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DECLARATION

We hereby declare that the project entitled "Li - Fi DATA TRANSFER SYSTEM USING ARDUINO" is an original work submitted by us to the **Department of Electronics and Communication Engineering, NARAYANA ENGINEERING COLLEGE, GUDUR** and we have not submitted the same to any other University or Institute for the award of any Degree.

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ABSTRACT

LiFi technology utilizes led's for transmitting data. It is subsidiary of optical remote communication technology utilizing light from Led to convey rapid communication. Apparent light communication works by turning the Led now and again at exceptionally high velocity, it can't be seen by the human eye. So here we develop a data transfer system that uses the Li Fi technology. This system serves the following advantages:

• No Wires Needed

• Reliable Communication with No Data Loss

• Low Cost of Developing the System

The system makes use of a LDR sensor module along with Atmega Microcontroller, basic electronics components, power supply and Bread board to develop this system. The system allows us to use LIFI medium for data transfer. We make use of a LiFi transmitter using the serial monitor on Arduino IDE this concept. The serial monitor converts written text message into light flash data for transmission. The user needs to start the serial monitor and type the 8-bit Code to be transmitted. On sending the message the serial monitor controls the LED to transmit the message.

This light message as it falls on the LDR receiver, it is decoded and sent to the microcontroller for processing. The atmega microcontroller decodes and processes the message sent and then displays it over an Serial monitor.

CONTENTS

CHAPTER – 1

INTRODUCTION

The exponential growth of data transmission requirements and the increasing number of connected devices have posed significant challenges to traditional wireless communication technologies such as Wi-Fi. To address these challenges, Light Fidelity (Li-Fi) has emerged as a promising alternative. Li-Fi is a groundbreaking technology that uses visible light communication (VLC) to transmit data at high speeds, leveraging the existing lighting infrastructure. This innovative approach not only offers higher data transfer rates but also alleviates the spectrum congestion associated with radio frequency (RF) communication.

Li-Fi technology was first introduced by Professor Harald Haas in a 2011 TED Talk, where he demonstrated its potential to revolutionize wireless communication. By modulating the intensity of LED light bulbs, data can be encoded and transmitted to a photodetector, which then decodes the information. Unlike Wi-Fi, which relies on RF signals, Li-Fi utilizes the visible light spectrum, offering a vast, unlicensed bandwidth that is free from electromagnetic interference. This unique characteristic makes Li-Fi particularly attractive for environments where RF communication is either impractical or unsafe, such as hospitals and aircraft.

In our project, we explore the practical implementation of Li-Fi using two Arduino microcontrollers, an LED, a Light Dependent Resistor (LDR), and several resistors. The Arduino boards serve as the core components, facilitating the encoding and decoding of data through light signals. The LED acts as the transmitter, varying its light intensity to convey binary data, while the LDR functions as the receiver, detecting changes in light intensity and converting them back into electrical signals. This setup demonstrates the fundamental principles of Li-Fi and provides a hands-on experience in building a simple yet effective communication system.

The significance of this project lies in its ability to showcase the feasibility of Li-Fi technology using readily available and inexpensive components. By integrating basic electronic components with microcontrollers, we can highlight the potential applications of Li-Fi in various fields, from smart homes to industrial automation. Moreover, this project serves as an educational tool, offering insights into the workings of Li-Fi and inspiring further exploration and innovation in the realm of wireless communication.

CHAPTER – 2

RELATED WORK

The field of Li-Fi has seen significant advancements since its inception, with numerous research projects and practical implementations demonstrating its potential. This section reviews some of the notable related work in the area of Li-Fi, particularly focusing on similar implementations involving Arduino microcontrollers and basic electronic components.

Early Research and Development

The foundational work on Li-Fi by Professor Harald Haas laid the groundwork for subsequent research. His initial experiments showcased the ability to achieve high data transfer rates using visible light, sparking interest in the academic and industrial communities. Researchers have since explored various aspects of Li-Fi, including modulation techniques, hybrid systems combining Li-Fi and RF communication, and the development of standards such as IEEE 802.15.7.

Arduino-Based Li-Fi Systems

Numerous projects have utilized Arduino microcontrollers to create cost-effective Li-Fi systems. For instance, a study conducted at the University of Edinburgh demonstrated a basic Li-Fi communication setup using Arduino boards, LEDs, and photodetectors. The project highlighted the feasibility of using microcontrollers to control LED modulation and process received signals, providing a practical introduction to Li-Fi technology for educational purposes.

