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OPTIMIZED LI-FI COMMUNICATION SYSTEM USING ARDUINO AND SMARTPHONE FLASHLIGHT FOR ENHANCED DATA RATE AND ACCURACY

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ABSTRACT

Li-Fi (Light Fidelity) technology is a cutting-edge kind of wireless connection that transmits data using light waves rather than conventional radio frequencies. It investigates the use of Arduino, a widely available and reasonably priced microcontroller platform, for Li-Fi data transfer. A straightforward and effective Li-Fi communication system that is simple to incorporate into a variety of applications is proposed in this research. The system is made up of an Arduino board interfaced with a light-emitting diode (LED) for data transmission and a photodiode for data receiving. In order to facilitate smooth data sharing between devices in a Li-Fi network, a communication protocol must be developed. Unlike the conventional Wireless Fidelity (Wi-Fi) architecture, Light Fidelity (Li-Fi) technology is a wireless communication system that uses the visible light spectrum to deliver data quickly and securely. This paper describes a Li-Fi communication system that makes use of a smart phone. By using the built-in smart phone flashlight as a source to send data and detecting the impact of employing external light detector sensors attached to an Arduino UNO circuit to receive data, this suggested method seeks to maximize the bit rate with high precision. In order to determine which light sensor could achieve a greater data bit rate and to test the system's performance under varying transmitter-receiver distances, four practical experiments were carried out. The evaluation findings showed that the suggested research outperformed the others in terms of data bit rate, reaching over 100 bps with 100% correctness.

Keywords: LiFi Technology, Visible Light Communication (VLC), Arduino UNO, Photodiode Sensor

I. INTRODUCTION

Data transmission systems that are quicker, safer, and use less energy are in high demand due to the quick development of wireless communication technology. Using the visible light spectrum for high-speed communication, Light Fidelity (Li-Fi) has become a possible substitute for traditional Wi-Fi. Wider bandwidth, less interference, and improved data security are some benefits of Li-Fi over radio frequency-based systems. In this regard, the practical implementation of Li-Fi systems for real-world applications is made possible by the integration of affordable and adaptable platforms such as Arduino. The construction of an optimal Li-Fi communication system using a smart phone flashlight for data transmission and a photodiode sensor for signal reception is the main emphasis of this work. The suggested solution makes use of smart phones' widespread availability to develop a straightforward but efficient communication structure. The technology guarantees dependable data transport with increased precision by creating an effective communication protocol. To assess system performance under various conditions, such as distance and sensor kinds, experimental study is conducted. The technology is appropriate for short-range wireless communication applications because of the results, which show improved data rates and reliable accuracy.

Figure.1: Conceptual Illustration of Li-Fi Communication System Using LED-Based Data Transmission

II LITERATURE REVIEW

Author (Year)	Method/Approach	Key Findings	Limitations
Kumar *et al.* (2026)	Arduino-based secure Li-Fi system	Achieved high-speed and secure data & audio transmission	Sensitive to ambient light and alignment issues
Rahman *et al.* (2025)	Arduino-based Li-Fi using LED & photodiode	Low-cost and energy-efficient short-range communication	Limited transmission range
Hassan *et al.* (2025)	Laser-based Li-Fi communication	Higher bit rate (~512 bps) and improved detection efficiency	High cost and complexity
Sharma *et al.* (2025)	Smartphone flashlight with Arduino Li-Fi	Achieved 100% accuracy and improved bit rate	Performance depends on environmental conditions
Lee *et al.* (2024)	Smartphone-based VLC system	Reliable communication up to ~1.5 m and secure transmission	Requires line-of-sight, limited distance

III SOFTWARE USED

To illustrate this idea, we utilize an open-source Android app for a Li-Fi transmitter. For transmission, the program transforms typed text messages into light flash data. To send text in the form of light, the user must launch the application, type the message, and hit the enter key. It uses the cell phone's flashlight to flash the light for a few seconds in accordance with the text's coding. We can send messages like "hi," "good morning," and more with this software. This app specifies the maximum amount of data that we can send. We must update the app's source code with the new information in order to send a lot of fresh data to the recipient. An Android-based system that uses visible light rather than radio frequencies to facilitate wireless connection is called a Li-Fi mobile application. The LED flashlight on the smart phone serves as a transmitter for this app. Using encoding methods like On-Off Keying (OOK), where "1" is represented by LED ON and "0" by LED OFF, the program transforms text messages entered by users into binary data. The data is then transmitted as light signals by the flashlight blinking quickly in accordance with this binary sequence. A microcontroller like an Arduino decodes the signal back into the original text once a sensor like an LDR or photodiode on the receiving end detects these changes in light. This method uses current smart phone hardware to show the fundamental idea of Visible Light Communication (VLC) in an easy and affordable way.

