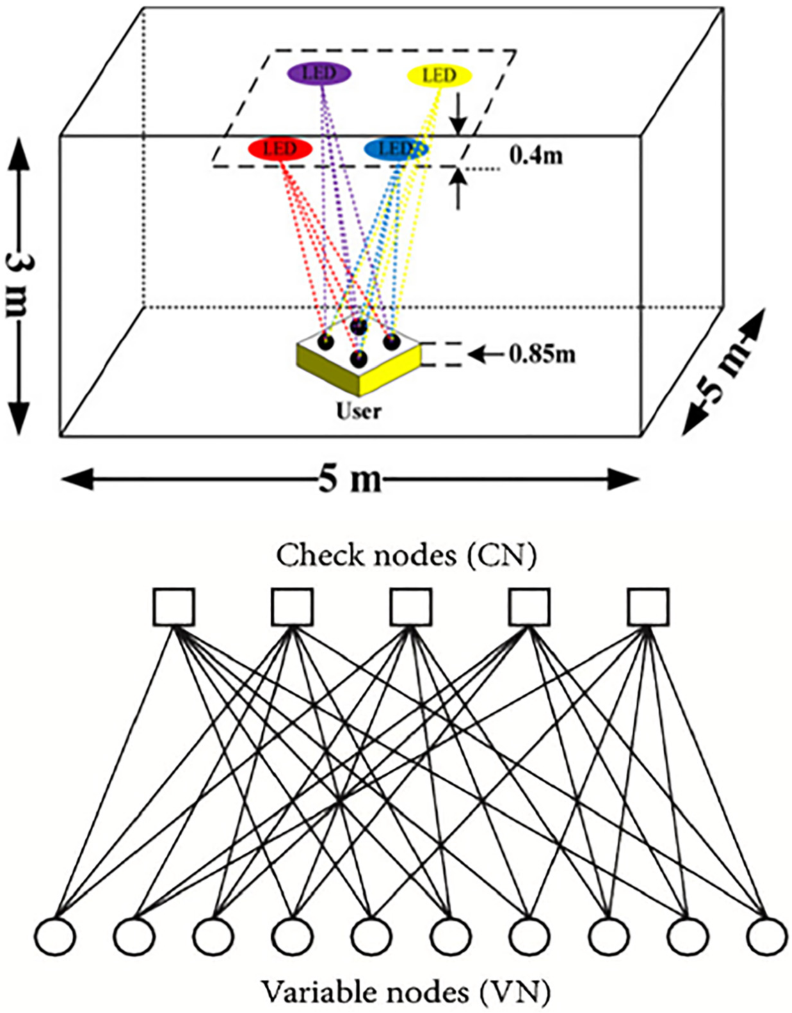

Fig. 4. Node analysis and node distribution of laser light operations

"Laser" is an abbreviation for "light and lasers via stimulated emission of radiation". Based on the theoretical work of Charles Hard and Arthur Leonard Schawlow, the first laser was created in 1960 at Hughes Research Labs by Theodore H. Maiman [31, 34, 35]. The coherent light that a laser emits sets it apart from other light sources. Lasers can be concentrated in a small space thanks to their spatial coherence, making it possible to use them for processes like lithography and laser cutting, as shown in Fig. 4. Additionally, spatial coherence enables a laser beam to collimate, which enables the use of LIDAR and laser pointers over long distances. This technique works on a node-point basis, like a hot point.