In a similar vein, a project presented at the International Conference on Communication Systems and Network Technologies detailed the construction of a simple Li-Fi system using Arduino, LEDs, and LDRs. The researchers successfully transmitted data over short distances, showcasing the potential for low-cost implementations in educational settings and small-scale applications. This work underscored the importance of accessible hardware in promoting the understanding and adoption of Li-Fi technology.

Commercial and Industrial Applications

Beyond academic research, several companies have explored commercial applications of Li-Fi. PureLiFi, co-founded by Harald Haas, has developed various Li-Fi products, including USB dongles and integrated lighting solutions, aimed at providing secure and high-speed wireless communication. Their work demonstrates the scalability of Li-Fi from experimental setups to market-ready products.

Moreover, industries such as healthcare and aviation have shown interest in Li-Fi due to its inherent advantages over RF communication. For example, hospitals have implemented Li-Fi to enable safe and interference-free data transmission, while airlines are investigating its use for in-flight communication systems. These applications highlight the diverse potential of Li-Fi in environments where traditional wireless technologies face limitations.

CHAPTER - 3

PROPOSED MODEL

The proposed Li-Fi model aims to demonstrate the basic principles of visible light communication using simple and accessible components. The system comprises a transmitter circuit and a receiver circuit, each controlled by an Arduino microcontroller. The model transmits an 8-bit data stream from the serial monitor through an LED, which is then detected by an LDR on the receiver side. The data transmission is carried out by modulating the light emitted by the LED, which is interpreted by the LDR and converted back into electrical signals.

The proposed model of Li-Fi model, we use an LED to transmit binary data and an LDR (Light Dependent Resistor) to receive it. The LED, controlled by a microcontroller or computer, transmits data in 8-bit binary form. The input data is given through a serial monitor, and the microcontroller reads it, modulating the LED to blink in a pattern corresponding to the binary data. Each bit in the sequence, whether a '1' or '0', is represented by the LED being on or off. The rapid blinking of the LED, imperceptible to the human eye, enables the transmission of data.

On the receiving end, the LDR acts as a photodetector, detecting the light emitted by the LED and converting it into a varying electrical signal based on the light intensity. This electrical signal is then read by a microcontroller or computer, which decodes the light pulses back into the original 8-bit binary data. The microcontroller processes the signal, determining whether each pulse corresponds to a '1' or a '0', based on the presence or absence of light. The decoded data is then displayed on the serial monitor, allowing me to verify the accuracy of the transmitted and received sequences.

This Li-Fi model effectively demonstrates the basic principles of visible light communication using simple components. It highlights the potential for high-speed, secure data transmission using light, while also showcasing some of the practical challenges, such as the requirement for a clear line of sight and the potential for interference from ambient light sources. Despite these challenges, the model provides a practical and cost-effective way to explore the capabilities of Li-Fi technology.

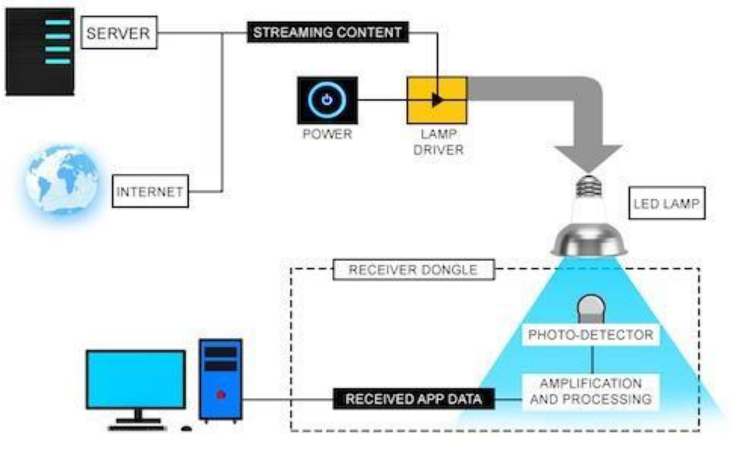

FIGURE-3.1: FUNCTIONAL BLOCK

CHAPTER - 4

WORKING

Li-Fi model, the user inputs 8-bit binary data via the serial monitor connected to the transmitting Arduino. The Arduino converts this data into a sequence of light pulses using an LED, with binary '1' represented by the LED being on and binary '0' by it being off. The LED blinks according to the binary sequence, with each bit transmitted for a fixed duration also we can change the duration .The working model of Li Fi technology is provided below :

