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# Visible Light Communication for Wireless Networking: Li-Fi Technology

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**Abstract:** Light Fidelity (Li-Fi) is an innovative technology that revolves around communication through the utilization of the visible light spectrum. Li-Fi primarily employs existing light sources, such as LEDs, to convey data by modulating the LED's light output. A photodetector device, capable of detecting changes in light intensity, receives and interprets the transmitted data. Consequently, this technology achieves dual purposes: illumination and communication simultaneously.

The present project involves the practical implementation of Li-Fi, where data is transmitted up to a distance of 2 - 3 meter, achieving a data rate of 115200 bits per second with a speed of 14 kbps.

**Keywords:** LED, Li-Fi, Visible light communication, Alternating current, Direct current, Printed circuit board.

## I. INTRODUCTION

Li-Fi refers to as light fidelity, is a wireless system that utilizes LED (Light Emitting Diode) or infrared light to transmit data. Introduced in 2011 by Professor Harald Haas, a mobile communication professor at the University of Edinburgh, the term "Li-Fi" was coined during his TED Global talk, where he presented the concept of "Wireless data from every light." The technology relies on a light source and controllers to transmit an internet signal through light waves.

In the contemporary era, with approximately 1.4 million radio stations, base stations serving over 5 billion mobile users and mobile phones transmitting data exceeding 600 TB, the demand for wireless communication is immense. Traditional wireless communication using radio waves faces challenges in terms of scalability, availability and security.

To address these issues, scientists propose the idea of wireless data transmission through Light Emitting Diodes (LEDs). The latest advancement in this field is Li-Fi, which leverages LED technology for data transmission, offering higher speed and flexibility compared to Wi-Fi. The Li-Fi system comprises two primary components: the transmitter and the receiver.

In the transmitter section, the input signal undergoes modulation with a defined time period, and the data is transmitted using LED bulbs, representing 0's and 1's through the flashes of light. The flashes emitted by the LED bulbs correspond to the binary digits, 0 and 1. On the receiving end, a photodiode captures the flashes of light from the LED, amplifying the signal and producing the desired output. In this project we implemented the Li-Fi in which we make one transmitter part and other is the receiver part. The transmitter sends the signal to the receiver and receiver receives the signal.

## II. DESIGN & IMPLEMENTATION OF LI-FI SYSTEM

The project is divided in two parts one is transmitter and other is receiver. In the transmitter part components we use power supply, voltage regulator (7805), ESP 32 module, Gate driver (TC4427), resistor, N-channel MOSFET (IRF530) and LED. In the receiver part components we use photodiode (PD638C), resistor, amplifier (LM358) and ESP 32 module. So let's first discuss the transmitter part.

