# LI-FI BASED TEXT COMMUNICATION

# PROJECT REPORT

*Submitted by*


**PRAKASH B (910420104021)**
**SAKTHIKUMAR T (910420104027)**
**SAM SOLOMON K (910420104028)**


*In partial fulfillment for the award of the degree*

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# ANNA UNIVERSITY : CHENNAI 600 025

## BONAFIDE CERTIFICATE

Certified that this project report "**LI-FI BASED TEXT COMMUNICATION** " is the bonafide work of " **PRAKASH B (910420104021), SAKTHIKUMAR T (910420104027), SAMSOLOMON K (9104202104028)** who carried out the project work under my supervision.

| | |
|---|---|
| **SIGNATURE** | **SIGNATURE** |
| **Dr.P.RAVIKUMARAN,M.E.,Ph.D.,** | **Mrs.M.NIVEDHIDHA,M.E.,(AP/CSE)** |
| **HEAD OF THE DEPARTMENT** | **SUPERVISOR** |
| Dept. of Computer Science and Engineering | Dept. of Computer Science and Engineering |
| Fatima Michael College of Engg & Tech | Fatima Michael College of Engg & Tech |
| Madurai – 625 020 | Madurai – 625 020 |

Submitted for the project viva-voce examination on………………..

**Internal Examiner** **External Examiner**

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## Abstract

Light fidelity (Li-Fi) technology is a wireless communication system that utilizes visible light spectrum to transmit data with high speed and secure manner compared to the traditional Wireless Fidelity (Wi-Fi) architecture. In this paper a smartphone is used in Li-Fi communication system. The aim of this proposed approach is to maximize the bit rate with high accuracy by using the flashlight of built-in smartphone camera as a source to send data and detect the effect of using a Light Dependent Resistor(LDR) light sensor that is connected to Arduino UNO circuit to receive data. which light sensor accomplish higher data bit rate and tested the system performance under changing the distance between transmitter and receiver. The evaluation results demonstrated that the data bit rate is better with the proposed research than the others, where it reached more than 100 bps with accuracy 100%.

They have proposed a technique that uses LED for data transmission in which a large number of data packets are transferred through light communication technology within less time period compared to existing techniques

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# LIST OF ABBREVIATION

| ABBREVIATION | EXPANSION |
|---|---|
| LI-FI | Light Fidelity |
| WI-FI | Wireless Fidelity |
| LDR | Light Dependent Resistor |
| LED | Light-Emitting Diode |
| LCD | Liquid Crystal Display |
| VLC | Visible Light Communication |
| IOT | Internet Of Things |
| OOK | On-Off Keying |
| PWM | Pulse Width Modulation |
| I/O | Input/Output |
| LGPL | Lesser General Public License |
| GPL | General Public License |
| USB | Universal Serial Bus |
| IDE | Integrated Development Environment |
| | |

# CHAPTER 1

## 1.Introduction

Li-Fi is a wireless communication technology that uses visible light to send data at high speed between devices. In the most recent years, the studies on Visible Light Communication (VLC) are conducted to overcome the radio spectrum congestion. The process behind Li-Fi is to transfer data at high speed using light waves from any light source even the ordinary light table. Li-Fi can be considered as an optical version of Wi-Fi, so that instead of using radio waves to transfer the data it uses visible .

Professor Harald Hass, the chair of Mobile Communications at the University of Edinburgh, institute Li-Fi; demonstrated a Li-Fi prototype at the TED Global conference in Edinburgh on 12th July 2011. He illustrated the ability of using Light Emitting Diodes (LED’s) for data transmission .

In his experiment, a LED bulb of table lamp was used to send a blooming flower video which was displayed on a screen. In the meanwhile, the light of LED bulb was blocked from time to time with his hand to prove that the blub was the source of the video data .

In real sense, a smartphone can be defined as a mobile phone with advanced features and functionality beyond traditional functionalities like making phone calls and sending text messages. The smartphone is equipped with advance hardware, such as sensors (environment sensors, position sensors, and motion sensors), built-in camera, wireless internet connection, and more powerful software that are used to play videos, display photo, email, weather application, and much more .

In this research, data wireless communication based on Li-Fi technique is investigated, where a transmitter is smartphone that send data using built-in flash of camera. Moreover, at the receiver, it takes advantage of existence of LDR light sensor, which motivate us to examine a smartphone to Arduino UNO Board text communication system based
on Li-Fi.

## 1.2 Li-Fi Technology

Li-Fi technology mechanism is bidirectional communication that utilize a visible light to transmit data. The infrastructure of such technology is already available where the light source can be used for lighting and communication concurrently.

Li-Fi can be consider as an optical version of Wi-Fi, so that instead of using radio waves to transfer data it uses visible light . Table 1 illustrates a comparison of speed transmission for several wireless technologies .

**Table 1: Comparison of Speed for Different Wireless Technologies**

| Technology | Speed |
|---|---|
| Li-Fi | ~1 Gbps |
| Wi-Fi – IEEE 802.11n | ~150 Mbps |
| IrDA | ~4 Mbps |
| Bluetooth | ~3 Mbps |
| NFC | ~424 Kbps |

In order to prove the truth of Li-Fi, a comparison must be made to know the fundamental difference between Wi-Fi and Li-Fi technologies. Li-Fi has many great features such as it can achieve high data rates as compared to Wi-Fi technology. In addition, the Li-Fi consume less power, more efficient, and word world availability of light source, while Radio waves cannot be used in all environments, particularly in airplanes, chemical and power plants, and in hospitals since it causes malfunction or substantial problems to the human and this equipment. No other infrastructure is required when Li-fi technology since light of sources are already installed . Moreover, Li-Fi could prove the future of secure wireless communication since light definitely does not penetrate through walls and thus data transmission using Li- Fi does not lead to hack the network .

By using the Internet of Things (IoT) technology, there will be an enormous number of devices that will be connected to internet. This causes another issue for the current Wi-Fi networks and might be completely saturated and incapable to accommodate that number of users . This features could solve the four essential problems namely, capacity, cost, efficiency, and security, that a wireless communication is faced these days. Thus for a green, clean and even a safe future many wireless data transmission systems will be deployed utilizing Li-Fi instead of Wi-Fi technology. Table 2 shows a comparison of Li- Fi with Wi-Fi .

**Table 2. Comparison of Wi-Fi and Li-Fi**

| Parameters | Li-Fi | Wi-Fi |
|---|---|---|
| Transmitter | LED | Antenna |
| Frequency | band 1000 times of THz | 2.4 GHz |
| Standard | IEEE 802.15.xx | IEEE 802.11xx |
| No of users All over | Under The Lamp.(LEDs) | Depend on access Point. |
| Topology | Point to Point | Point to Multipoint |
| Communication | Based on Visible Light Communication (VLC). | Based on Radio Frequency Communication |
| Availability | Anywhere, available in Airplanes and Underwater | Limited |
| Power Consumption | Less | More |
| Environment Impact | Low | Medium |
| Cost | Low | High |
| Bandwidth | Unlimited | Limited |

Figure 1 illustrates how Li-Fi technology works. Li-Fi communication system consists of two parts; a transmitter part and receiver part. The transmitter part, is represented by LED lamp or flash, which is responsible for sending data. By turning LED on/off at very high speeds, the LED can send out high bandwidth wireless data. The switch on/off enables data transmission in binary format, turns LED on represents binary ‘1’ and turns LED off represents binary ‘0’. Data is converted into pulses of light and directed to the receiver part. The receiver part consists of photo detector sensor (or known as a light sensor) that is used to senses the change in light intensity. This light signal is then converted into data original format .