1. **Transmitter Side**:
    - **Data Input**: The user inputs an 8-bit binary data via the serial monitor connected to the transmitting Arduino.
    - **Data Encoding**: The transmitting Arduino converts the binary data into a sequence of light pulses using the LED. Each binary '1' is represented by turning the LED on, and each binary '0' is represented by turning the LED off.
    - **Light Modulation**: The Arduino controls the LED's state (on or off) according to the binary data, with each bit being transmitted for a fixed duration, ensuring the receiver can accurately detect the signal.
2. **Receiver Side**:
    - **Light Detection**: The LDR in the receiver circuit senses the changes in light intensity caused by the LED's modulation. The LDR's resistance changes with the light intensity, which in turn alters the voltage across it.
    - **Signal Conversion**: The receiving Arduino reads the analog voltage values from the LDR and converts them to digital signals. It uses predefined threshold values to differentiate between '1' (high light intensity) and '0' (low or no light intensity).
    - **Data Decoding**: The Arduino reconstructs the binary data from the detected light pulses and displays the received 8-bit data on the serial monitor.

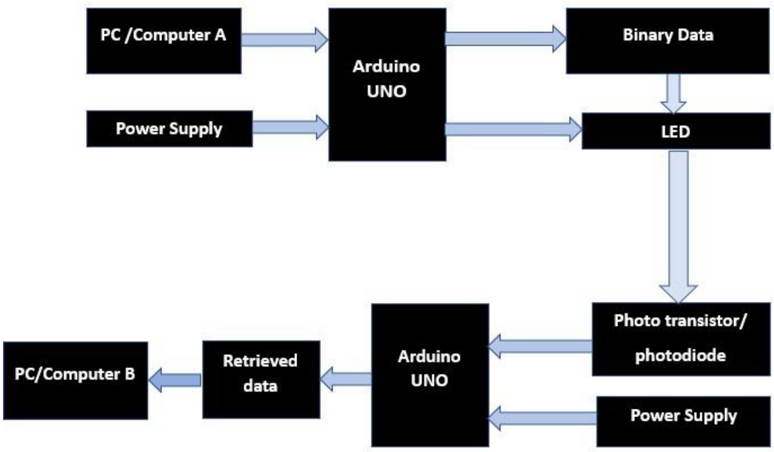

FIGURE-4.1 :Li Fi Model

CHAPTER – 5

HARDWARE COMPONENTS

Transmitter Side:

- ❖ Arduino Uno (Transmitting)
- ❖ LED (Light Emitting Diode)
- ❖ Resistor (for LED)

Receiver Side:

- ❖ Arduino Uno (Receiving)
- ❖ LDR (Light Dependent Resistor)
- ❖ Resistor (for LDR)

5.1 - HARDWARE DESCRIPTION

5.1.1 - ARDUINO UNO

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc. It was initially released in 2010. The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins, six of which are capable of PWM (Pulse Width Modulation) output, and 6 analog I/O pins. It is programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. The Arduino Uno can be powered by a USB cable or a barrel connector that accepts voltages between 7 and 20 volts, such as a rectangular 9-volt battery. It has the same microcontroller as the Arduino Nano board and the same headers as the Leonardo board.

The Arduino Uno is widely used in various projects due to its ease of use, flexibility, and extensive community support. It is suitable for both beginners and advanced users and can be utilized in a wide range of applications, including robotics, automation, IoT**.**

FIGURE-5.1.1.1 :ARDUINO IDE

5.1.2 – LED

An LED (Light Emitting Diode) is a semiconductor device that emits light when an electric current passes through it. LEDs are widely used in electronic circuits, displays, indicators, and as light sources in various applications. In the proposed Li-Fi communication system, the LED serves as the transmitter by emitting light pulses encoded with binary data.

The LED used in the Li-Fi system is a small, low-power light source that can be easily controlled by the Arduino microcontroller. It is typically a small, solid-state device with two leads: an anode (positive terminal) and a cathode (negative terminal). When forward voltage is applied to the LED, electrons recombine with electron holes within the device, releasing energy in the form of photons. The color of the light emitted by the LED depends on the material used to construct the semiconductor.