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**2.1 Li-Fi Transmitter**

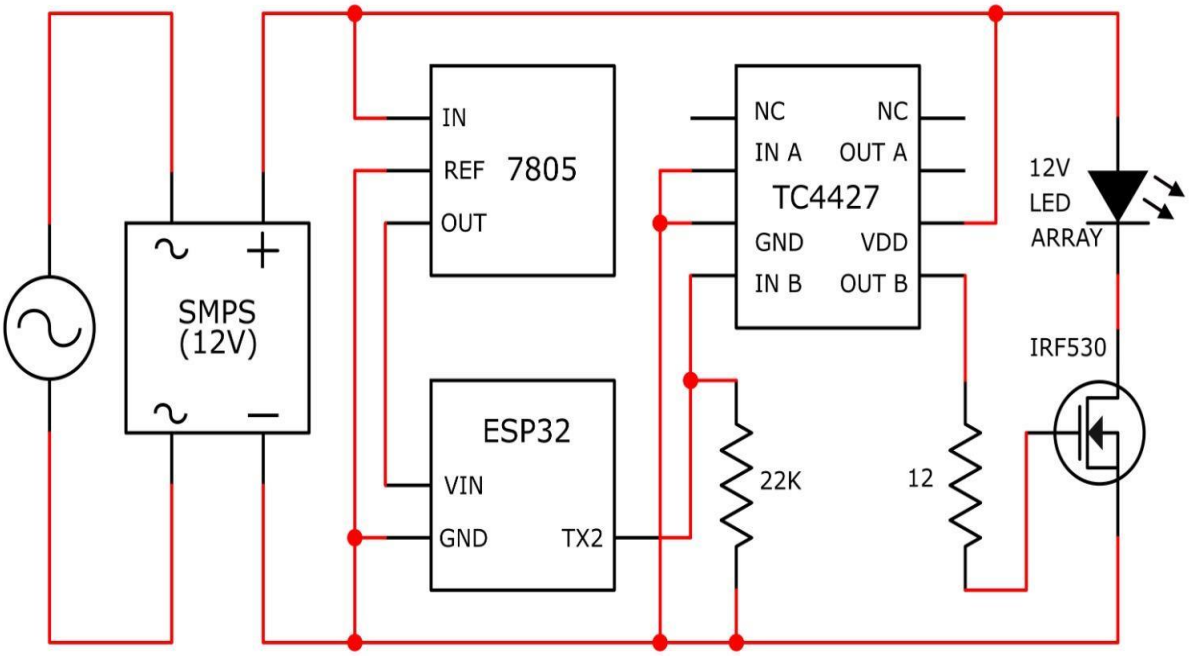


Fig. 2.1 Block diagram of Li-Fi transmitter

Figure 2.1 shows the block diagram of Li-Fi transmitter, the Li-Fi transmitter consists of following components :-

**2.1.1 Power Supply :-** A power supply is a device or system which converts the alternating current (AC) to the firm direct current (DC) voltage and then be used by different electrical devices.

**2.1.2 Voltage Regulator (7805) :-** A voltage regulator is an electronic component which regulates the voltage or we can say that automatically maintains a constant voltage. The 7805 IC is a widely employed voltage regulator integrated circuit in diverse electrical and electronic circuits. Its function is to take an unregulated input voltage ranging from 7V to 35V and generate a steady and fixed output voltage of 5V DC.

**2.1.3 ESP 32 Module :-** The ESP 32 is a chip created by Espressif systems. It belongs to a family of cost-effective and energy–efficient microcontrollers, known as system–on–a–chip (SOC) which come equipped with integrated Wi-Fi and dual–mode Bluetooth capabilities. In this project it's like a operating system which helps to send the message via Bluetooth.

**2.1.4 Gate Driver (TC4427) :-** The TC 4427 MOSFET drivers can swiftly charge or discharge gate capacitances of 1000 pF in less than 30 ns. These components offer sufficiently low impedances in both the ON and OFF states, ensuring that the intended state of the MOSFET remains unaffected, even in the presence of substantial transients.

**2.1.5 N – Channel MOSFET (IRF530) :-** The IRF 530 is an N-channel MOSFET specifically engineered for high speed and high power applications. It is capable of handling a continuous current of 14 A at a voltage of 100 V. In pulse mode, it exhibits the capacity to drive a load of up to 56 A.

**2.1.6 Light Emitting diode (LED) :-** A light emitting diode (LED) is a semiconductor component that produces light as a result of the flow of electric current through it. As current traverses through an LED, the recombination of electrons with holes takes place leading to the emission of light. LEDs facilitate the flow of current in the forward direction while impending current in the reverse direction.