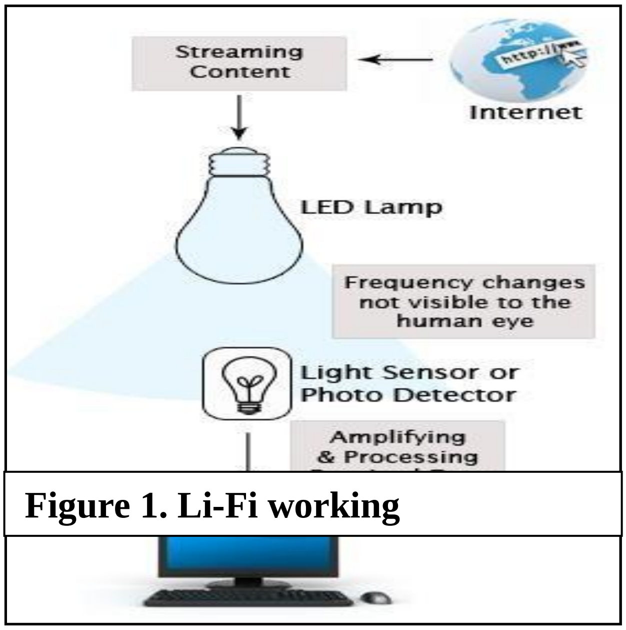



**Figure 1. Li-Fi working**

### 1.3 Related Work

In the past few years, there has been a large amount of research tried with Li-Fi technology, and taking advantage of its many features to become an alternative transmission medium for wireless data transmission. In this section, experiences with the smartphone-based VLC communication system will be briefly discussed and analyzed. It may support us enhance the limitations of previous research and problem solving.

In the authors developed a system for sending data between two smartphones based on VLC technique. This system consists of transmitter and receiver part. In the transmitter part, the flashlight of built-in smartphone camera is used to send binary data, by turning flash on/off, on if the binary data is 1 and off for 0, according to On-Off Keying (OOK) modulation scheme. In the receiver part, there is an ambient light sensor, which built-in smartphone sensor used to discover the flickering of flash (on/off). This system achieved a low data bit rate about 9 bps and the maximum distance between the transmitter and receiver was 15 cm.

In the authors proposed a method to enable bidirectional VLC communication between smartphone and tabletops. In smartphone to tabletop stage, they utilize a flash of built-in smartphone camera to transmit data optically to the camera of tabletop. The authors developed an android application, which is used to turn the flash on/off to transmit data .

The pulse width modulation (PWM) is utilized to encode binary data, 0 and 1, using different length of flash pulses. When the authors tested that system a transmission data rate was reached to 20bps. Moreover, to transmit data from tabletop to smartphone, the authors utilized a built-in camera in smartphone, and they implemented a test program on the tabletop that transmits bit sequences at different frequencies. Based on results they conclude that data is transmitted at rates of up to 33 bps.

In the authors implemented a system which transmits the information of credit card that are stored on the smartphone, over a secure visible light link to a simple inexpensive receiver circuit module that is attached to the ATM machine. The authors used an embedded flashlight of smartphone as a transmitter while a receiver part consists of Arduino Mega kit and photodetector sensor, which is Light Dependent Resistor (LDR) that is used to detect light signal. Many experiments are conducted by replacing LDR with photodiode sensor and using PWM scheme instead of OOK to get data bit rate from 4.2 to 15 bps.

In the authors implemented the Li-Fi data transmission system that consists of transmitter circuit and receiver circuit. The transmitter circuit comprised of Arduino UNO and LED where the data is encoded and send via light of LED, while at receiver circuit the photodiode is utilized to sense the incoming light of transmitter circuit and decode the data back to original format. This prototype achieves a speed about 11,520 bps only that is not of a high arrangement of Gbps.

In the authors developed an application of Li-Fi based wireless communication system using VLC, where the transmitter section consists of array of LEDs that connected to Arduino UNO circuit, while the receiver section consists of array of PNP diode (BPW34) that are connected to Arduino UNO. Current effective data transmission speed is 100 bits/sec, while the distance between transmitter and receiver does not exceed 1 foot because of the infiltration of ambient light.

# CHAPTER 2
# HARDWARE DETAILS

## Requirement:

- Arduino UNO Board
- 16×2 LCD Display
- LDR Module
- Breadboard
- Jumper Wires

### 2.1 Arduino UNO Board

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical and digital world. The project's products are distributed as open-source hardware and software, which are licensed under the GNU Lesser General Public License (LGPL) or the GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form, or as do-it-yourself (DIY) kits. Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or Breadboards (shields) and other circuits. The boards feature serial communications interfaces, including Universal Serial Bus (USB) on some models, which are also used for loading programs from personal computers. The microcontrollers are typically programmed using a dialect of features from the programming languages C and C++. In addition to using traditional compiler toolchains, the Arduino project provides an integrated development environment (IDE) based on the Processing language project. The Arduino project started in 2003 as a program for students at the Interaction Design Institute Ivrea in Ivrea, Italy, aiming to provide a low-cost and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

The name Arduino comes from a bar in Ivrea, Italy, where some of the founders of the project used to meet. The bar was named after Arduin of Ivrea, who was the margrave of the March of Ivrea and King of Italy from 1002 to 1014.

### 2.1.1 Features of the Arduino UNO

- Microcontroller: ATmega328 Operating
- Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