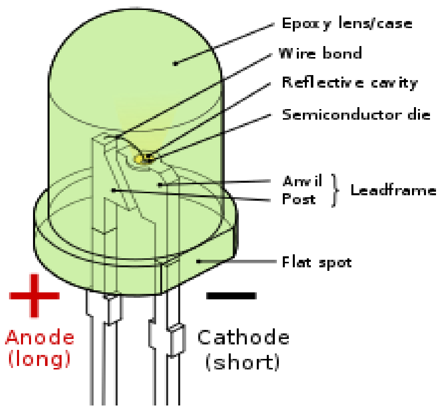

FIGURE-5.1.2.1 :MICRO SERVO MOTOR(SG90)

5.1.3 – LDR

An LDR (Light Dependent Resistor), also known as a photoresistor, is a type of resistor whose resistance varies with the intensity of light incident upon it. LDRs are commonly used in light-sensitive electronic circuits and devices, including light meters, camera exposure controls, and automatic street light systems. In the proposed Li-Fi communication system, the LDR serves as the light sensor on the receiving side, detecting the light pulses emitted by the LED.

The LDR used in the Li-Fi system is a passive electronic component made of a semiconductor material that exhibits a decrease in resistance with increasing light intensity. It typically consists of a light-sensitive material, such as cadmium sulfide (CdS) or cadmium selenide (CdSe), encased in a transparent resin or glass package. The resistance of the LDR decreases when exposed to light and increases in darkness.

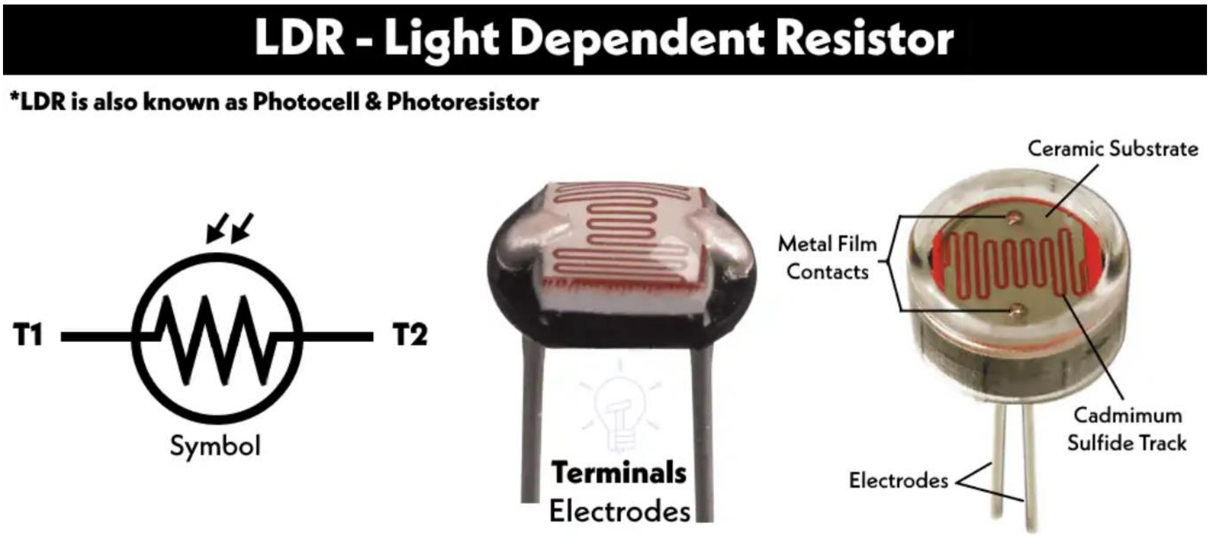

FIGURE-5.1.3.1: LDR & Symbol

5.1.4 – USB Cable

A USB cable to Arduino connector is used to connect the Arduino microcontroller board to a computer or power source for programming and power supply. In the proposed Li-Fi communication system, the USB cable is used to connect the Arduino Uno to a computer running the Arduino IDE (Integrated Development Environment) for programming and uploading code.

The USB cable typically has a Type A USB connector on one end, which plugs into a USB port on the computer or a USB power adapter. The other end of the cable features a Type B USB connector, which plugs into the USB port on the Arduino Uno board.

FIGURE-5.1.4.1: USB CABLE

5.1.5 - JUMPER WIRES

Jumper wires are electrical wires with connectors or pins at each end, used to interconnect the components on a breadboard or connect various electronic components in a circuit. In the proposed Li-Fi communication system, jumper wires are used to establish connections between different components, such as the Arduino board, LED, LDR, resistors, and breadboard.

Jumper wires come in different lengths, colors, and types, such as male-to-male, male-to-female, and female-to-female. Male-to-male jumper wires have pins at both ends, allowing them to connect between male headers on components or breadboard sockets.

