

# Wireless Data Transfer Using Li-Fi Technology {Text & Audio}

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**Abstract-** — In Recent Years, The Rapid Growth Of Wireless Communication Technologies Has Led To Congestion In The Radio Frequency (Rf) Spectrum. Technologies Such As Wi-Fi, Bluetooth, And Cellular Communication Rely Heavily On Rf Waves, Which Suffer From Limitations Like Limited Bandwidth, Interference, Security Issues, And Restricted Usage In Sensitive Environments Such As Hospitals And Aircraft. To Overcome These Challenges, Light Fidelity (Li-Fi) Has Emerged As A Promising Alternative Wireless Communication Technology.

**Keywords:** Li-Fi, Led's, Visible Light Communication (Vlc), Transmitter, Receiver.

## I. INTRODUCTION



Li-Fi Is A Wireless Communication System That Uses Visible Light For Data Transmission Instead Of Radio Waves. It Operates By Modulating The Intensity Of Light Emitted From Light Emitting Diodes (Leds) At Very High Speeds, Which Is Imperceptible To The Human Eye. The Modulated Light Is Detected By A Photodiode At The Receiver Side And Converted Back Into Electrical Signals, Enabling Data Transmission Through Light.

This Project, Titled “Li-Fi Based Data And Audio Communication System Using Arduino,” Focuses On The Design And Implementation Of A Li-Fi Communication System. The System Enables One-Way Transmission Of Digital Data And Audio Signals Using Li-Fi Modules On Two Separate Sides. Each Side Consists Of An Arduino Microcontroller, A High-Brightness Led For Transmission, And A Photodiode For Reception, Allowing Both Transmitting And Receiving Operations.

The Arduino Microcontroller Is Used As The Central Processing Unit For Encoding, Transmitting, Receiving, And Decoding The Information. Digital Data Is Transmitted Using Intensity Modulation Of The Led, While Audio Signals Are

Captured Through A Microphone, Processed, And Transmitted Via Visible Light. At The Receiver End, The Photodiode Detects The Modulated Light, And The Recovered Signal Is Amplified And Reproduced Through A Speaker.

The Proposed System Demonstrates A Secure, Interference-Free, And Energy-Efficient Communication Method, Making It Suitable For Short-Range Indoor Applications. This Project Highlights The Potential Of Li-Fi Technology As An Alternative To Conventional Wireless Communication Systems And Showcases Its Practical Implementation Using Low-Cost Hardware Components.

## II. LITERATURE REVIEW

Wireless Communication Has Become An Essential Part Of Modern Technology, Enabling Data Transmission Without Physical Connections. Conventional Wireless Systems Such As Wi-Fi, Bluetooth, And Cellular Networks Primarily Use Radio Frequency (Rf) Waves For Communication. Although These Technologies Provide Mobility And Convenience, They Suffer From Limitations Such As Limited Bandwidth, Electromagnetic Interference, Security Concerns, And Restricted Usage In Rf-Sensitive Environments Like Hospitals, Aircraft, And Industrial Plants. These Challenges Have Motivated Researchers To Explore Alternative Wireless Communication Technologies.

Light Fidelity (Li-Fi) Is An Emerging Wireless Communication Technology That Uses Visible Light For Data Transmission. The Concept Of Li-Fi Was First Introduced By Harald Haas, Who Demonstrated High-Speed Data Transmission Using Led Light Sources. Li-Fi Utilizes Rapid Modulation Of Led Light

Intensity To Transmit Information, Which Can Be Detected By A Photodiode At The Receiver. Since Visible Light Has A Much Wider Spectrum Than Rf, Li-Fi Offers Significantly Higher Data Rates And Reduced Interference.

Several Researchers Have Explored The Use Of Leds And Photodiodes For Wireless Data Communication. Early Studies Focused On One-Way Communication Systems Where Text Or Sensor Data Was Transmitted Using Simple On-Off Keying (OOK) Modulation. These Systems Proved That Leds Can Effectively Transmit Digital Data Over Short Distances With Minimal Hardware Complexity. However, Such Systems Were Limited To Unidirectional Communication And Low Data Rates.