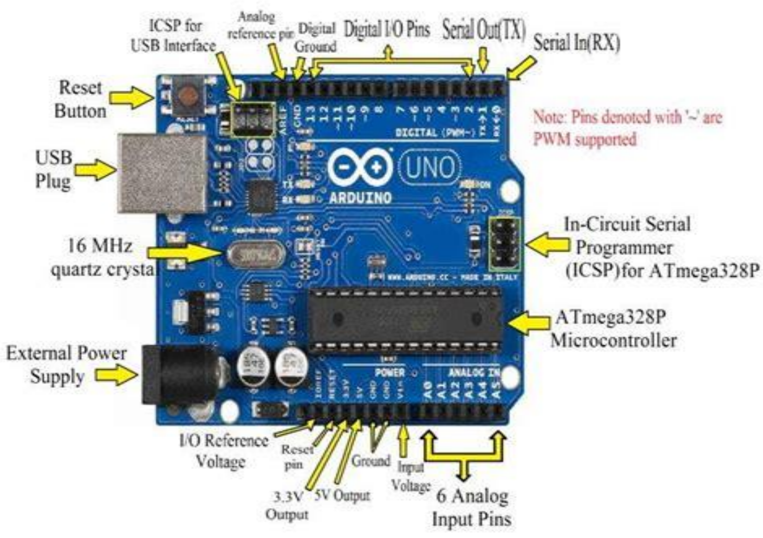



**Figure 2. Arduino UNO**

### 2.1.2 ARDUINO HARDWARE PART

Arduino is open-source hardware. The hardware reference designs are distributed under a Creative Commons Attribution Share-Alike 2.5 license and are available on the Arduino website. Layout and production files for some versions of the hardware are also available. Although the hardware and software designs are freely available under copyleft licenses, the developers have requested the name Arduinoto be exclusive to the official product and not be used for derived works without permission. Theofficial policy document on use of the Arduino name emphasizes that the project is open to incorporatingwork by others into the official product. Several Arduino-compatible products commercially released have avoided the project name by using various names ending in -duino. Most Arduino boards consist of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560) with varying amounts of flash memory, pins, and features. The 32-bit Arduino Due, basedon the Atmel SAM3X8E was introduced in 2012. The boards use single or double-row pins or female headers that facilitate connections for programming and incorporation into other circuits. These may connect with add-on modules termed shields. Multiple and possibly stacked shields may be individually addressable via an $I^2C$ serial bus. Most boards include a 5 V linear regulator and a 16 MHz crystal oscillator or ceramic resonator. Some designs, such as the LilyPad, run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. Arduino microcontrollers are pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory. The default bootloader of the Arduino UNO is the optiboot bootloader. Boards are loaded with program code via a serial connection to another computer. Some serial Arduino boards contain a level shifter circuit to convert between RS232 logic levels and transistor–transistor logic(TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232. Some boards, such as later-model Uno boards, substitute the FTDI chip with a separate AVR chip containing USB-to-serial firmware, which is reprogrammable via its own ICSP header. Other variants, such as the Arduino Mini and the unofficial Boarduino, use a detachable USB-to- serial adapter board or cable, Bluetooth or other methods. When used with traditional microcontroller tools, instead of the Arduino IDE, standard AVR in-system programming (ISP) programming is used.

The Arduino board exposes most of the microcontroller's I/O pins for use by other circuits.

The Diecimila, Duemilanove, and current Uno provide 14 digital I/O pins, six of which can produce pulse- width modulated signals, and six analog inputs, which can also be used as six digital I/O pins. These pins are on the top of the board, via female 0.1-inch (2.54 mm) headers. Several plug-in application shields arealso commercially available. The Arduino Nano, and Arduino-compatible Bare Bones Board and Boarduino boards may provide male header pins on the underside of the board that can plug into solderless breadboards. Many Arduino-compatible and Arduino-derived boards exist. Some are functionally equivalent to an Arduino and can be used interchangeably. Many enhance the basic Arduino by adding output drivers, often for use in school-level education, to simplify making buggies and small robots. Others are electrically equivalent but change the form factor, sometimes retaining compatibility with shields, sometimes not. Some variants use different processors, of varying compatibility.

### 2.1.3 ARDUINO SOFTWARE PART

IDE The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclicexecutive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding thatis loaded into the Arduino board by a loader program in the board's firmware.

A program written with the Arduino IDE is called a sketch. [58] Sketches are saved on the development computer as text files with the file extension .ino. Arduino Software (IDE) pre-1.0 saved sketches with the extension .pde.

**A minimal Arduino C/C++ program consist of only two functions:**

- setup(): This function is called once when a sketch starts after power-up or reset. It is used to initializevariables, input and output pin modes, and other libraries needed in the sketch.

- loop(): After setup() has been called, function loop() is executed repeatedly in the main program. Itcontrols the board until the board is powered off or is reset.

## 2.2 16×2 LCD Display

**Figure 3. LCD Display**

### 2.2.1 Introduction

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal.

An LCD consists of two glass panels, with the liquid crystal material sandwiched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed. Polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.

Each polarizer is pasted outside the two glass panels. These polarizers would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarizers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction.

The light rays passing through the LCD would be rotated by the polarizer'sss, which would result in activating/highlighting the desired characters The LCDs are lightweight with only a few millimeters thickness. Since the LCDs consume less power, they are compatible with low power electronic circuits, and can be powered for long durations.

The LCDs don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCDs have long life and a wide operating temperature range.

Changing the display size or the layout size is relatively simple which makes the LCDs more customer friendly. The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range.

These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

### 2.2.2 Power Supply

The power supply should be of +5V, with maximum allowable transients of 10mV. To achieve a better / suitable contrast for the display, the voltage (VL) at pin 3 should be adjusted properly.

A module should not be inserted or removed from a live circuit. The ground terminal of the power supply must be isolated properly so that no voltage is induced in it. The module should be isolated from the other circuits, so that stray voltages are not induced, which could cause a flickering display.

### 2.2.3 Hardware

Develop a uniquely decoded 'E' strobe pulse, active high, to accompany cach module transaction. Address or control lines can be assigned to drive the RS and R/W inputs.

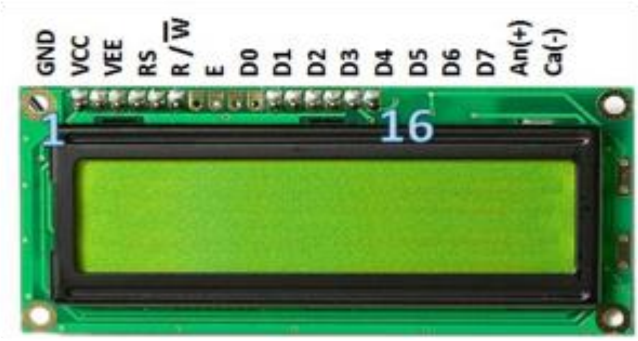
If a parallel port is used to drive the RS, R/W and 'E' control lines, setting the 'E' bit simultaneously with RS and R/W would violate the module's set up time. A separate instruction should be used to achieve proper interfacing timing requirements.

### 2.2.4 Mounting

Cover the display surface with a transparent protective plate, to protect the polarizer. Don't touch the display surface with bare hands or any hard materials. This will stain the display area and degrade the insulation between terminals. Do not use organic solvents to clean the display panel as these may adversely affect the display.

### 2.2.5 Pin Diagram

HD44780 – 16x2 LCD
Pin Description




| PIN | Description | |
|---|---|---|
| GND | GND connection | |
| VCC | $V_{cc}$ = 3.3 – 5 V | |
| VEE | LCD Character Dimmer | |
| RS | Control Signals | Selects between writing a command or data |
| R / W | | Read or Write operation. This pin is usually wired to GND |
| E | | Falling edge will trigger an operation |
| D0 | Data Lines | Least significant bites, usually not connected since LCD is used in 4-bit operation. |
| D1 | | |
| D2 | | |
| D3 | | |
| D4 | | Most significant bites. Data and commands are written to these pins 1 nibble at a time, starting with the most significant nibble (MSN). |
| D5 | | |
| D6 | | |
| D7 | | |
| An(+) | Power supply for the back light, $V_{cc}$ | |
| Ca(-) | GND connection for the backlight, GND | |

## 2.3 LDR Module

### 2.3.1 Introduction

LDR or Light Dependent Resistor is one type of variable resistor. It is also known as a photoresistor. The Light Dependent Resistor (LDR) works on the principle of "Photo Conductivity". The LDR resistance is change according to the light intensity falls on the LDR. When light intensity increase on the LDR surface, then the LDR resistance will decrease and the element conductivity will increases. When light intensity decrease on the LDR surface, then the LDR resistance will increase and the element conductivity will decrease.