FIGURE-5.1.5.1: JUMPER WIRES

5.1.6 - BREAD BOARD

A breadboard, also known as a prototyping board or solderless breadboard, is a versatile tool used to build and test electronic circuits without the need for soldering. In the proposed Li-Fi communication system, the breadboard serves as a platform for connecting and testing the various electronic components, including the Arduino board, LED, LDR, resistors, and jumper wires.

The breadboard consists of a rectangular plastic board with numerous interconnected metal clips or sockets beneath the surface. These clips or sockets are arranged in a grid pattern, typically with two sets of rows labeled as rows and columns. The holes in the breadboard are used to insert the electronic components and jumper wires, creating electrical connections between them.

The breadboard allows for quick and easy experimentation with electronic circuits. Components can be inserted and removed from the breadboard without damaging them, making it ideal for rapid prototyping and testing of circuit designs.

In the Li-Fi system, the breadboard serves as the central platform for connecting and testing the Arduino board, LED, LDR, resistors, and jumper wires. It provides a convenient and flexible environment for building and troubleshooting the electronic circuit before finalizing the design.

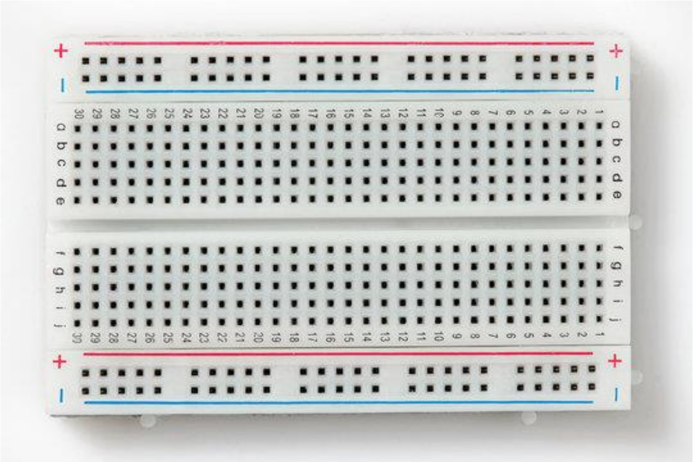

FIGURE-5.1.6.1: BREAD BOARD

CHAPTER – 6

CIRCUIT DIAGRAM

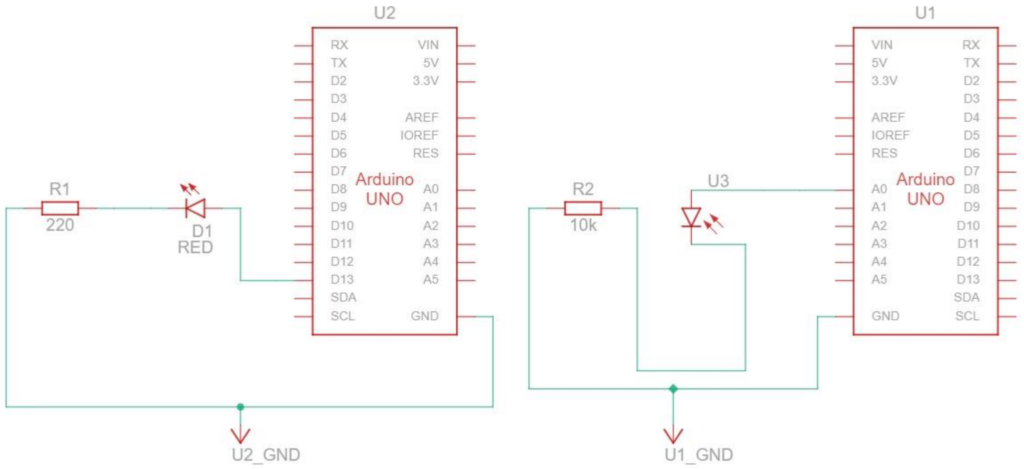

FIGURE-6.1:CIRCUIT DAIGRAM

Make connections according to the above diagram. Connect Arduino's 5V pin with the VCC pin of the LED and the positive leg of the LDR. Connect the Arduino's ground (GND) pin with the ground (GND) terminal of both the LED and the negative leg of the LDR. The digital output pin (e.g., pin 9) of the Arduino is connected to the anode (+) of the LED, and the analog input pin (e.g., A0) of the Arduino is connected to the cathode (-) of the LED.

Description:

- Connect the 5V pin of the Arduino Uno to the anode (+) of the LED and the positive leg of the LDR.
- Connect the GND pin of the Arduino Uno to the cathode (-) of the LED and the negative leg of the LDR.
- Connect the digital output pin (e.g., pin D13) of the Arduino Uno to the anode (+) of the LED.
- Connect the analog input pin (e.g., A0) of the Arduino Uno to the cathode (-) of the LED.