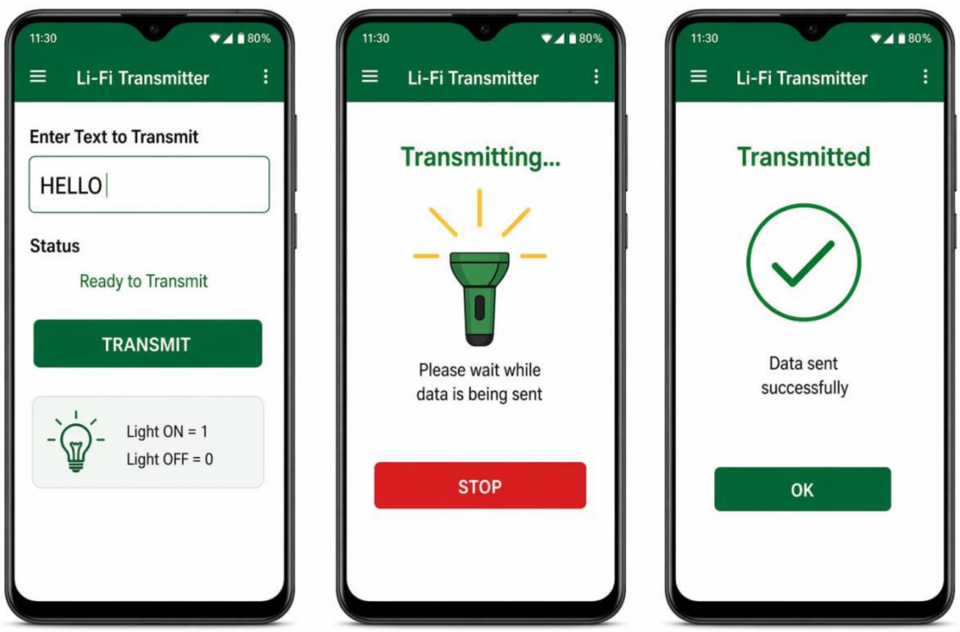

Figure 2: Li-Fi Transmitter App Interface

IV HARDWARE REQUIREMENTS

An Arduino Uno, an LDR sensor, an LCD display, jumper wires, and a 1 kΩ resistor are used in the suggested system. The Arduino manages data transmission and reception, the LDR picks up light signals from the transmitter, and the LCD shows the data it has received while the auxiliary components ensure proper circuit operation

Ardunio Uno

The Arduino Uno is a microcontroller-based board based on the ATmega328P that offers digital and analog input/output pins for interfacing with different sensors and circuits. It is widely used in applications like vehicle tracking, IoT automation, accident detection, robotic systems, and the medical field for temperature and heartbeat monitoring systems. It also has an easy-to-use development environment based on Processing. The Arduino Uno R3 microcontroller board, which is based on the ATmega328P and serves as the system's primary control unit, is depicted in Figure 3. It has analog and digital I/O pins for connecting to sensors and modules, facilitating effective communication and data processing.

Figure 3: Arduino Uno R3 Microcontroller Board

LDR Sensor

The LDR sensor utilized at the receiver side to detect light signals is depicted in Figure 4. The control unit then transforms the signals into serial data and transmits it to output devices. With a response latency of roughly 10 milliseconds, a photo resistor displays large resistance in the dark (mega ohms) and low resistance in the light (few hundred ohms). Because of its affordability and ease of usage, it is frequently utilized in automatic and light-sensitive switching applications. However, limited response time and ambient light can have an impact on its performance.

Figure 4: LDR Sensor

LCD Display

The LCD display used to view the data received from the Li-Fi communication system is depicted in Figure 5. It is frequently interfaced with Arduino using digital pins for effective data presentation and offers an easy-to-use interface for real-time text output display. It uses little electricity and can read alphanumeric characters. By giving instant feedback on sent data, the LCD improves system usability.