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**2.2 Li-Fi Receiver**

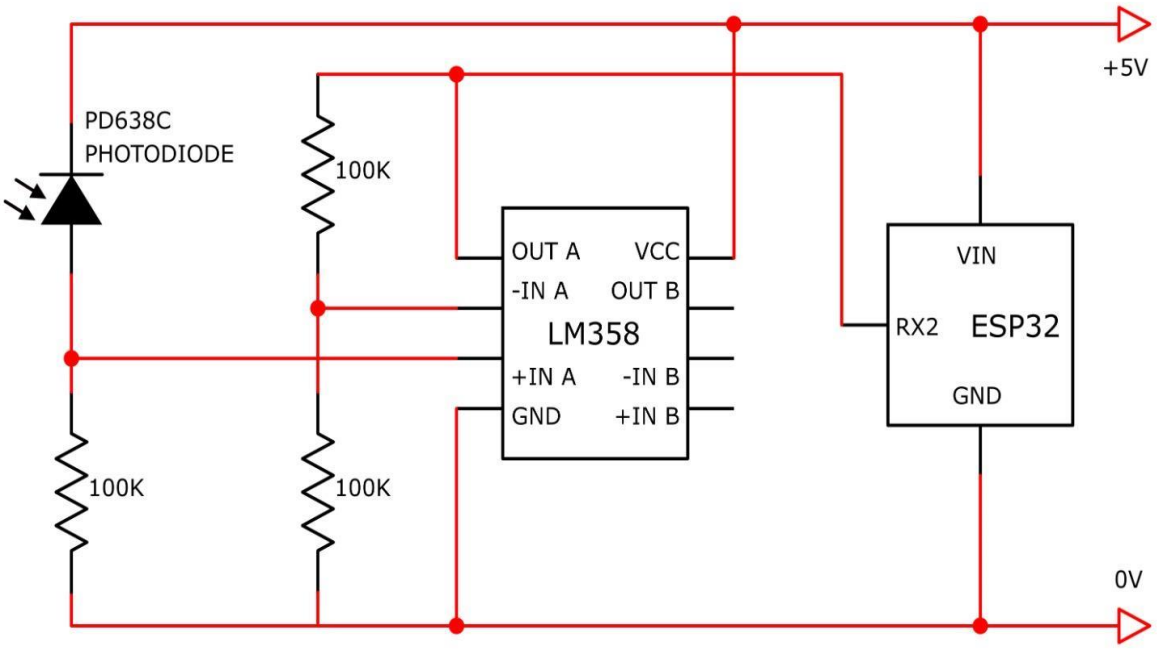


Fig. 2.2 Block diagram of Li-Fi receiver

Figure 2.2 shows the block diagram of Li-Fi receiver, the Li-Fi receiver consists of following components :-

**2.2.1 Photodiode PD638C :-** A photodiode is a semiconductor device featuring a P-N junction that transforms photons (or light) into an electric current. The P-layer is characterized by an excess of holes (positively charged) while the N-layer has an abundance of electrons (negatively charged). When the photodiode receives the light which contains the message then it sends to the ESP32 module.

**2.2.2 Resistor :-** A resistor is an electrical element that controls or regulates the passage of electrical current within an electronic circuit. Additionally, resistors find application in supplying precise voltage to active devices like transistors.

**2.2.3 Amplifier LM358 :-** The LM 358 IC is a dual operational amplifier integrated circuit featuring two independent Op-Amps powered by a shared power supply. It incorporates two separate compensated operational amplifiers characterized by low power consumption and a high gain frequency. Specifically designed to function on a single supply, the LM358 accommodates a broad range of voltage variations.

**2.3 Project Implementation**

Figure 2.3 shows the implementation of Li-Fi transmitter and Li-Fi receiver.
STEP 1 :- First we take the one led bulb.
STEP 2 :- Then we remove the led's which is inserted in the bulb we use only the external structure of the bulb.
STEP 3 :- Now we add the power supply inside the bulb structure.
STEP 4 :- After that we made the transmitter part which we use ESP 32 module, Voltage regulator gate driver and N-channel MOSFET. In which first we take the ESP 32 module, it's a programmable device which had inbuilt Wi-Fi and Bluetooth facility.

Now we program the ESP 32 module by using Arduino IDE

We use the Bluetooth services for transmitting the data and receiving the data which is inbuilt in the ESP32 module. We have to just download the any Bluetooth app from google playstore which is sending or receiving data on our device. For this project we use the " Serial Bluetooth " named app for sending and receiving the data and vice – versa.