This is a simple project where we are using an LED and an LDR. The communication between the transmitter and receiver is facilitated by the LED emitting light pulses, which are detected by the LDR. The combination of both components working simultaneously allows the system to function effectively. It's crucial to position the LED and LDR properly for optimal performance. Ensure that the LED and LDR are placed opposite to each other and perpendicular to the gates to ensure the system works perfectly.

CHAPTER-7

SIMULATION PROCEDURE

1. **Install and Set Up Proteus**:

- Download and install the Proteus software from the official website.
- Open Proteus and create a new project by selecting "New Project" from the File menu.
- Name your project and specify the project location, then click "Next" and choose "Create a schematic from scratch."

2. **Add Components to the Schematic**:

- Open the "Components Library" by clicking on the "P" button on the left toolbar.
- Search for and add the following components to your project:
  - Two Arduino Uno boards
  - LED (Light Emitting Diode)
  - LDR (Light Dependent Resistor)
  - Resistors (appropriate values for LED and LDR)
  - Jumper wires
  - Virtual Terminal
- Place these components on the schematic workspace.

3. **Connect the Components on the Transmitter Side**:

- Connect the 5V pin of the first Arduino Uno to the anode (+) of the LED.
- Connect a resistor in series with the LED and then connect it to the GND pin of the Arduino Uno.
- Connect the digital output pin (e.g., pin 9) of the Arduino Uno to the anode (+) of the LED.

4. **Connect the Components on the Receiver Side**:

- Connect the 5V pin of the second Arduino Uno to one leg of the LDR.
- Connect the other leg of the LDR to one leg of a resistor (e.g., 10kΩ).
- Connect the other leg of the resistor to the GND pin of the second Arduino Uno.
- Connect the junction between the LDR and the resistor to the analog input pin (e.g., A0) of the Arduino Uno.

5. **Set Up the Virtual Terminal**:

- From the "Components Library," add a Virtual Terminal to the schematic.
- Connect the TX pin of the receiving Arduino (pin labeled "TX") to the RX pin of the Virtual Terminal.
- Connect the GND pin of the Arduino to the GND pin of the Virtual Terminal.

6. **Set Up Power and Ground Rails**:

- Connect the 5V and GND pins of each Arduino to the respective power and ground rails on the breadboard.
- Ensure that all components on the breadboard are correctly powered by connecting them to the appropriate rails.

7. **Program the Arduinos**:

- Write the code for the transmitting Arduino to send data by blinking the LED.
- Write the code for the receiving Arduino to read data from the LDR and send it to the Virtual Terminal.
- Upload the respective codes to the Arduino Uno boards within Proteus by using the "Edit Code" feature in Proteus.

8. **Run the Simulation**:

- Once all connections are made and the code is uploaded, click on the "Play" button in Proteus to start the simulation.
- Observe the LED blinking on the transmitter side and the LDR detecting the light changes on the receiver side.
- Check the Virtual Terminal in Proteus to verify the data being received and displayed.
- Verify the functionality of the circuit by observing the output on the Virtual Terminal.