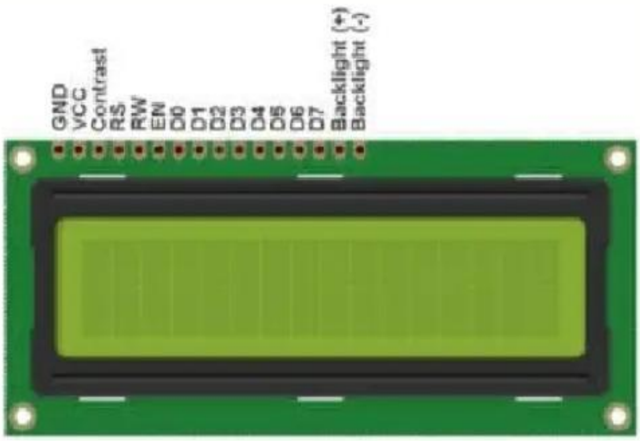

Figure 5: LCD Display

Jumper Wires

The jumper wires used to provide electrical connections between the Arduino, sensors, and other circuit components are seen in Figure 6. They offer a dependable and adaptable method of solderless prototyping. For a variety of connections, jumper wires come in male-to-male, male-to-female, and female-to-female varieties. They guarantee that the system's power distribution and signal transmission are done correctly.

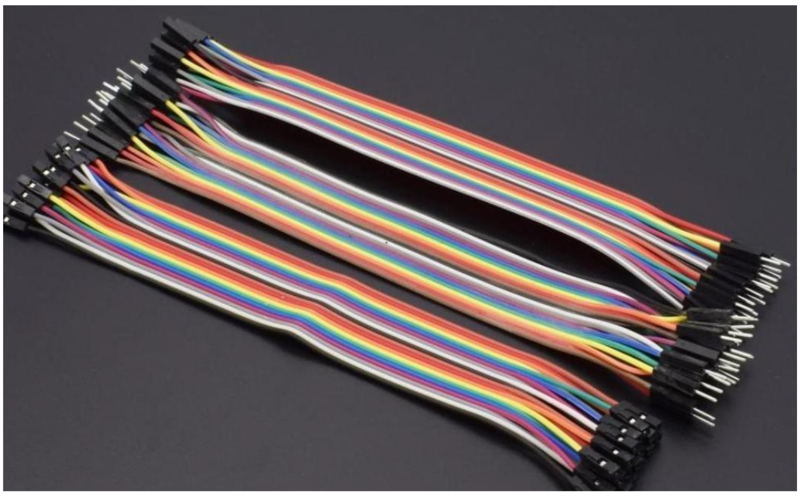

Figure 6: Jumper Wires

1k Ohm Resistor

The 1 kΩ resistor used to control current flow and safeguard circuit components is seen in Figure 7. It guarantees steady operation of the Li-Fi system and aids in regulating voltage levels. In order to guard against damage from excessive current, resistors are frequently employed with sensors and LEDs. Additionally, it helps the circuit achieve dependable signal conditioning.