4.2. Simulation

The only way to create light with an extremely narrow spectrum is by using lasers, which have the maximum degree of spatial synchronization. Alternately, femtosecond-long, wide-spectrum ultrashort light pulses may be made via temporal coherence. Electroacoustic transducers, also known as loudspeakers, are devices that convert electrical audio streams into the desired sound. A loudspeaker system, also known as a "box" or "speaker", is made up of one or more of these speaker drivers, an enclosure, and electrical connections, which may or may not include a crossover. An analogy with the driver of a loudspeaker can be made between a linear motor and a diaphragm that converts the motion of the motor into the motion of air or sound. The acoustic equivalent of the original, unamplified electronic signal is achieved by electronically amplifying an audio signal, usually through a microphone, recording device, or radio broadcast, to a power level that drives the motor. Proteus is a proprietary software toolset used primarily for electrical design automation, as shown in Fig. 5. The application is principally used by electronic engineers and technicians to create circuits and electronic layouts for PCB manufacture. The original version of what is now referred to as Proteus Design Suite, PC-B, was developed in 1988 for the Disk Operating System (DOS) by the company's CEO, John Jameson. Support for schematic capture was added in 1990, and Windows environments were adopted at the same time. In 1996 SPICE, Proteus included multipathing simulation, followed by microcontroller simulation in 1998.