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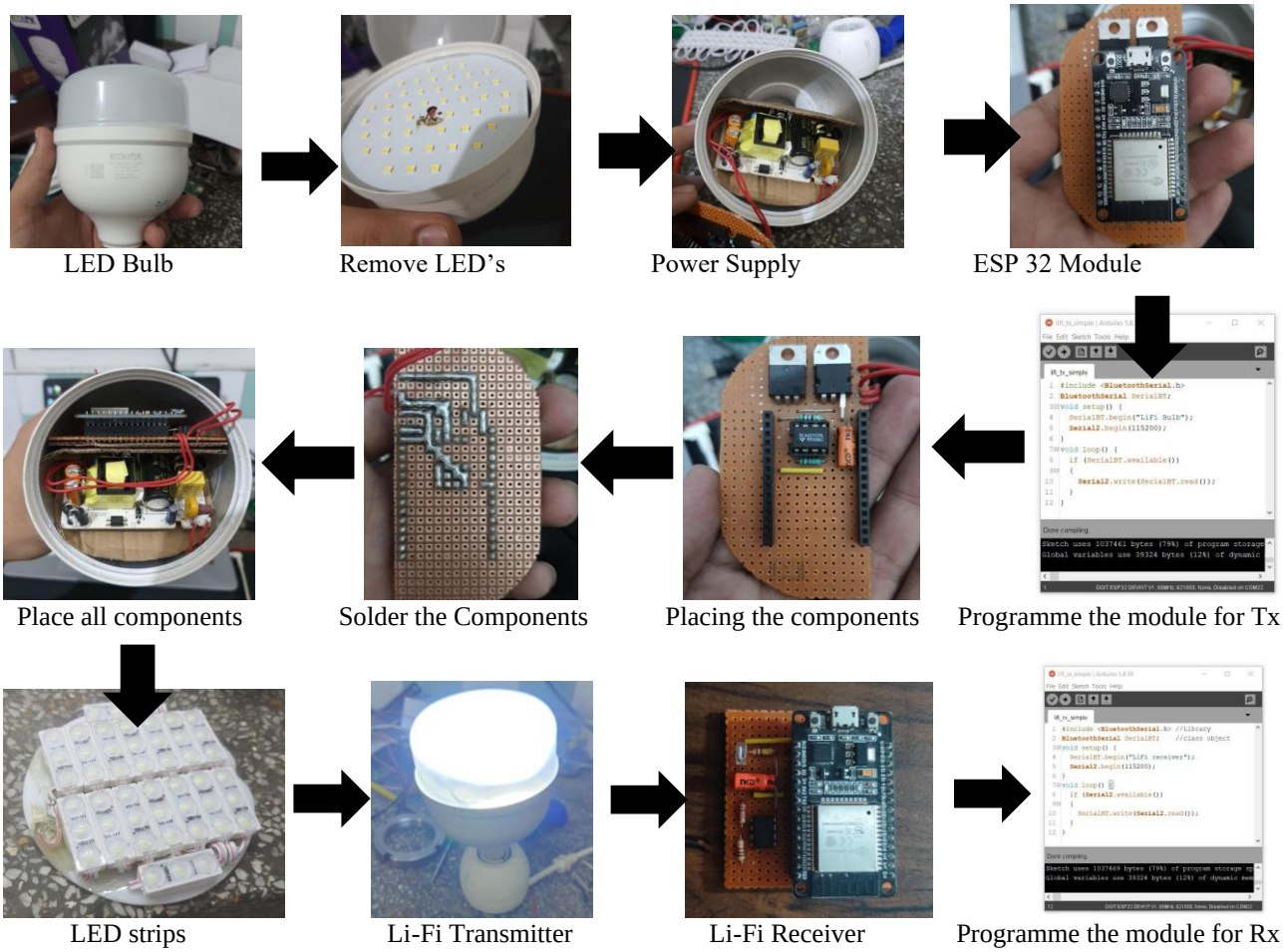


Fig. 2.3 Implementation of Li-Fi Transmitter & Li-Fi receiver

STEP 5 :- Now we place the voltage regulator, gate driver and N -channel MOSFET, resistor and capacitor on the printed circuit board (PCB).
STEP 6 :- After placing the components we solder all the components according to the connection diagram.
STEP 7 :- Now we place the solder PCB and the ESP 32 module on inside the bulb structure.
STEP 8 :- Take one round shape board and paste the LED strips 12 V on the board.
STEP 9 :- Now the Li-Fi Transmitter is ready to transmit the data.
STEP 10 :- Now we works on the Li-Fi receiver, firstly we take one photodiode, resistor, capacitor, amplifier and ESP32 module. Place all components on the PCB board.
STEP 11 :- After that solder all the components according to the connection diagram.
STEP 12 :- Now we Program the ESP 32 module receiver by using Arduino IDE.
STEP 13 :- Now the receiver is also ready for receiving the data.