Figure 7: 1k Ohm Resistor

V PROPOSED MODEL

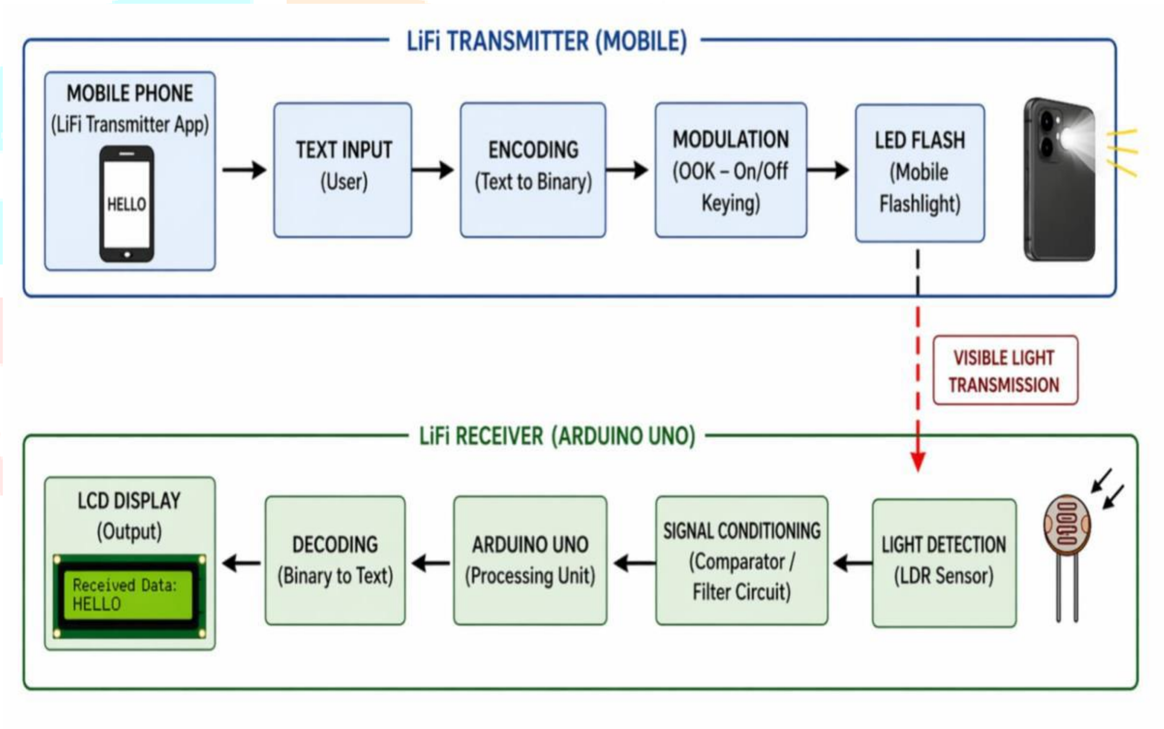

Figure 8: Architecture of Li-Fi Communication System

The general architecture of a LiFi communication system with a mobile transmitter and an Arduino-based receiver is depicted in Figure 8. Using a LiFi transmitter app on a mobile phone, the user starts the procedure by entering text. During the encoding phase, this text is transformed into binary data. On-Off Keying (OOK), in which "1" denotes light ON and "0" denotes light OFF, is then used to modulate the binary signal. This modulated signal is transmitted as visible light by the mobile flashlight LED. After passing through empty space, the light arrives at the receiver part. An LDR (Light Dependent Resistor) sensor detects changes in incoming light. A signal conditioning circuit is used to filter out noise and stabilize the detected signal. The Arduino Uno microcontroller subsequently processes the conditioned signal. The binary data is decoded back into legible text by the Arduino. The LiFi communication process is then finished when the output is shown on an LCD panel.