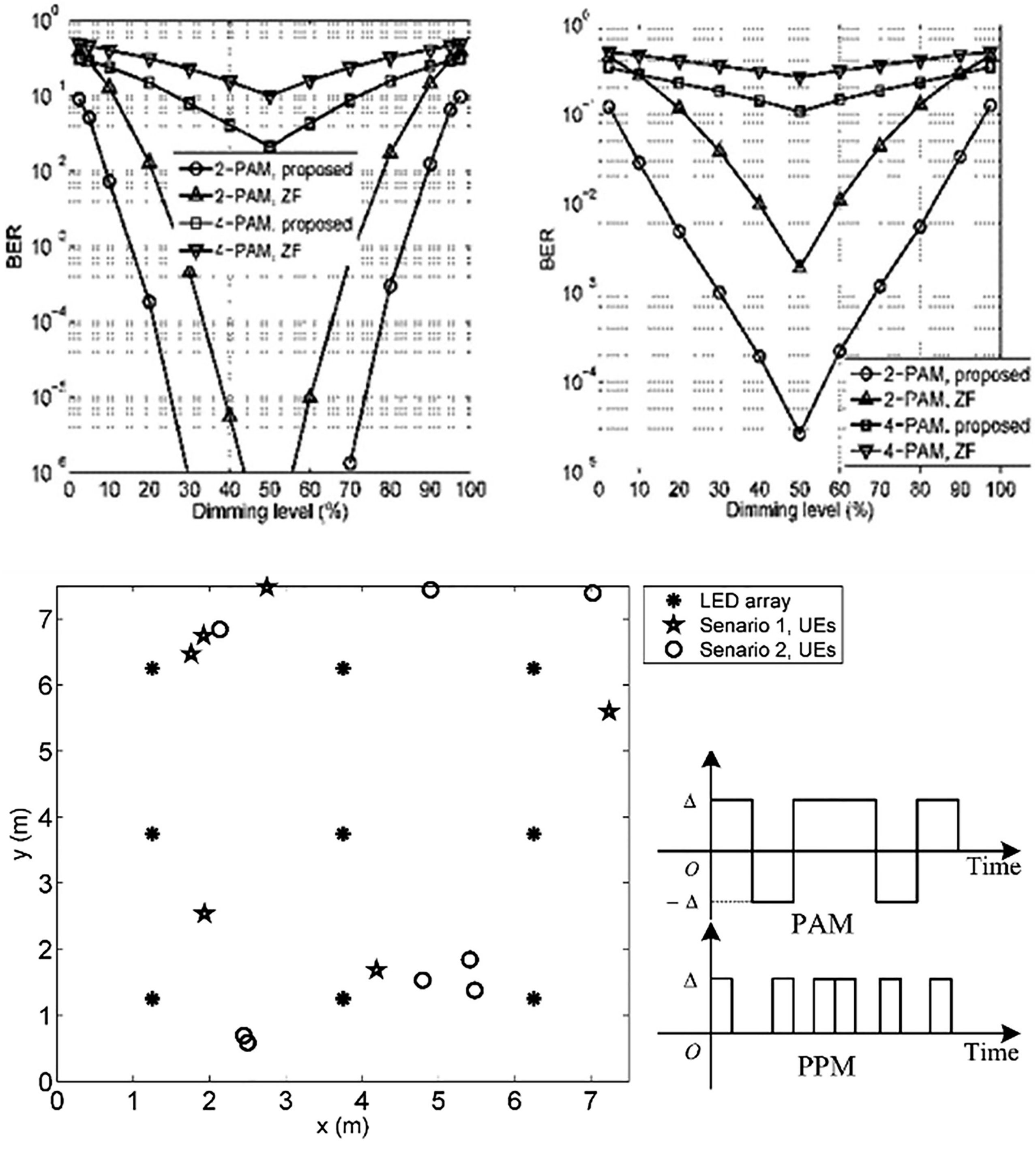

Fig. 5. Proteus software simulation

Shape-based autorouting was introduced in 2002, and 3D visualization of printed circuit boards was added in 2006. 2011 saw the creation of a specific Integrated Development Environment (IDE) for simulations, and 2015 saw the addition of Minneapolis College of Art and Design (MCAD) import and export. 2017 saw the introduction of support for high-speed design.

Deployment of Li-Fi technology in practical wireless access networks necessitates calculating techniques for determining the key operational characteristics, identifying sites where Li-Fi systems can be most efficiently utilized. The development of architectural suggestions for the system, its parts, and the sequence in which they interact compiles a collection of operational indicators for telecommunications systems.

A new model is being developed that mirrors the system with customer service procedures. Define a mathematical apparatus for finding the primary key indicators of telecommunications system operations. This work investigates the approach of evaluating the energy waste of LEDs in light pathways within actual wireless access organization situations in a normal office space.

The following scheme represents the model of a Li-Fi network. Receiving and transmitting modules are critical components of such a system. Figure 2 depicts these components in further detail. An approximation of the components and their functional purpose is provided. Taking this into account, a dynamic routing model of laser signal interaction across transceivers is developed.

A no-view line and a LOS comprise the VLC channel (NLOS), it depicts the geometry of VLC dispersion inside a single room. Each receiver is considered to have a photodetector. The straight-line path between both transceivers is known as LOS, and the appropriate Euclidean distance is indicated by the fact that each receiver has a photodetector. The line segment channel in between transceivers is denoted by LOS, and the relevant Euclidean distance is denoted by d_{iu}.

The direction of emission and attenuation linked with the LOS path are denoted by d_{iu}, $\varphi_{i,u}$ and $\psi_{i,u}$ respectively. To broadcast data, many different types of LEDs with modulation bandwidths ranging from many tens of MHz to around 150 MHz or even too many scores were used. A detector or photovoltaic grid is frequently used to detect a signal on the receiver side [35]. It depicts many sorts of models of a light-emitting diode's intensity of radiation and their related values of the Lambert radiation parameter m. Consider the following situation to acquire precise indications for the operation of the Li-Fi network. Let us have a system where user 1 sends data to user 2. The signal is sent from user #1's transmission module to the reception module on the ceiling, where it is picked up by a cluster of LED lights mounted on the ceiling. Photons are transformed into electric current once they have been collected by the photodetector [36–41]. The optical energy is converted into electric current, which then enters the microprocessor, which controls the LED panel. The signal was transferred from the microcontroller to the data by the second user. The power of the intermediate transmitter is defined as the ratio of the received data to the value of the transmission data, which is determined by the structural features of a particular bulb. This is critical to remember. When transmitting information from a set of LED bulbs on the ceiling to user 2's receiver, the previously outlined processes apply. Table 1 includes the data required to execute the computations.