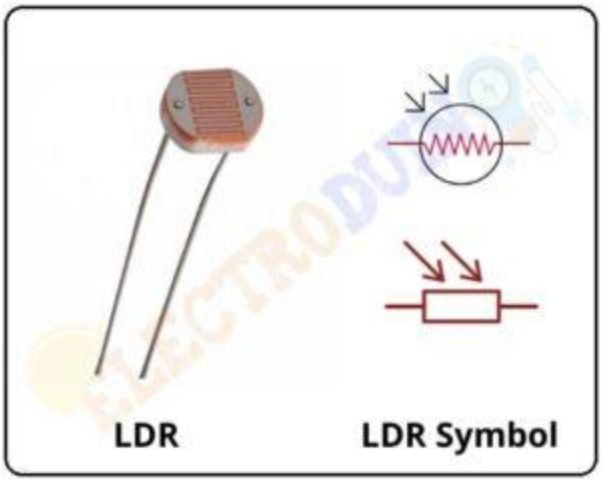



**Figure 4. Light Dependent Resistor & Symbol**

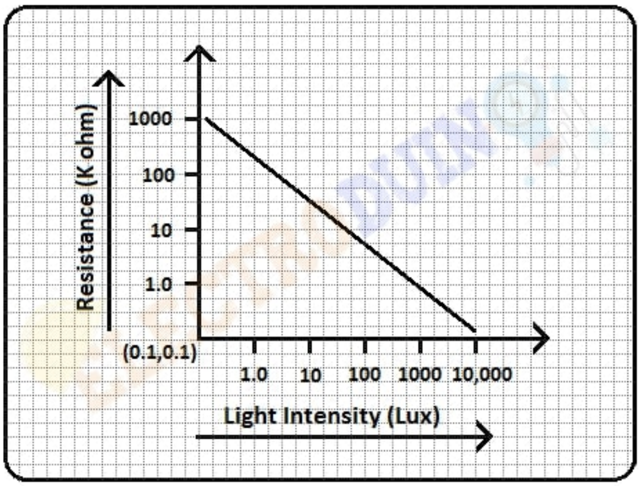



**Figure 5. LDR Light Intensity vs resistance graph**

### 2.3.2 Pin Diagram

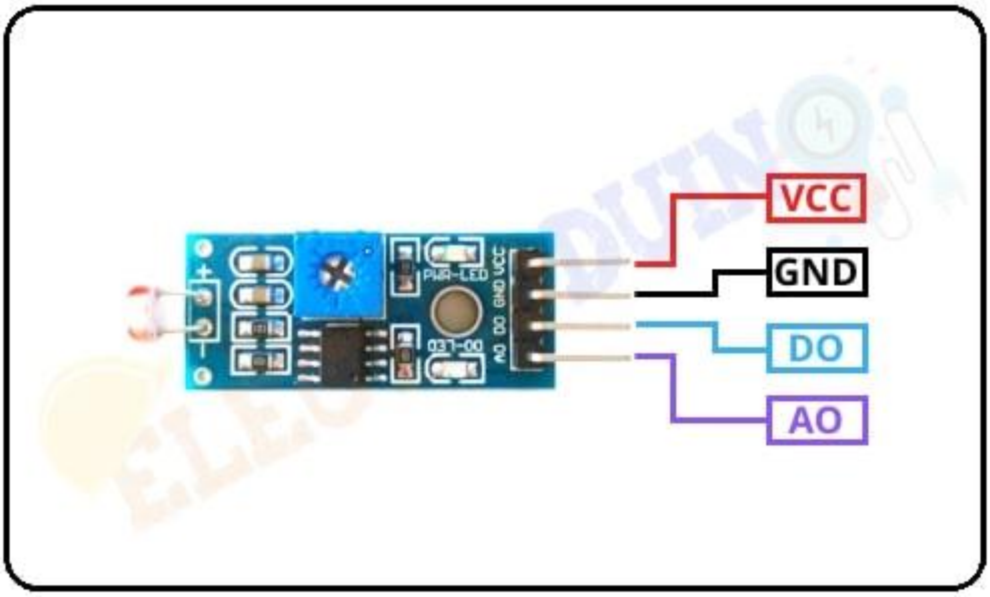



**Figure 6. LDR Module**

**Table 3.LDR Module Pin Description**

| Pin No | Pin Name | Description |
|---|---|---|
| 1 | VCC | +5 v power supply Input Pin |
| 2 | GND | Ground (-) power supply Input Pin |
| 3 | DO | Digital Output Pin |
| 4 | AO | Analog Output Pin |

### 2.3.3 Circuit Diagram

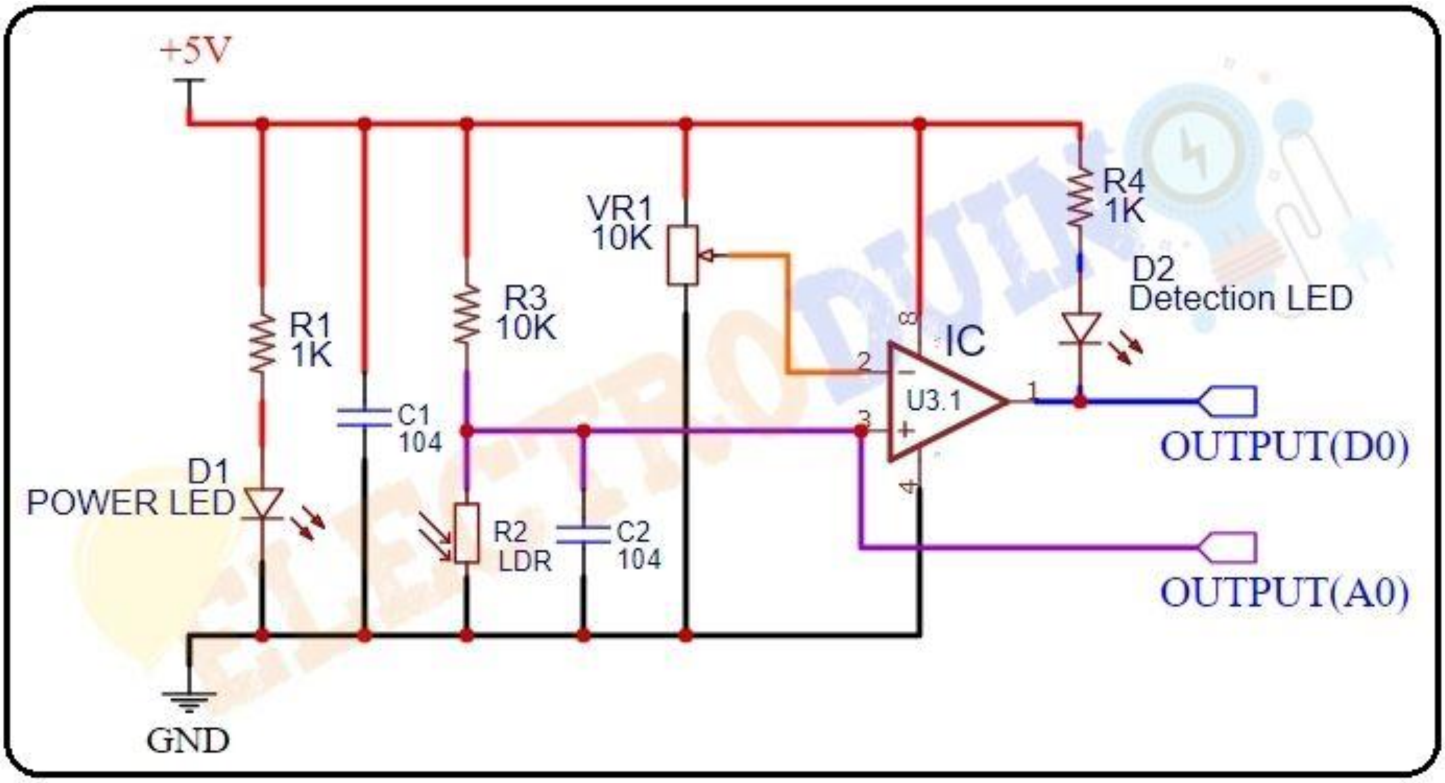



**Figure 7. LDR Circuit Diagram**

### 2.3.4 Variable Resistor

The LDR sensor module has an onboard variable resistor or potentiometer, this variable resistor is a **10k preset**. It is used to set the sensitivity of this LDR sensor. Rotate the preset knob to adjust the sensitivity of the light intensity detection. If we will rotate the preset knob in the clockwise direction, the **sensitivity** of the light intensity detection will **increase**. If it rotated counterclockwise direction, the sensitivity of the light intensity detection will **decrease**.