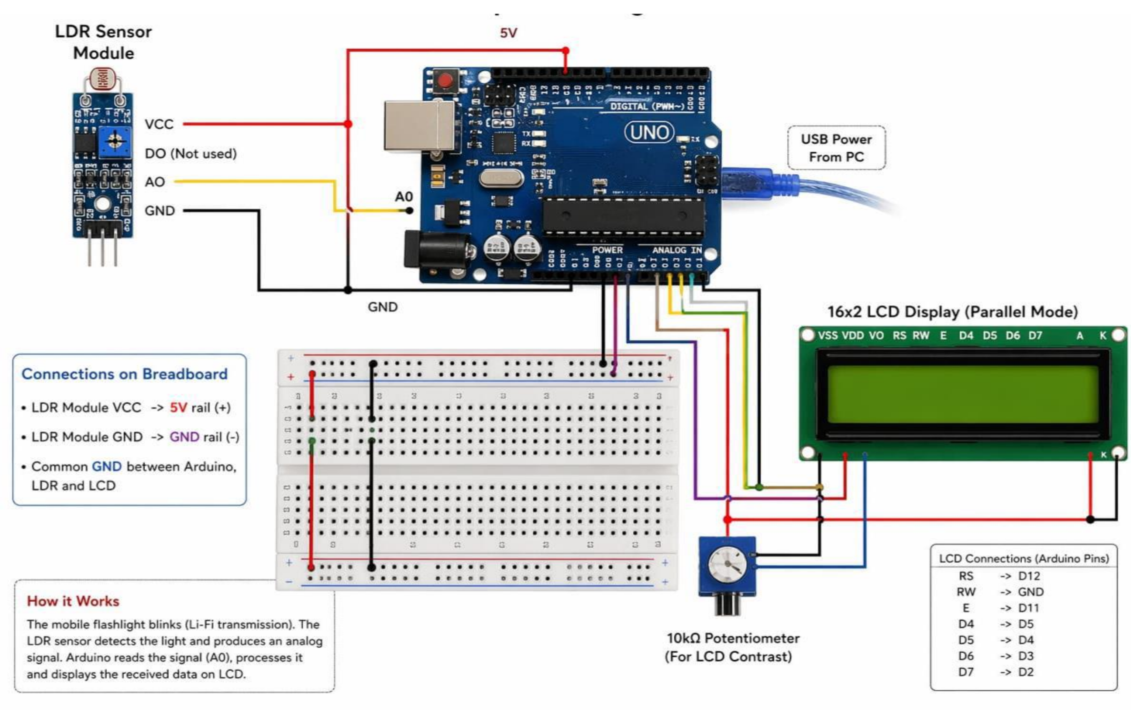

Figure 9: LiFi Receiver Circuit Diagram Using Arduino Uno, LDR Sensor, and 16×2 LCD Display

The hardware connections of a LiFi receiver system using an Arduino Uno, an LDR sensor module, and a 16x2 LCD display are shown in detail in Figure 9. The Arduino's 5V and GND pins are used to power the LDR sensor module, and its analog output (AO) is linked to the Arduino's A0 pin. This configuration does not make advantage of the LDR module's digital output (DO). To distribute electricity and keep all of the components connected, a breadboard is used. The LDR sensor sends analog signals to the Arduino Uno, which serves as the primary processing unit. The fluctuations in light intensity that the LiFi source transmits are represented by these signals. To show the received data, a 16x2 LCD display is interfaced in parallel mode with the Arduino. The LCD control and data pins (RS, E, D4–D7) are connected to a number of Arduino digital pins. The LCD display's contrast can be changed by connecting a 10kΩ potentiometer. A PC's USB connection powers the system. In general, the system recognizes light signals, uses an Arduino to process them, and then shows the information that has been decoded on the LCD panel.

VI RESULT AND ANALYSIS

The experimental configuration of the LiFi receiver system working in a dark setting to reduce external light interference is depicted in Figure 10. To receive optical signals, the breadboard, LCD display, and Arduino-based circuit are put together and operated. The transmitter source's light fluctuations are detected by the LDR sensor. All components are connected by wires, which guarantee appropriate power distribution and signal flow. The lit LCD panel indicates that the system is in active operation. The accuracy of transmitted signal detection is enhanced by the controlled illumination situation. The configuration shows how light-based data can be received in real time. The layout demonstrates how LiFi technology may be used practically. For effective testing, the parts are assembled in a compact manner. Overall, it confirms that the LiFi receiver operates in low light.

The hardware implementation of the LiFi receiver system utilizing an Arduino Uno and a breadboard is shown in Figure 11. An LDR sensor module, an LCD display, and connecting jumper wires are all part of the circuit. A USB cable is used to power and program the Arduino. The breadboard is used to distribute power and arrange connections. To display received data, the LCD display is interfaced in parallel mode. The Arduino receives analog input from the LDR sensor, which records light signals. All components are guaranteed to communicate properly thanks to the wiring configuration. The system layout is easy to understand and appropriate for creating prototypes. The developed circuit diagram serves as the basis for connecting each component. All things considered, it is the physical implementation of the LiFi receiver system.