To calculate how much energy is emitted during the transfer of a light signal to the receiver from the transmitter, use the following mathematical equation:

$$H_{PLiFi} = H_{LOS} + H_{NLOS} \tag{1}$$

The LOS channel, according to [13], may be computed as follows:

$$H_{LOS}^{i,u} = \frac{(m+1)Apd}{2\pi d_{i,u}^2}\cos^m(\phi_{i,u})g_f g_c(\psi_{i,u})\cos(\psi_{i,u}) \tag{2}$$

Where, $m = \frac{-ln(2)}{ln(\cos\phi_{1/2})}$. The Lambertian discharge mechanism is represented by the operators below:

Table 1. The data required to execute the computations

Parameter	Symbol	Value
Photo detector	h	2 m
Area of detection	A_{pd}	1 m^2
Coefficient of optical filter	g_f	1
Refractive index	n	1,5
Half-intensity radiation angle	$\Phi_{1/2}$	60°; 1,047 rad
Photodetector field view	$\psi_{\max}$	90°; 1,571 rad
Power of optical transmitter	P_{opt}	3 W
Optical energy coefficient into electric	k	3
Responsivity receiver	R_{pd}	0.53 A/W
Coefficient of Reflection from obstacles	p_ω	0.8

$\phi_{1/2}$ represents the emission direction with 1/2 the strength of the principal optical axis.
A_{pd} - physical region of Parkinson's disease;
g_f – gain of optical filter's.
g_c $(\psi_{i,u})$ is an abbreviation for laser concentration gains, which is described as follows:

$$g_c(\psi_{i,u}) = \begin{cases} \frac{n^2}{\sin^2(\psi_{\max})}, \psi_{i,u} < \psi_{\max} \\ 0, \psi_{i,u} > \psi_{\max} \end{cases} \tag{3}$$

where n stands for the refractive index.

$\psi_{\max}$ is the semiangle of the PD's field of vision (FOV).

Let L_{iu} define the relative separation between the sender (i) and the receiver (u) as varying from 1 to 2 m in 0.5 m increments, and the angle i,u as varying from 40 o to 75 o, or from 0.669 rad to 1,309 rad. Using Pythagoras' theorem and some trigonometric adjustments, we can calculate the angles.

$$\phi_{iu} = \Psi_{iu} = arctg\left(\frac{L_{iu}}{h}\right) = \begin{matrix} 0.464 \\ 0.644 \\ 0.785 \end{matrix} \tag{4}$$

The MathCad application was used to do the computations. The following are the H_{LOS} results:

$$H_{LOS} = \frac{(m+1)A_{pd}\cos(\phi_{iu})^m g_f g_c \cos(\Psi_{iu})}{2\pi\left(\frac{L_{iu}}{\sin(\phi_{iu})}\right)^2} \tag{5}$$

Based on the dataset obtained, the result of H_{LOS} at the fastest route is $4{,}686^*10^{-5}$ between the light and the photo detector, and $2{,}929^*10^{-5}$ at the largest distance (according to the input data). For the sake of simplicity, only the reflection of the first order is considered in the NLOS route. First-order reflection is divided into two parts.

Distances are indicated by $d_{i,w}$ and $d_{w,u}$. The ranges of beam and incident are $\varphi_{i,w}$ and $\theta_{i,w}$ for the original section, and $\theta_{w,u}$ i $\psi_{w,u}$. for such a second section. Because the route allocation throughout the room is quite small, delays among these diverse paths may be ignored. In other terms, information from various pathways is believed to arrive at the receiver at the same time. The following method is used to determine the NLOS of a Li-Fi channel:

$$H_{NLOS}(x) = \int_{\min\vartheta iw}^{\max\vartheta iw} \frac{(m+1)Apd}{2\pi\left(diw\,(\vartheta iw) + \frac{x}{\cos\,(\vartheta wu(\vartheta iw))}\right)^2} {}^{*} \quad (6)$$

$$^{*}p_w \cos^m\left(\phi_{i,w}(\vartheta iw)\right) g_f g_c \cos\left(\psi_{w,u}(\vartheta iw)\right)$$

$$\cos\,(\vartheta iw) \cos\,(\vartheta wu(\vartheta iw)) d\vartheta iw$$

where A_w denotes a small wall reflection zone, and ρ_w denotes wall reflection.