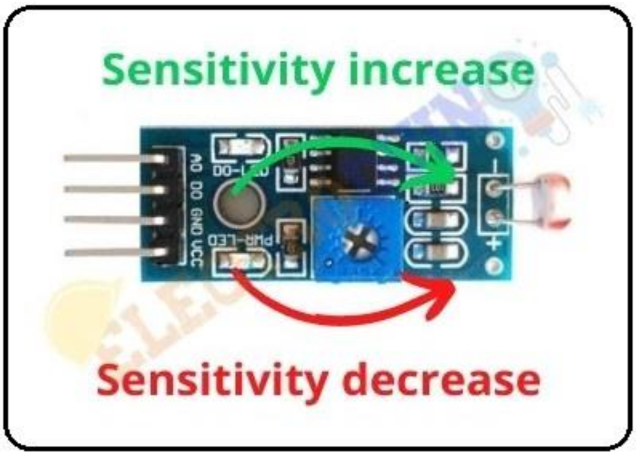



**Figure 8. LDR Module Adjustment**

### 2.3.5 Power LED

This onboard LED indicates the LDR sensor module power supply is ON or OFF. When we turn on the sensor power supply this Green LED is also turn on.

### 2.3.6 Output LED

When the LDR sensor detects the light, the green LED is turn on. When the LDR sensor detects the darkness, the green LED is turn off.

## 2.4 Breadboard

A Breadboard is simply a board for prototyping or building circuits on. It allows you to place components and connections on the board to make circuits without soldering. The holes in the breadboard take care of your connections by physically holding onto parts or wires where you put them and electrically connecting them inside the board. The ease of use and speed are great for learning and quick prototyping of simple circuits. More complex circuits and high frequency circuits are less suited to breadboarding. Breadboard circuits are also not ideal for long term use like circuits built on perfboard (protoboard) or PCB (printed circuit board), but they also don’t have the soldering (protoboard), or design and manufacturing costs (PCBs).

The breadboard is the bread-and-butter of DIY electronics. Breadboards allow beginners to get acquainted with circuits without the need for soldering, and even seasoned tinkerers use breadboards as starting points for large-scale projects.

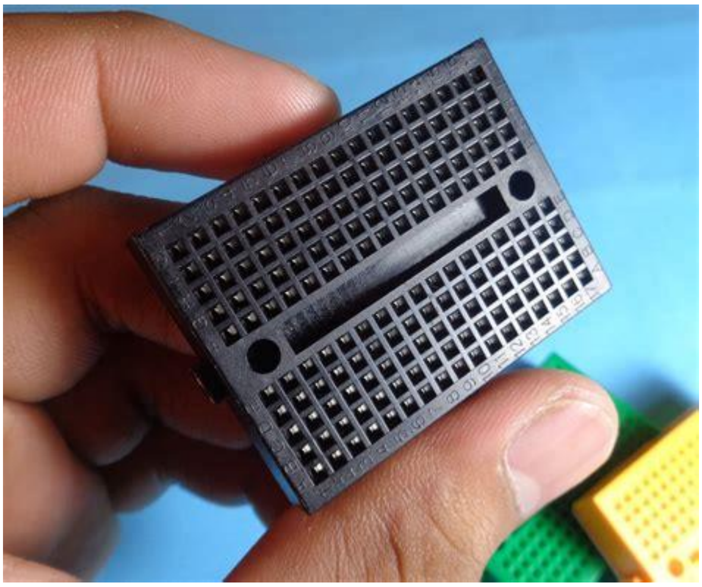


**Figure 9. Breadboard (Mini)**

## 2.4 Jumper Wires

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. Fairly simple. In fact, it doesn’t get much more basic than jumper wires.

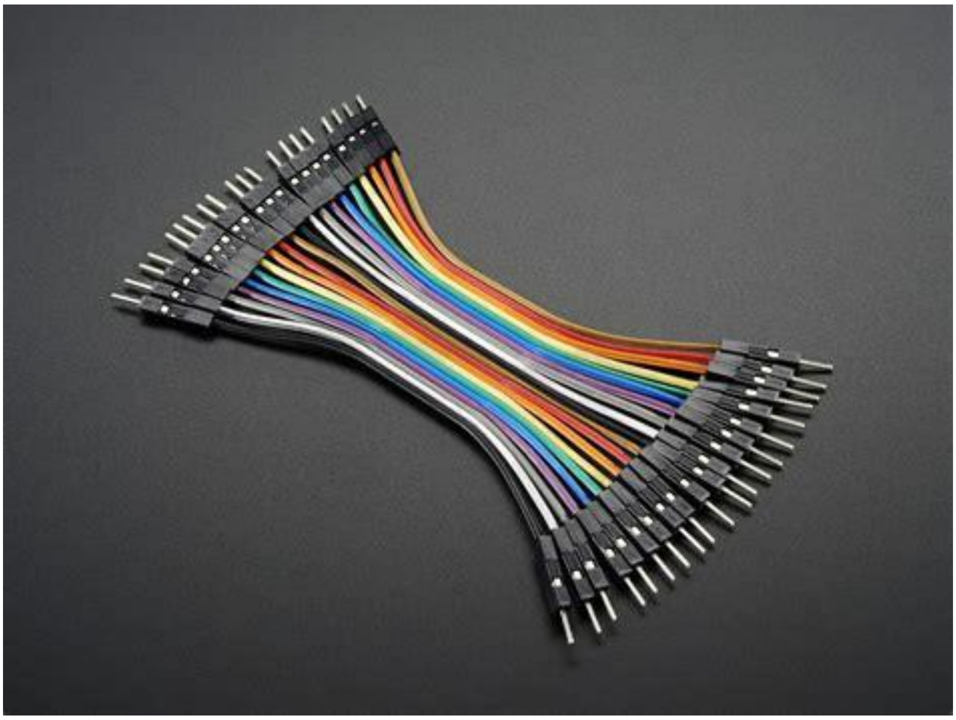


**Figure 10. Jumper Wire**

# CHAPTER 3
# PROPOSED SYSTEM DESIGN

Proposed system consists of two parts, transmitter part and receiver part. The transmitter part contains a light source, which is LED flash of built-in smartphone that is used to transmit data. While the receiver part composed of light detector sensor, which is used to detect the light signal and convert it to original data.

Initially, the proposed model investigates how the smartphone built-in light sensor can be utilized to implement smartphone to arduino UNO text communication system based on VLC, then figures out if the data rate achieved by this type of communication is approved by the expected Li-Fi's throughput. Later, the external light sensor was examined to demonstrate how to improve the data bit rate.

