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Wireless Communication through the Light

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Abstract: *Li-Fi stands for Light Fidelity. The technology is new and was proposed by the German physicist Harald Haas in 2011. Li-Fi (Light Fidelity) technology is a revolutionary wireless communication method that utilizes light to transmit data, offering an alternative to traditional radio frequency-based Wi-Fi. In Li-Fi systems, data is transmitted through the modulation of light intensity, typically using LED bulbs. This technology leverages the vast bandwidth of visible light spectrum, enabling high-speed data transmission with minimal interference. Li-Fi would use transceiver-fitted LED lamps that can light a room as well as transmit and receive information. Since simple light bulbs are used, there can technically be any number of access points. Light waves cannot penetrate through walls, Li-Fi offers inherent security benefits by confining signals within the physical boundaries of a room, making it more resistant to external eavesdropping or interception. Data is encoded in the light, which blinks at speeds imperceptible to the human eye, and a photodetector interprets these light changes back into data. Li-Fi can potentially offer faster data transfer speeds, reduced interference, and enhanced security, as the communication is confined to the line of sight of the light source. However, it requires direct light exposure, which limits its range and coverage compared to Wi-Fi.*

Keywords: Li-Fi, Wi-Fi, Visible Light Communication, Light-based, High-Speed Data Transfer Technology

I. INTRODUCTION

In today's world of overcrowded (data communication), Li-Fi is a new and efficient way of wireless communication. Li-Fi uses LED lights to transmit data. The Transmission of data is done wirelessly. The current wireless networks that connect us to the Internet becomes very slow when many devices are connected. Also, with the increase in the number of devices, which uses the Internet, the availability of fixed bandwidth makes it much more difficult to enjoy high data transfer rates and to connect a secure network. Radio waves are just a small part of the electromagnetic spectrum available for data transfer. Li-Fi has got a much broader spectrum for transmission of data compared to conventional methods of wireless communications that are done on radio waves. Wireless Data Communication has become an imperative part of our personal and professional life. In last few decades, the demand of wireless communication has increased exponentially.

Fig.1: Future of Li-Fi Technology

Li-Fi is high-speed data transfer through visible light can reduce connectivity issues in densely populated areas, fostering communication and access to information. Li-Fi can bridge the digital divide, ensuring that even remote and underserved communities have access to the internet, empowering them with educational and economic opportunities.

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Li-Fi offers a more secure means of data transmission, reducing the risk of cyber threats and enhancing data privacy for individuals and organizations in India. Li-Fi can play a major role in relieving the heavy loads which the current wireless system is facing. Thus, it may offer additional frequency band of the order of 400 THz compared to that available in RF communication which is about 300 GHz. It is a system that represent alternative solution for wireless communication, high-speed data transfer technology.

II. LITERATURE REVIEW

The concept of Li-Fi was first introduced by Professor Harald Haas from the University of Edinburgh in 2011 during a TED Global talk. In this talk, Haas demonstrated how an LED light bulb could be used to transmit data more efficiently than traditional Wi-Fi technology. This groundbreaking idea laid the foundation for the development of Li-Fi as a viable alternative to radio frequency (RF)-based wireless communication. Before Professor Haas's formal introduction, the idea of using visible light for communication had been explored. However, Haas's work was pivotal in conceptualizing and demonstrating a practical application of this technology.

TED Global Talk in 2011: Harald Haas showcased a working prototype that used light emitted from an LED bulb to stream a high-definition video. This demonstration highlighted the potential of Li-Fi to offer a high-speed, secure, and interference-free wireless communication system.

Formation of pure Li-Fi: Following the positive reception of his TED talk, Professor Haas co-founded pureLi-Fi, a company dedicated to the commercialization and further development of Li-Fi technology. The company's aim is to develop products and solutions that can integrate Li-Fi into everyday devices and infrastructures. As Li-Fi came into limelight, it is ruling on the Education System, Corporate life, like University of Edinburgh, Scotland – theLi-Fi Research and Development Centre at the University of Edinburgh focuses on enhancing data rates, improving the efficiency of LED modulation, and integrating Li-Fi with existing wireless communication systems. Fraunhofer Institute for Telecommunications, Germany involved in advancing Li-Fi technology. Oldcomm, France is another key player in the Li-Fi industry, focusing on developing solutions for smart cities, transportation, and healthcare. IIT Delhi, IIT Madras, IISc Bangalore works on high-speed data transmission, indoor navigation, applications in healthcare and education sector also various Indian Government projects like Smart cities mission, Digital India, Advanced modulation schemes such as Orthogonal Frequency Division Multiplexing (OFDM) and Colour Shift Keying (CSK) are being developed to enhance data rates and efficiency. Research is focusing on integrating Li-Fi with existing RF systems to create hybrid networks that leverage the strengths of both technologies. Studies are being conducted on optimizing the energy consumption of Li-Fi systems, making them more sustainable and cost-effective Experimental setups and prototypes are being developed to test the feasibility and performance of Li-Fi in real-world scenarios, including smart homes and industrial environments.