Let us do the computation, substituting the gap between both the wall and the photodetector for the parameter x:

$$\begin{aligned} \text{Hnlos}(0) &= 4.074 \times 10^{-10} \\ \text{Hnlos}(2) &= 1.91 \times 10^{-13} \\ \text{Hnlos}(6) &= 2.205 \times 10^{-14} \\ \text{Hnglos}(9) &= 9.863 \times 10^{-15} \end{aligned} \quad (7)$$

In the best case, $H_{NLOS}(0)$ equals to $4{,}074^{*}10^{-10}$, this is 5 orders of scale less than the best route value (H_{LOS}). As a result, we shall disregard the H_{NLOS} value throughout the remainder of this study.

$$\text{Thereafter} : H_{Li-Fi} = H_{LOS} + H_{NLOS} = H_{LOS}, \quad (8)$$

Which means that: $H_{Li\text{-}Fi} = H_{LOS}$

The photons are received in a light sensor now at the received signal and transformed into an electrical charge, the value of which could be quantified as shown in:

$$I_{elec} = \frac{R_{pd} H^{i,u}_{Li-Fi} P_{opt}}{k} \quad (9)$$

Where, R_{pd} – detector responsivity;

P_{opt} – transfer optical signal per Li-Fi access point,
κ – is a transformation factor from optoelectronics to power production; the P_{opt}/κ factor is equal to the strength of the signal.

The findings of calculations done using MatLab software with the input data supplied in Table 1 are displayed in the received signal power and the value of the electric current in the photodetector. The received signal has an optimum output of 0.043079 W and a lowest value of 0.00011096 W. It must be noted that its light sensor may receive signals ranging from 4–6 W to 500–3 W; therefore, the values received are within the allowable range. The maximum electric current value is 0.06847 A, while the smallest value is 0.00017643 A.

5. RESULTS AND DISCUSSION

By comparison with other works, our result is far better than previous works. We overcame some of the limitations of previous work and created a new technique for this system. That is how we compared our work with others' in Table 2. BER findings for a distance range of 150–300 cm as a function of data rate. The light levels range from approximately 651 l× (150 cm) to 134 l× (300 cm).

We successfully tested the proposed method that can transmit and receive audio, video, and other data at speeds approaching 2 GB/s. Our model produces flawless outcomes, and every piece of equipment functions flawlessly. The following are some comparisons between the current model and previous research. The result depends on the power of light and distance between receiver and transmitter.

With increased data rates and greater transmission distances, the BER values rise. With longer transmission distances, the optical power received at the receiver will decrease, and the SNR of the VLC system will deteriorate. The data rate needs to be decreased in order to comply with the pre-FEC restriction. 150 cm, 200 cm, 250 cm, and 300 cm all have total data rates of 2.28 GB/s, 1.74 GB/s, 1.50 GB/s, and 0.90 GB/s, respectively. After deducting overhead, the data rates are 2.0 GB/s, 1.53 GB/s, 1.32 GB/s, and 0.79 GB/s [8]. Internet connection speed as measured by the testmy.net website.

Learn that our Li-Fi system's top speed is 550 kbps, which is not all that different from the theoretical limit of 666 kbps. As depicted in Fig. 5, we gather information on connection speed. The network's speed was tested by downloading 500 kB of random data. Standard connection speeds are thought to be 300 kbps [42].

Finally, we effectively completed our study and made sure everything was running as planned. First, we start our system and test it under different settings. When the laser light hits the solar panel, the audio can be transmitted. We created this technique to transport audio using laser light. Our major goal was to employ the wireless transmission method. Because of its precision, our study has several advantages. Some of the benefits are listed below: Unlike Wi-Fi, which operates on the radio frequency spectrum, Li-Fi operates on the visible wavelength spectrum, which is still underutilized. Li-Fi addresses the problem of radio