### 2.4 Project Working

First we gave the supply to the project then the power supply convert the AC (alternating current) to the DC (direct current). Then the voltage regulator regulates the voltage and converts to the 5 V and passes the current to the ESP32 module. The ESP 32 module works on the 3.3 V voltage so it have inbuilt voltage regulator it regulates the 5 V voltage to the 3.3 V voltage. Now the ESP 32 module is in the ON mode it starts the working according to the program which data is receive on the board on the transmitted pin it transmits to the gate driver. We send data on the ESP 32 module by the Bluetooth. The gate driver sends the transmitted data to the N – channel MOSFET which act as a switch here. When the data received on the N – channel MOSFET it transmits the data to the LED which we made and the light transferred the data. When the light strike on the photodiode, it receives the data and sends to the amplifier for amplification the data and process it. Now receiving data passes to the ESP 32 module and it sends the data on the connected device through the Bluetooth. By this process the project works.

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## III. RESULT & DISCUSSION

By doing this practical we obtain some results which are :-

- It transmitted the signal over a range of 2 - 3 meter.
- If the distance increased in between the transmitter and the receiver, then the receiver device shows randomly some of the garbage values.
- If there is some obstacle present in between the transmitter and the receiver or light not receive on the photodiode by any error it shows the garbage values on the connected device instead of the original message.
- The data received on the connected device by just blink an eye. It transmits 115200 bits per second and obtain the 14 Kbps speed approximately.

As is customary in discussions, any topic typically has two facets – advantages and disadvantages. Likewise in our project exhibits certain merits and limitations. In terms of advantages it boasts security, speed, low power consumption and cost effectiveness. On the other hand the project has limitations for instance it is not suitable for use in an open environment where signals may be affected by other ambient lights and obstacles between the transmitter and receiver can hinder the transmission of signals.

Fig. 3.1 Li-Fi Transmitter


Fig. 3.2 Li-Fi receiver

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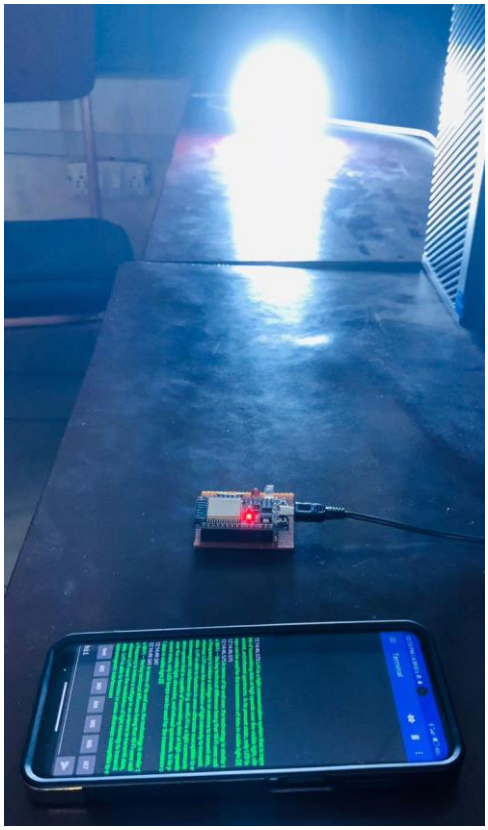

Fig. 3.3 Li-Fi transmitter & Receiver

## IV. CONCLUSION & FUTURE SCOPE

As the electromagnetic spectrum experiences increasing congestion, Li-Fi technology emerges as a promising solution, offering a faster, safer, more environmentally friendly, superior, and healthier prospect for wireless communication systems. Upon full development, each light source has the potential to serve as a Li-Fi access point. In practical terms, this means that wherever there is an LED light bulb, there is the possibility of establishing a data communication facility. In the coming years, it is anticipated that Li-Fi will integrate seamlessly with other wireless complementary technologies, forming a novel ubiquitous computing platform. The implementation of Li-Fi in this project serves as a small-scale example of how conventional LED bulbs can transition into Li-Fi bulbs for signal transmission. It is worth noting that, unlike the potentially hazardous RF spectrum affecting humans and birds, Li-Fi is not expected to have any physical or mental impact on individuals, though occasional light effects on the eyes may occur. As with many advancements, there are inherent advantages and disadvantages to consider.

For the future scope we use the Li-Fi technology in various fields such as airplanes, hospital, petrochemical industry, In home and office appliances, smart lighting and underwater so on.

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