Figure 10: Experimental Setup of LiFi Receiver System in Dark Environment

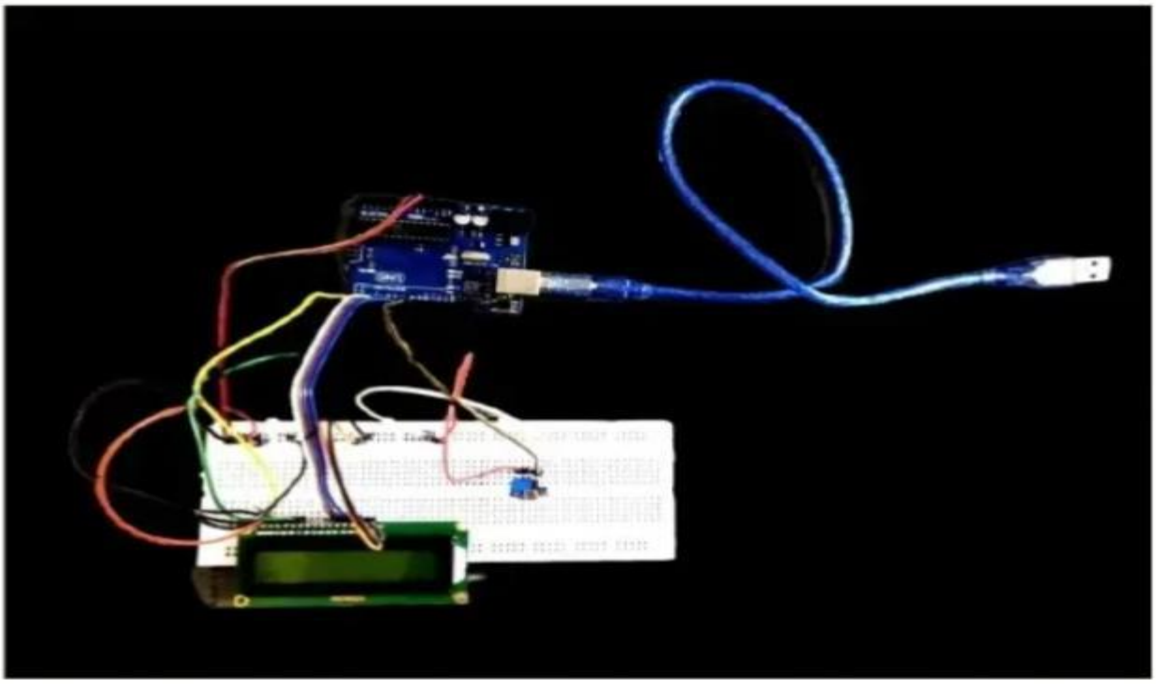

Figure 11: Hardware Implementation of LiFi Receiver Using Arduino and Breadboard

The LiFi communication system's LCD display output is displayed in Figure 12. A green lighting that indicates the power supply illuminates the display. It displays the data that was received after being decoded from light signals. The transmitted message determines which characters show up. Before displaying incoming signals, the Arduino processes them. For clear vision, the LCD runs in 16x2 modes. The output verifies that the signal was successfully received and decoded. The clarity and brightness show that the contrast has been adjusted correctly. The display is the system's last output unit. Overall, it confirms that LiFi data transmission and reception are efficient.