Table 2. Comparison with other works

Reference	Modulation	Data rate	Baseband processing	Network access	Live broadcast
[7]	WDM-OFDM	11.28 Gbps	Offline	No	No
[8]	OFDM	1.6 Gbps	Real-time	Yes	No
[9]	OFDM	2 Gbps	Offline	No	No
[10]	OFDM	2.5 Gbps	Real-time	No	No
[37]	OFDM	150 Mbps	Real-time	No	No
[39]	OFDM	26.8 Kbps	Real-time	No	No
[40]	OOK	0.87 Mbps	Real-time	Yes	No
[41]	OOK	0.5 Mbps	Real-time	Yes	No
Our Result	**OOK**	**1.98 Gbps**	**Real-time**	**Yes**	**Yes**

frequency signal interference due to the vast range of the light wave frequency spectrum. Low use and maintenance expenses are required for Li-Fi. Light waves, since they are impenetrable, give greater privacy, security, and monitoring than Wi-Fi. User-friendliness: The entire system requires very little energy. Audio transmission in a wireless system; audio transmission in a Li-Fi system. The system is small, inexpensive, and simple to use. This study has several possible applications in today's modern and practical world, some of which are listed below: Relief from RF Spectrum Mobile Connectivity, Smart Lighting, Hazardous Environments, and RF Avoidance.

The VLC system's 3 dB spectrum can be expanded from 17 to 366 MHz (starting frequency at 10 MHz) using such a single compact luminescent white light or a separate, low-cost receiver. This transmission throughput is 1.60 Gbit/s via 16QAM-OFDM with a modulation spectrum of 400 MHz, and the BER is less than the pre-FEC limit of 3.8 103 after 1 m of free-space broadcast. Using a QPSK-OFDM signal with a modulation spectrum of 350 MHz, a data rate of 0.7 Gbit/s may be reached across a long range of 2 m [8].

6. CONCLUSION

This article takes an in-depth look at audio transmission systems that use Li-Fi technology. The concept of "Li-Fi" is now creating quite a stir all over the world. Our system is routinely used with this infrastructure and can be used without requiring any significant changes. Visible light communication can be a fast-developing technique in the field of wireless technology, as we have demonstrated with this research. We have successfully completed the study, compared it with the published papers of other researchers, and found that our proposed model is quite modern and able to perform very well to a large extent. Especially when it comes to live broadcasting, it is unparalleled. Very little delay was found in live broadcasts, which were within nanoseconds. In terms of data transfer, this proposal has been able to yield results close to 2 gigabytes. VLC, OOK, a Lambertian discharge mechanism, LOS, NLOS, and HLOS method models have been used in this study, which have been able to provide very good results. Simultaneous live broadcasting and data exchange at such a high rate were not possible with any previous model. This research proves that this technology is environmentally friendly. Our proposal foreshadows the beginning of a massive wireless revolution with bandwidth, fast and secure data transfer, audio transfer, and the growing need for environmentally and demonstrably human-friendly technologies. This new technology is generally touted as environmentally benign and safe. It can also be used in potentially hazardous situations, such as in thermal and nuclear power plants, without causing electromagnetic interference. As a result, Li-Fi can effectively replace Wi-Fi. We are considering adding many features to our study in the future to get better results. Some of the actions we are considering are as follows: We are considering adding more functions in the future, such as data exchange over longer distances, lossless transmission, and video distribution methods.

DECLARATIONS

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Authors' contributions: In this study, we investigated various transmission and reception techniques while transmitting and receiving data via free-space optical communications (FSOC) using light technology. We have shown that our technique can distinguish the best results from others. We are encouraged by the research now available to investigate Li-Fi technology. We believe we can create a system that continuously transmits data while remaining stationary and living without the use of a mobile network. For this study, we gathered photos from simulations, the actual study, and some online, laser-limited evidence for the application of our approach. The effectiveness, exceptional performance, and accuracy of our method for transmitting data by light were determined by the examination's findings. In order to improve the data transmission and reception in free space optical systems (FSOS) for wireless technology, we will continue to research in the future. O. Faruq: Conceiving the idea, simulation, study supervision, writing and drafting, data collection and comparison. K.R.S. Rahman and N. Jahan: testing, data collection, simulation. S. Rokoni and M. Rabeya: making studies, testing, result drafts, data collections.

Software application code availability: We are not able to reveal our unique code. However, we have used OptySim, Matlab, and C to create our code, schematics, and simulations.

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