III. METHODOLOGY

Traditional Wi-Fi often struggles with slow speeds, congestion, and security issues like hacking, especially in busy areas and sensitive places like hospitals. These problems are due to the increasing demand for wireless internet and the limitations of radio frequencies used by Wi-Fi. The main objective of this Implementation of Li-Fi Technology is to send the data with high speed from one location to other location. Improve the security of wireless communication. Li-Fi-enabled LED bulbs can serve both as sources of light and as communication devices, offering a dual-functionality that enhances energy efficiency and reduces the need for additional infrastructure. Li-Fi can contribute to energy efficiency by leveraging LED lighting systems and optimizing the use of visible light for data transmission. Sure, here's a step-by-step explanation of how the project works:1. Transmitter End: - You type something into Teraterm software on your PC. This data is transmitted through the USB port. - The data is then sent to the CP2102 USB-to-Serial converter. - The CP2102's TX (transmit) pin is connected to an IR (Infrared) LED. The CP2102 converts the serial data into electrical signals and sends them to the IR LED.2. Transmission through Li-Fi:- The IR LED emits infrared light carrying the data. - This light propagates through the air to the receiver end.3. Receiver End: - A photodiode (or phototransistor) receives the modulated infrared light. - The received light signal is converted back into an electrical signal by the photodiode. - This electrical signal is sent to the input of an LM311 comparator.4. Signal Processing: - The LM311 comparator compares the received signal with a reference voltage. - If the received signal is above the

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reference voltage, the LM311 produces a digital output signal.5. Arduino Interface: - The digital output signal from the LM311 is connected to one of the digital input pins of an Arduino board. - The Arduino reads this signal as a digital input.6. Data Display: - The Arduino receives the digital data and processes it. - The Arduino then sends the received data to a 16x2 LCD(Liquid Crystal Display) for visual display.7. LCD Display: - The 16x2 LCD receives the data from the Arduino and displays it on its screen.So, in short, you're transmitting data from your PC through a serial connection and converting it into light pulses using an IR LED. At the receiver end, these light pulses are detected by a photodiode, converted back into electrical signals, and processed by an Arduino to display the original data on a 16x2 LCD screen. This setup forms a basic Li-Fi (Light Fidelity) communication system

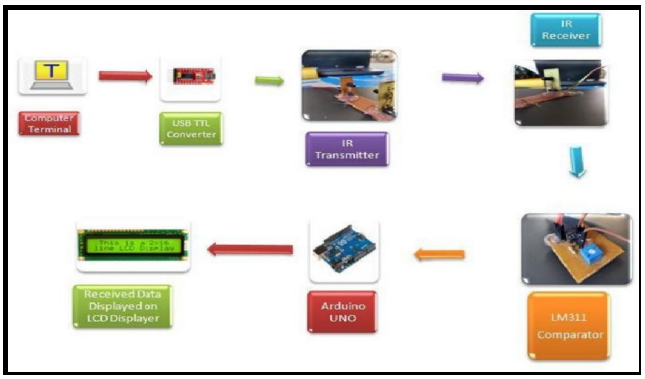

Fig.: 2 Block Diagram

Working:

At the transmitter end of the Li-Fi communication system, data input occurs through the Teraterm software on a PC, which is transmitted via the USB port. The CP2102 USB-to-Serial converter then processes this data, converting it into electrical signals. These signals are subsequently routed to the transmit (TX) pin of an IR (Infrared) LED. The CP2102 effectively acts as a bridge, facilitating the conversion of serial data into light pulses emitted by the IR LED. Once emitted, the modulated infrared light serves as the carrier for the transmitted data, propagating through the air to reach the receiver end. Here, at the receiver end, a photodiode (or phototransistor) captures the incoming light signals. The photodiode then performs the crucial task of converting the modulated infrared light back into electrical signals, which are necessary for further processing. The next step involves signal processing, where the received electrical signals are fed into an LM311 comparator. This component compares the incoming signal with a predetermined reference voltage. If the received signal surpasses the reference voltage threshold, the LM311 generates a digital output signal, signifying successful data reception. The digital output signal from the LM311 comparator is interfaced with an Arduino board, where it is connected to one of the digital input pins. The Arduino reads this digital input, processing the received data for subsequent display. Finally, the processed data is forwarded to a 16x2 LCD (Liquid Crystal Display) for visual representation. The LCD serves as the user interface, displaying the original data received from the PC. This comprehensive setup realizes a basic Li-Fi communication system, enabling wireless data transmission and reception through the modulation of infrared light. Comparison Between Li-Fi and Wi-Fi and Other Radio Communication Technologies.