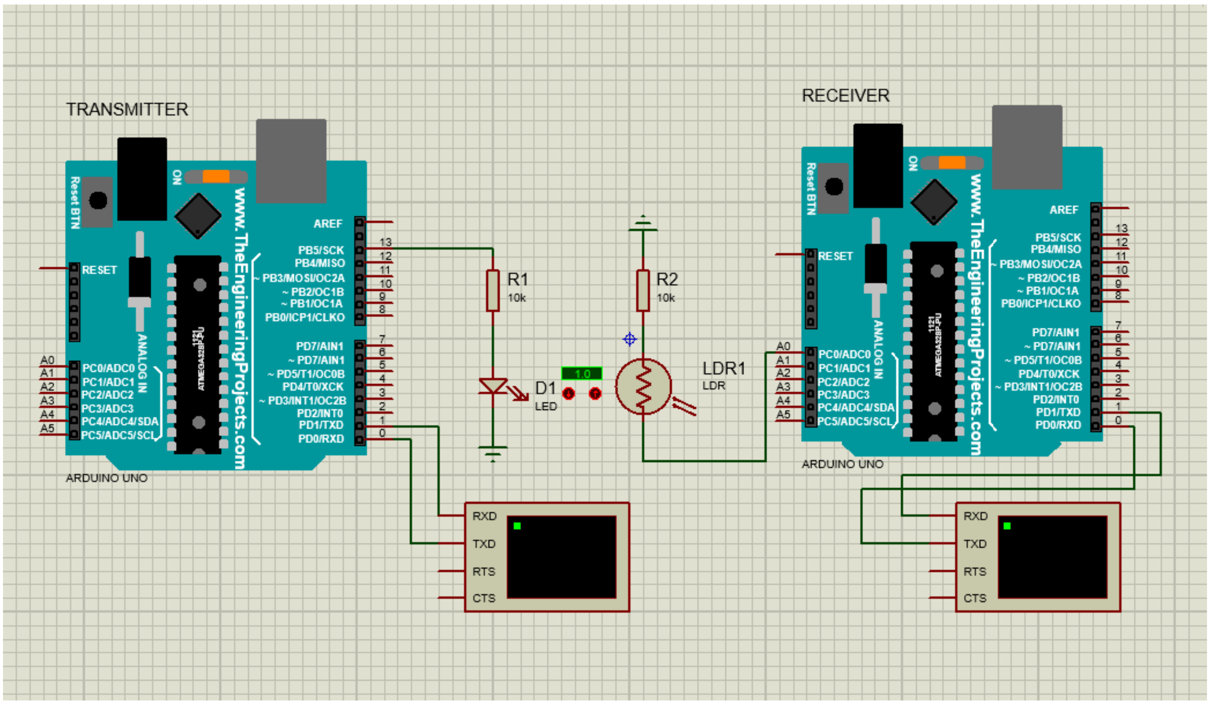

FIGURE-7.1:SIMULATED DAIGRAM ON PROTEUS

CHAPTER – 8

EXPERIMENTAL RESULTS

In general, the experimental results for Li-Fi technology involve testing the system in real-world scenarios to assess its effectiveness and reliability in wireless data communication using visible light. The performance of the Li-Fi system can be evaluated based on several key parameters:

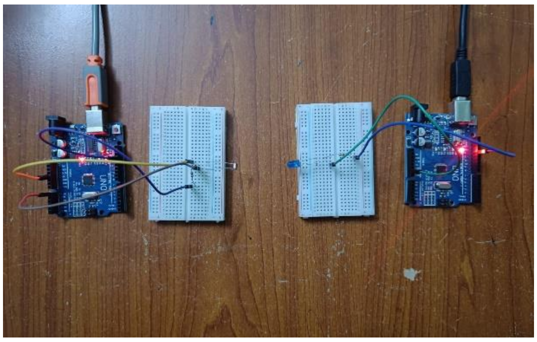

FIGURE-8.1.1:When Data is ‘0’

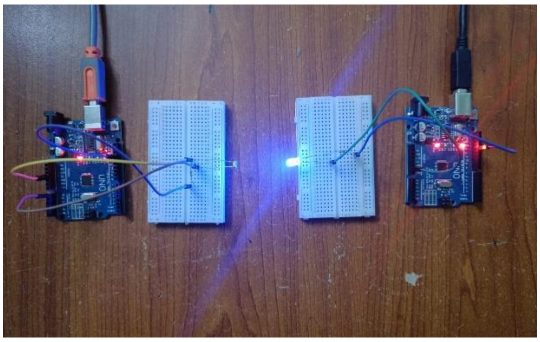

FIGURE-8.1.2:When Data is ‘1’