## 3.1 Transmitter Part

Transmitter part based on Li-Fi technique which consists of light source such as LED to transmit data. In this system, flash of built-in smartphone is utilized to send data.

The data is converted to binary format and encoded according to one of modulation scheme, which is OOK NRZ "non-return-to-zero". Hence, when the bit is "0" the flash will be turned off and when the bit is "1" the flash will be turned on. Thus, by turning flash light on and off at a very high speeds enables data to be transferred through light as a medium of communication. The following figure 11 displays the OOK NRZ mechanism.

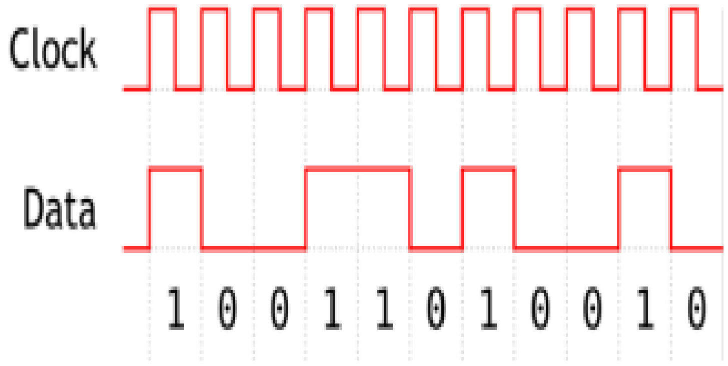



**Figure 11. OOK Scheme**

The transmitter read a data that is received from the user and it converts data into binary then transmits it after the flash light turn on by using OOK ‟ if the binary code is „1‟ and „off‟ for „0‟.

The proposed transmission process is illustrated as follows:

1.After convert the data to binary format, it will be sent it inform of packets where each packet consists of 8 bit as shown in figure 12.

2.As illustrated in figure 12, at the beginning of transmit each packet, an initial bit is sent, which is bit 1, to inform the receiver that the transmission process of this packet will be start.

3.Coherently the packets of data are sent, and there is a small time interval, which is equal to half of delay sensor response time, between one packet and another.

4.After sending whole packets, stop bits will be sent, which are 32 bits of 0, to inform the receiver part that the data transmission is completed.

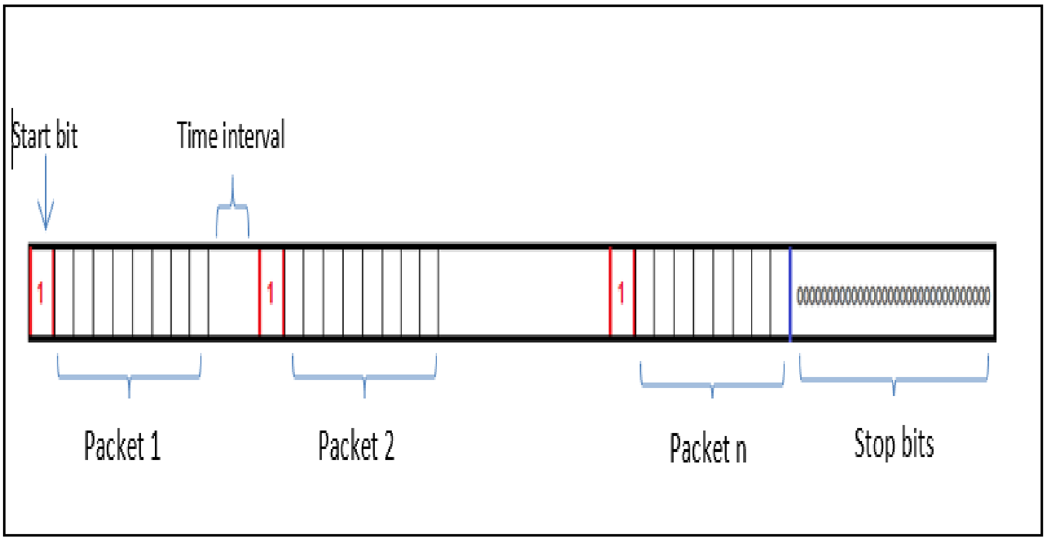



**Figure 12. Proposed Process of Segmentation Data to the Packets**

The flowchart that describes the flow procedure of proposed transmission process isshown in figure 13.

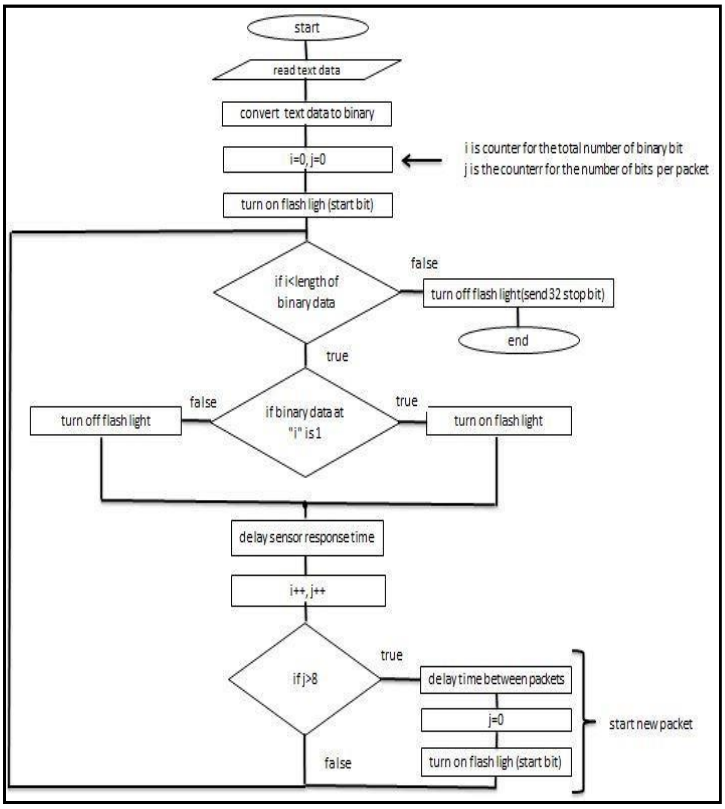



**Figure 13. Proposed Transmission Process**

## 3.2 Receiver Part

The receiver part comprises of light sensor to easily detect the light of smartphone's flash.

Using an external light detector sensor, like Light Dependent Resistor (LDR) to sense the flashlight of the transmitter part. In the proposed system, light detector sensor is connected to Arduino UNO circuit, where this circuit is connected to computer via USB port. Arduino UNO is an open source hardware that is equipped with ATmega328P microcontroller, 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button**.**

**The proposed receiving process is demonstrated as follows:**

- In both cases, the data reported by light detector sensor is compared with predefined **threshold** value, which is 500 lux (set by experiment), to identify whether this data represents bit **1** or **0**.
- The received bits are decoded back to original format and displayed at the receiver parton smartphone screen (if case **1** is applied) or on computer screen (if case **2** is applied).

Figure 14 designates the flowchart of the proposed receiving process.