We use computer as a Sender that sends the text data. Here we use USB TTL to facilitates serial data transfer to convert text in to binary. With the help of IR Transmitter which transmit binary data via infrared light. IR Receiver is used to receives binary data that transmitted to the IR Transmitter. Binary test Conversion that converts binary data into text. LM311 Comparator checks input voltage. With the help of Arduino UNO data is received and sends it to the LCD (Liquid Crystal Display).Finallytext data is displays on the LCD i.e. Outputs the text data received from the Arduino UNO.

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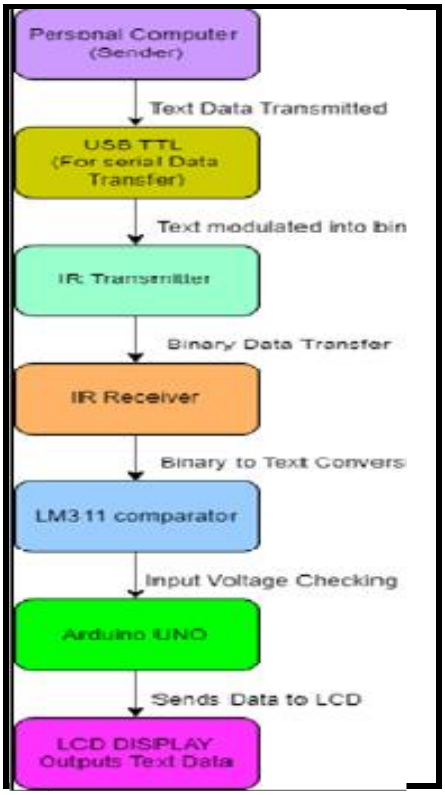

Fig.:3 Flow Chart

IV. RESULTS

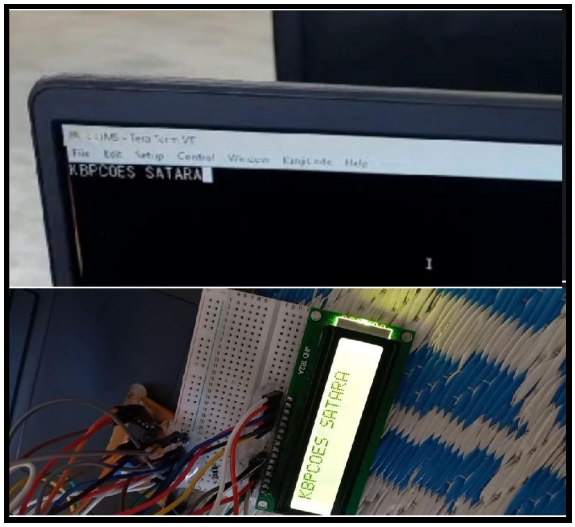

Fig.:4 Output

V. CONCLUSION

Our exploration of Li-Fi (Light Fidelity) technology for text data transmission underscores its immense potential and unique capabilities in modern communication systems. Its ability to achieve high-speed data transfer rates comparable to or exceeding those of conventional Wi-Fi networks holds immense promise for various applications, particularly in

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scenarios where rapid and reliable data communication is essential. while LiFi technology for text data transmission holds immense promise and offers compelling advantages, it is still in its nascent stages of development. Continued research, innovation, and collaboration are needed to address its limitations, expand its capabilities, and realize its full potential in diverse application of Li-Fi is poised to revolutionize the way we transmit and receive text data, ushering in a new era of secure, high-speed, and reliable communication.

VI. FUTURE SCOPE

The future of Li-Fi technology is bright, with opportunities for innovation and applications across various industries. As research and development efforts continue to advance, Li-Fi is poised to emerge as a key enabler of high-speed, secure, and reliable wireless communication in the digital age. Li-Fi technology can be utilized for indoor positioning and navigation systems, offering high-precision location tracking in environments where GPS signals may be unreliable or unavailable. One of the key advantages of LiFi technology is its inherent security features, as light waves do not penetrate through walls and are less susceptible to interception compared to radio frequencies. Li-Fi technology can also be utilized for in-flight entertainment systems, enabling passengers to access high-speed internet connectivity during flights

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