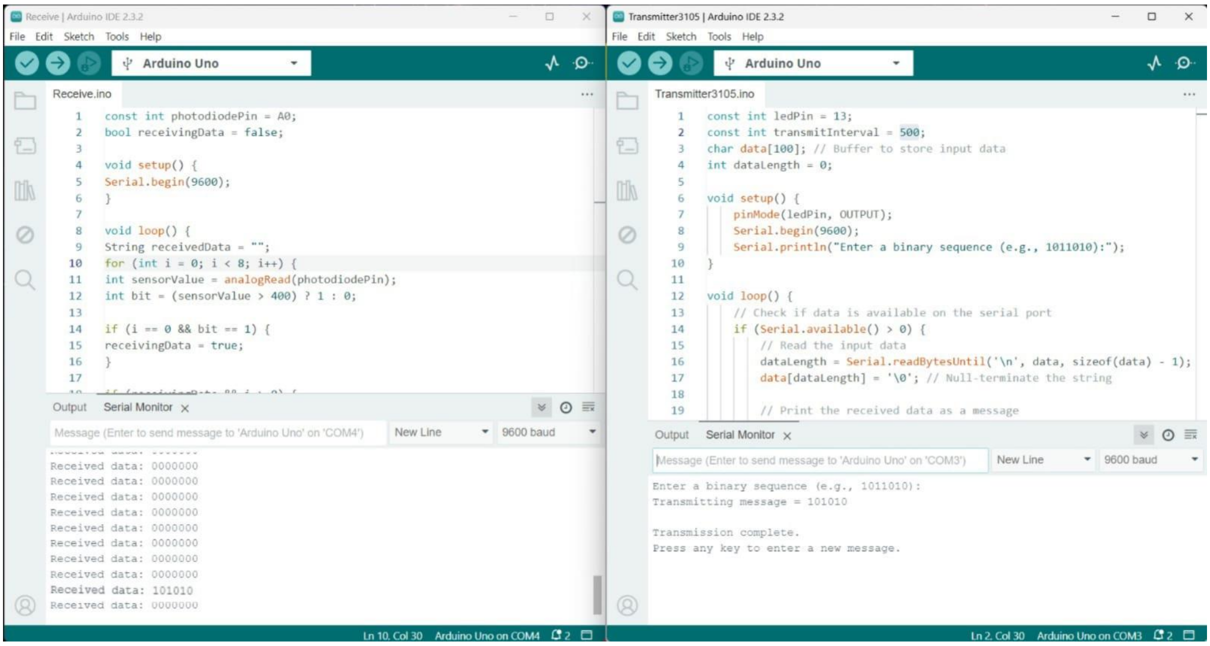

FIGURE-8.1.3:Serial Monitor Result of both Transmitter and Receiver

1. **Data Transfer Rate**:One of the primary metrics for assessing Li-Fi technology is its data transfer rate. This involves measuring the speed at which data can be transmitted and received using visible light as the communication medium. The data transfer rate of Li-Fi systems can be significantly higher than traditional Wi-Fi, with theoretical speeds reaching several gigabits per second (Gbps).

2. **Reliability**:The reliability of a Li-Fi system is crucial for its practical implementation. It involves assessing the system's ability to maintain a stable and consistent connection between the transmitter and receiver under various environmental conditions. Factors such as ambient light interference, distance between devices, and obstructions in the transmission path can affect the reliability of the Li-Fi link.

3. **Coverage Area**:The coverage area of a Li-Fi system refers to the geographical area over which the system can effectively transmit data. It is essential to evaluate the range and coverage of the Li-Fi signal to determine its practical applicability in different settings. While Li-Fi signals are confined to the area illuminated by the light source, the coverage area can be extended by using multiple transmitters or strategically placing light sources.

4. **Interference**:Interference from other light sources or ambient light in the environment can affect the performance of a Li-Fi system. It is essential to evaluate the system's susceptibility to interference and assess its ability to mitigate or minimize the impact of external light sources on data transmission. Shielding techniques, modulation schemes, and signal processing algorithms can be employed to reduce interference and improve the robustness of the Li-Fi link.

5. **Security**:Security is a critical aspect of any wireless communication system, including Li-Fi. Evaluating the security features of a Li-Fi system involves assessing its vulnerability to eavesdropping, interception, and unauthorized access. Encryption techniques, authentication protocols, and access control mechanisms can be implemented to enhance the security of Li-Fi communication and protect against potential security threats.

6. **Energy Efficiency**:Energy efficiency is another important consideration for Li-Fi technology, especially in applications where power consumption is a significant concern. Assessing the energy efficiency of a Li-Fi system involves evaluating the power consumption of the light sources, transmitters, receivers, and associated electronics. Optimizing the energy efficiency of the system can help reduce operating costs and extend the battery life of portable devices.

CHAPTER -9

CONCLUSION

In conclusion, the implementation of Li-Fi technology using Arduino microcontrollers has demonstrated its potential as a high-speed, secure, and energy-efficient wireless communication solution. Through our project, we have successfully explored the fundamental principles of Li-Fi and demonstrated its practical application in transmitting data using visible light. By evaluating key parameters such as data transfer rate, reliability, coverage area, interference, security, and energy efficiency, we have gained valuable insights into the capabilities and limitations of Li-Fi technology.

While Li-Fi offers several advantages over traditional Wi-Fi, including faster data rates and enhanced security, challenges such as line-of-sight communication and susceptibility to ambient light interference remain areas for further research and development. Overall, our project has contributed to advancing the understanding and implementation of Li-Fi technology, paving the way for future innovations in wireless communication systems.

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