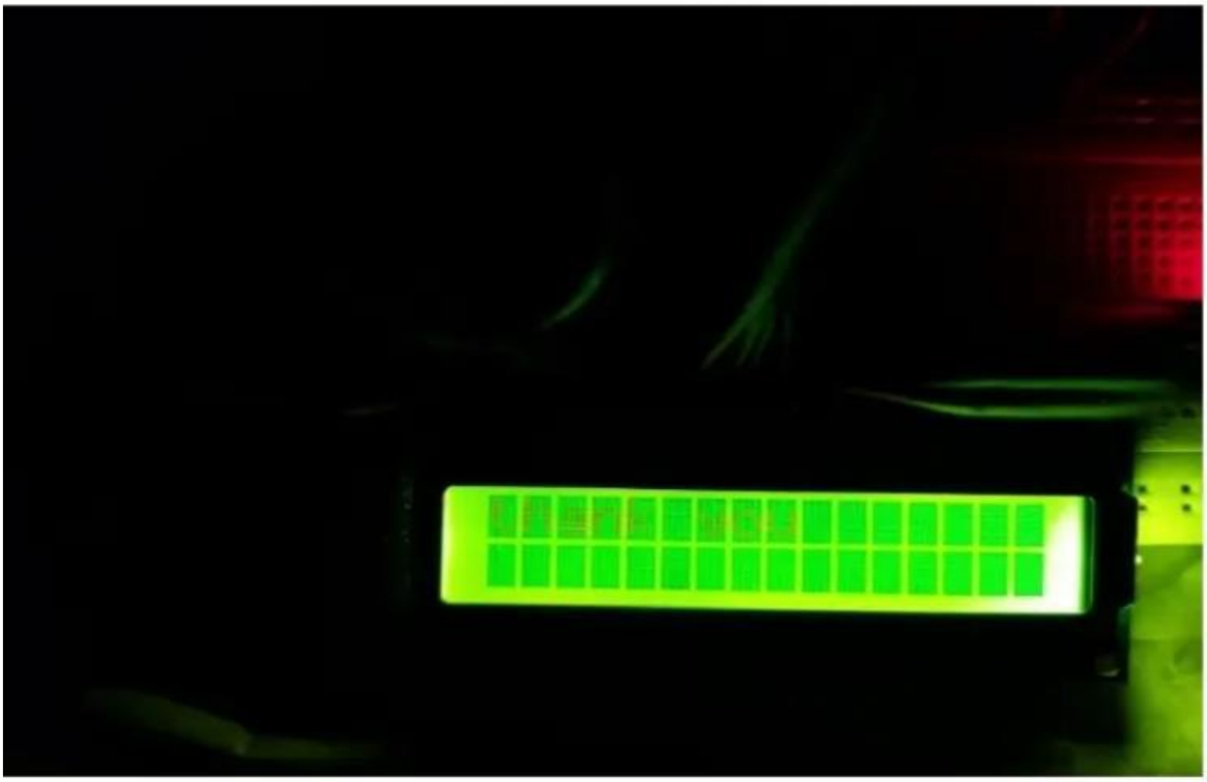

Figure 12: LCD Display Showing Received Data Output in LiFi System

The relationship between transmission rate and transmission distance in the LiFi system is depicted in Figure 13. According to the graph, the transmission rate falls with increasing distance. Different experimental settings or conditions are represented by two sets of data points. Stronger light intensity allows for faster data rates at shorter distances. Signal attenuation causes performance to decline with increasing distance. The trend line makes it evident that the transmission speed is gradually declining. The findings demonstrate LiFi's limitations over greater distances. The graph aids in the analysis of the dependability and effectiveness of the system. It offers information about the setup's ideal operating range. In general, it illustrates the performance.

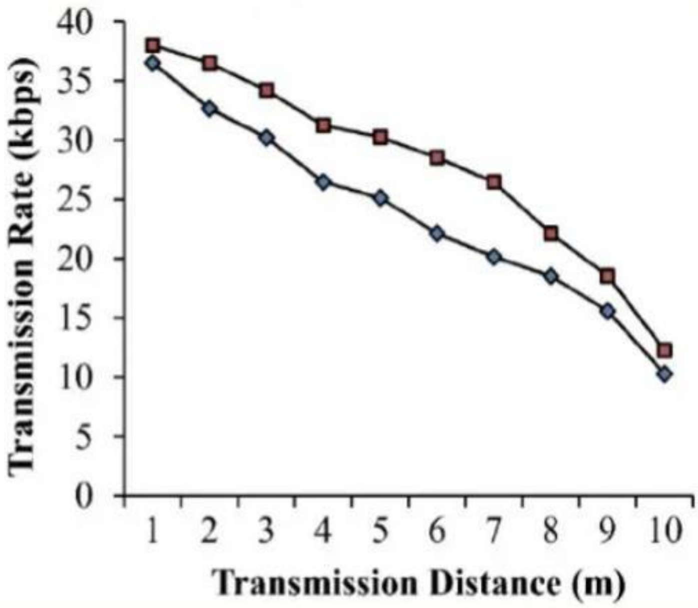

Figure 13: Graph of Transmission Rate vs Transmission Distance in LiFi Communication System

VII CONCLUSION

The Proposed Optimized Li-Fi Communication System effectively illustrates a straightforward, affordable, and effective technique for wireless data transmission by visible light using Arduino and a smart phone flashlight. The method accomplishes dependable communication with enhanced data rate and precision by using external light sensors interfaced with an Arduino Uno as the receiver and a smart phone's built-in flashlight as a transmitter. The experimental findings verify that the selection of light sensor has a major effect on performance, with some sensors offering greater signal detection and larger data rates. Furthermore, the transmission distance affects the system's performance, with shorter ranges demonstrating ideal efficiency. The system is suitable for real-time applications since the designed communication protocol guarantees seamless data transmission between devices. The effectiveness of the proposed design in comparison to traditional methods is demonstrated by the achievement of a data rate of over 100 bps with 100% correctness. All things considered, this work demonstrates that Li-Fi may function as a safe, energy-efficient, and interference-free substitute for conventional Wi-Fi systems. Applications where radio frequency communication is limited or ineffective can benefit from the suggested model. To further improve performance and scalability, future improvements could concentrate on expanding transmission range, refining modulation methods, and incorporating cutting-edge sensors.

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