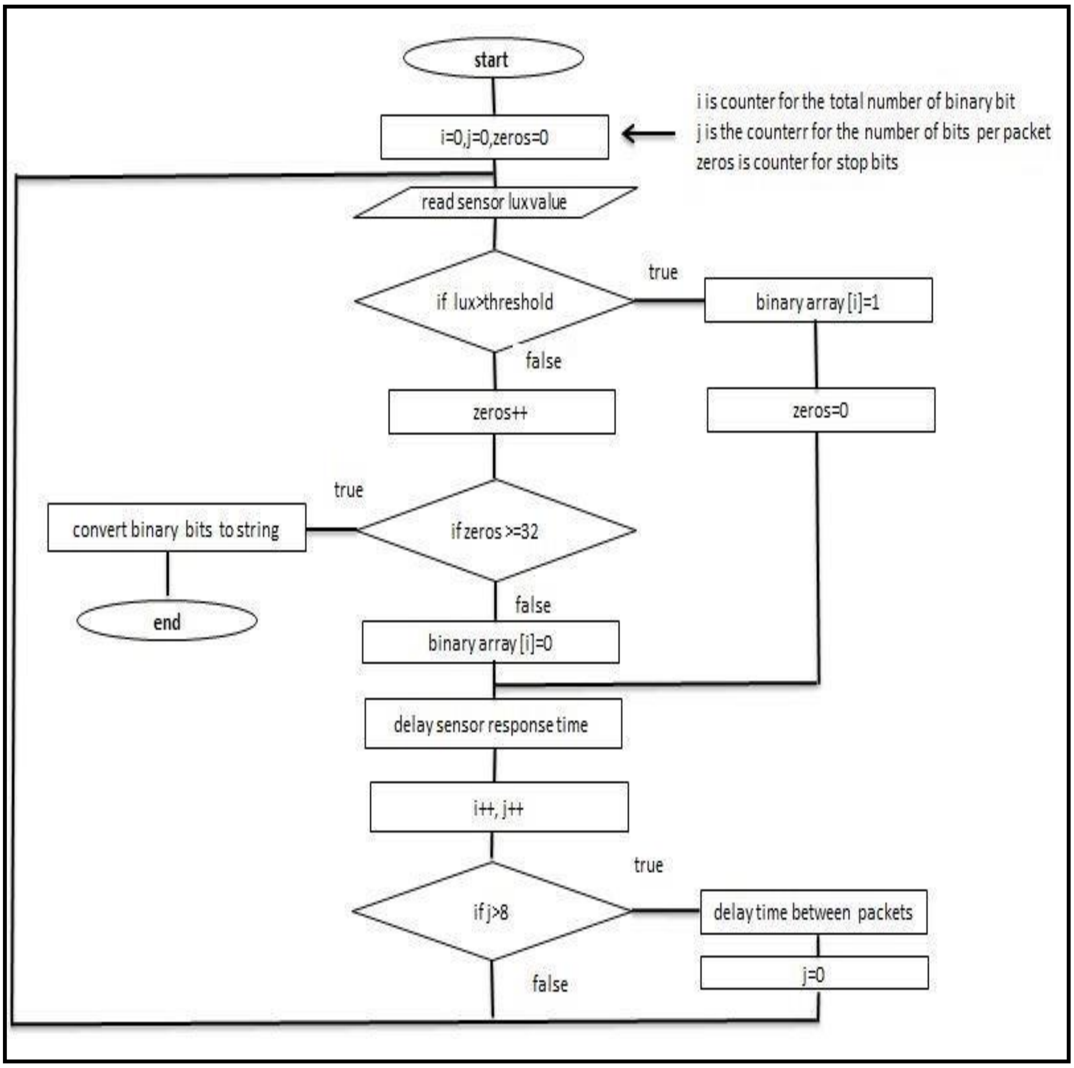



**Figure 14. Flowchart of Receiver Scenario**

It is an important to mention that a light detector sensor has a response time which effects on the data bit rate, as will be explained in 3.3**.**

### 3.3 Arduino UNO Programing Code

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x27, 16, 2);
#include <SoftwareSerial.h>
#define ldr 8
int val;
int val2;
String duration;
void setup() {
  // put your setup code here, to run once:
  Serial.begin(9600);
  pinMode(ldr, INPUT_PULLUP);
  lcd.begin(16,2);
  lcd.clear();
  lcd.print("LiFi Project");
  delay(3000);
  lcd.clear();
  lcd.print("Send any message");
  lcd.setCursor(0,1);
  lcd.print("from LiFi App..");
  delay(3000);
}

void loop() {
  // put your main code here, to run repeatedly:
  int val = digitalRead(ldr);
```

```
while(val == 0)
{
  int val2 = digitalRead(ldr);
  duration += val2;
  if(duration == "001")
  {
    Serial.println("Received message: hi");
    lcd.clear();
    lcd.print("hi");
  }
  if(duration == "0001")
  {
    Serial.println("Received message: hello");
    lcd.clear();
    lcd.print("hello");
  }
  if(duration == "00001")
  {
    Serial.println("Received message: how are you?");
    lcd.clear();
    lcd.print("how are you?");
  }
  if(duration == "000001")
  {
    Serial.println("Received message: I am fine");
    lcd.clear();
    lcd.print("I am fine");
  }
```

```
if(duration == "0000001")
{
  Serial.println("Received message: ok");
  lcd.clear();
  lcd.print("ok");
}
if(duration == "00000001")
{
  Serial.println("Received message: good morning");
  lcd.clear();
  lcd.print("good morning");
}
if(duration == "000000001")
{
  Serial.println("Received message: good afternoon");
  lcd.clear();
  lcd.print("good afternoon");
}
if(duration == "0000000001")
{
  Serial.println("Received message: good evening");
  lcd.clear();
  lcd.print("good evening");
}
if(duration == "00000000001")
{
  Serial.println("Received message: thank you");
  lcd.clear();
```

```
    lcd.print("thank you");
  }
  if(duration == "000000000001")
  {
    Serial.println("Received message: sorry");
    lcd.clear();
    lcd.print("sorry");
  }
  if(duration == "0000000000001")
  {
    Serial.println("Received message: sakthi");
    lcd.clear();
    lcd.print("sakthi");
  }
  if(val2 == 1)
  {
    duration = "";
    break;
  }
  delay(200);
 }
}
```

### 3.4 Experimental Results

The transmitter part of the proposed system implemented as an android application, called (Tx-application), running on smartphone with Android version 12. Android framework allow us utilizing android camera API to access camera’s flash and turn it on/off.

If applied, Rx-application is implemented using an Arduino software IDE, which is uploaded to Arduino board and executed by microcontroller in Arduino UNO board. Rx-application uses a built-in Arduino function to read a values reported by external light detector sensor.

The proposed system is experienced to send actual data as a text, from transmitter part to receiver part. To test the performance of the proposed system, the following experiments are conducted. Thus, at each experiment, the execution of proposed applications is repeated for 10 times to test an accuracy of transmission. In addition, performance of the system has been tested under the effect of varying the distance between transmitter part and receiver part.

In this experiment smartphone to Arduino UNO circuit communication system isexecuted based on VLC as shown in figure 15.

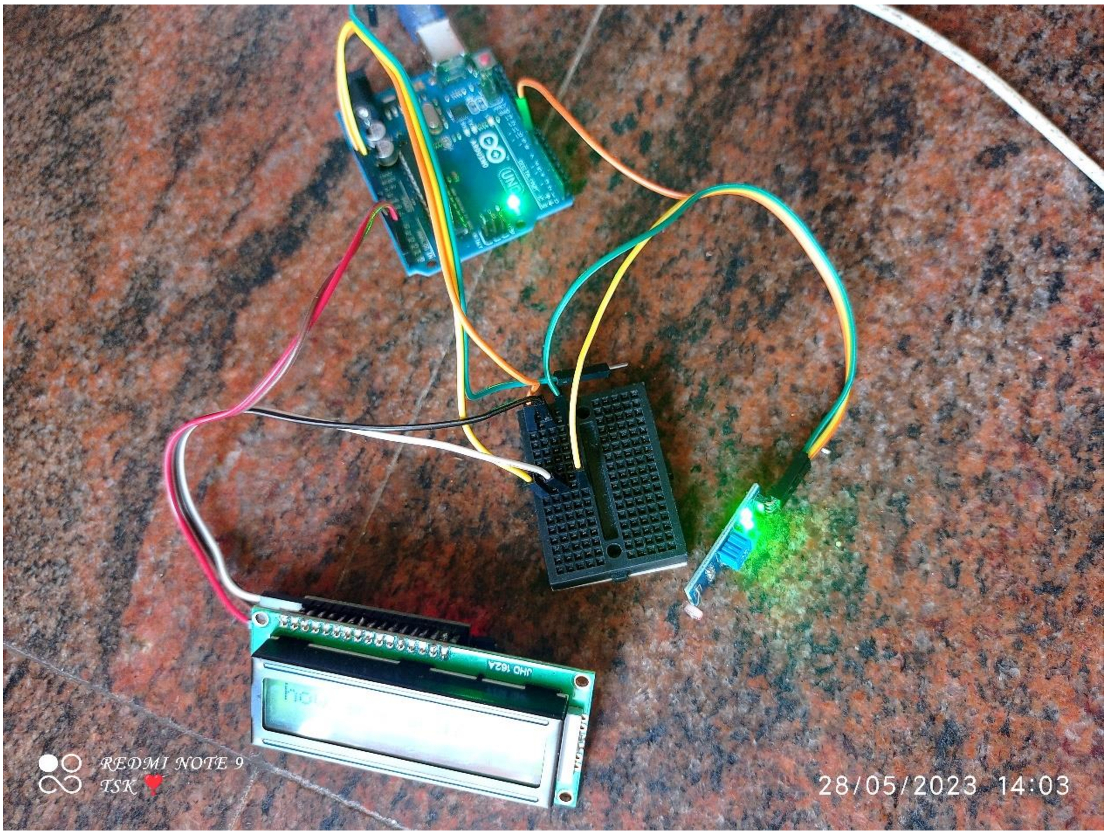



**Figure 15. Setup**

In this experiment, an external light sensor is used, which is called LDR or photo resistor sensor, where is connected to Arduino UNO circuit as illustrated in figure 16. LDR is commonly used to measure the light intensity. Its resistor is decreased as the intensityof light that LDR is exposed to increase and vice versa.

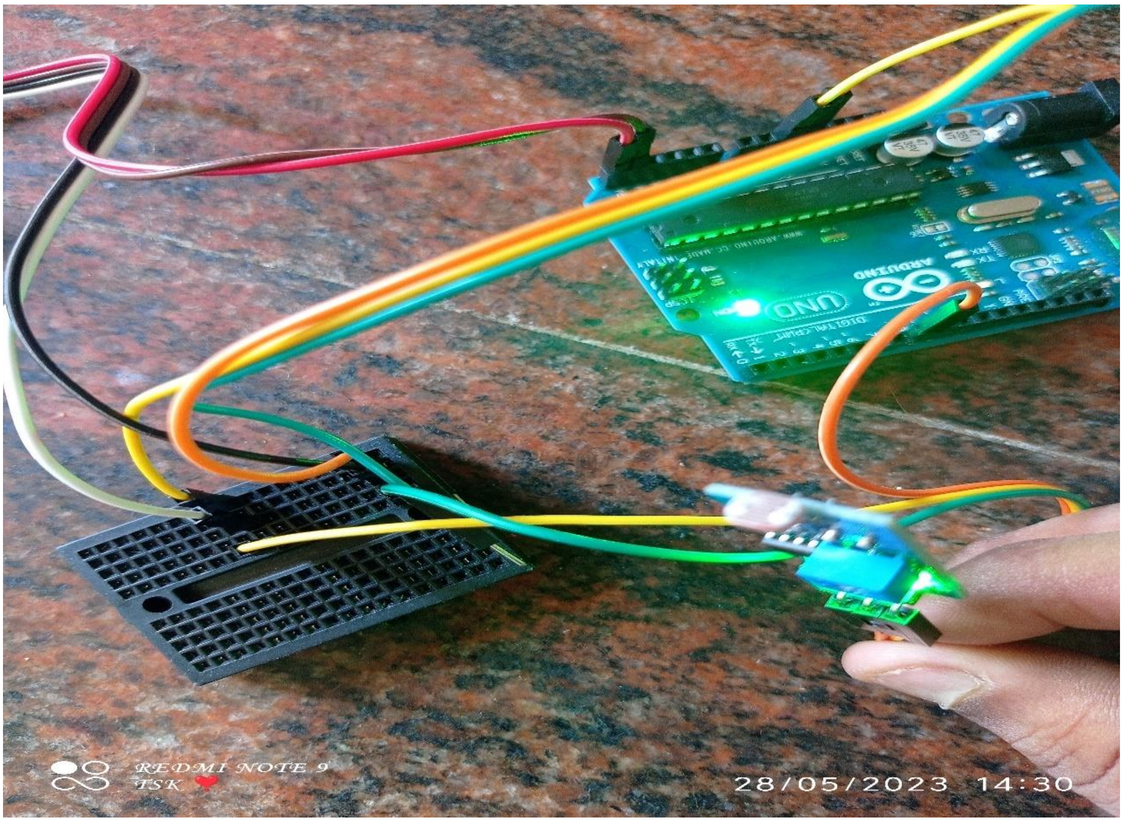



**Figure 16. Connect LDR Sensor to Arduino UNO**

This experiment is concerned with sending text data using Tx-application to the receiver part of the proposed system, which is represented by connected LDR sensor to the Arduino UNO circuit. The Rx-application at the receiver part is successfully received and display it on LCD display via serial port as shown in figure 17.





**Figure 17. Send Message and Displays Received Data**

**After repeating the execution of this experiment for 10 times, it is obtained thefollowing result:**

- The bit data rate is reached up to 40 bps with an accuracy of 100%.
- LDR sensor has a slow response time, which makes it unsuitable for VLC data transmission application.

In this paper, we deployed a communication system based on Li-Fi technology that utilizes a flash of smartphone camera at transmitter part to send data, while using light detector sensor to sense the intensity of flashlight at the receiver part. Through the survey and development of the proposed system

# CHAPTER 4
# CONCLUSION

The main purpose of our proposed project is to deploy a communication system based on Li-Fi technology that is capable of transferring data from transmitter part to receiver part. It has been successfully enabled sending text data via using flash of built-in smartphone camera as a media of communication, and receiving it correctly at the receiver part.

Therefore, there are some enhancements can be taken into account in further research to improve the data bit rate above 100 bps, these are given as follows:

- It will examine replacing OOK modulation scheme PWM.

- It can be experienced using simple circuit in the transmitter part, which consists of Arduino UNO and array of high power LEDs instead of using flashlight of smartphone.

- In order to increase the data bit rate, it can be suggested connecting fast photodiode sensor, its response time in nanoseconds, to Arduino UNO at receiver part and check the data bit rate under this situation.

# CHAPTER 5

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