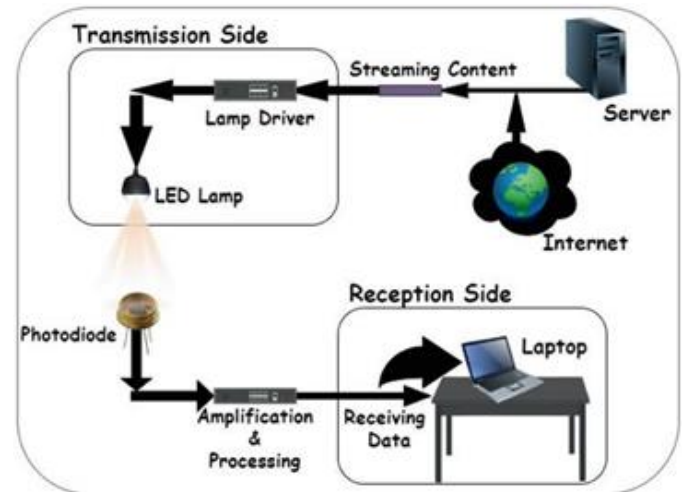
Further Research Extended Li-Fi Systems To Support Audio Transmission. In These Implementations, Analog Audio Signals Were Modulated Onto Led Light Using Intensity Modulation Techniques. Microphones And Audio Amplifiers Were Used At The Transmitter Side, While Photodiodes And Speaker Circuits Were Employed At The Receiver. These Studies Demonstrated That Li-Fi Could Successfully Transmit Audio Signals With Acceptable Quality Over Short Distances, Although Ambient Light Noise And Alignment Issues Affected Performance.

More Advanced Studies Proposed Bidirectional Or Two-Way Li-Fi Communication Systems. These Systems Used Separate Transmitting And Receiving Units On Both Sides, Enabling Full-Duplex Or Time-Division Duplex Communication. Microcontrollers Such As Arduino, Pic, And Arm-Based Controllers Were Commonly Used For Data Processing, Signal Encoding, And Decoding. These Implementations Improved System Flexibility And Enabled Real-Time Communication Between Two Nodes.

Recent Research Has Focused On Improving Li-Fi Performance By Using Better Modulation Techniques, Error Correction Methods, And Optical Filters To Reduce Noise From Ambient Light. Some Studies Have Also Integrated Li-Fi With Internet Of Things (IoT) Applications, Secure Communication Systems, And Smart Indoor Networks. Despite These Advancements, Li-Fi Systems Are Still Limited By Line-Of-Sight Requirements And Short Transmission Range.

From The Literature, It Is Observed That Most Existing Systems Focus On Either Data Transmission Or One-Way Communication. Limited Work Has Been Done On Low-Cost, Arduino-Based One-Way Li-Fi Systems Capable Of Transmitting Both Data And Audio. Therefore, This Project Aims To Design And Implement A Simple, Cost- Effective,

And Reliable Li-Fi Based One-Way Communication System Using Arduino, Demonstrating Practical Data And Audio Transmission Using Visible Light.



• **Existing System**

In The Existing Communication Systems, Wireless Data And Audio Transmission Are Predominantly Carried Out Using Radio Frequency (Rf) Based Technologies Such As Wi-Fi, Bluetooth, Zigbee, And Cellular Networks. These Technologies Utilize Electromagnetic Waves To Transmit Information Over Short And Long Distances And Are Widely Used Due To Their Ease Of Implementation And Mobility Support.

Wi-Fi Technology Is Commonly Used For High-Speed Data Communication In Indoor Environments, While Bluetooth Is Used For Short-Range Audio And Data Transmission. Cellular Networks Enable Long-Distance Communication And Support Both Voice And Data Services. Although These Rf-Based Systems Are Well Established And Reliable, They Suffer From Several Limitations Such As Limited Spectrum Availability, Electromagnetic Interference, Security Vulnerabilities, And High Power Consumption.

In Rf-Based Communication, Multiple Devices Share The Same Frequency Band, Which Often Leads To Signal Congestion And Interference, Especially In Densely Populated Areas. Additionally, Rf Signals Can Penetrate Walls, Making Them More Vulnerable To Unauthorized Access And Security Breaches. Due To These Reasons, Rf Communication Is Restricted Or Not Permitted In Sensitive Environments Such As Hospitals, Aircraft Cabins, Petrochemical Plants, And Defense Zones, Where Electromagnetic Interference Can Affect Critical Equipment.

For Short-Range Communication, Wired Systems Such As Ethernet Cables And Audio Cables Are Also Used. While Wired Communication Offers High Reliability And Security, It Lacks Mobility, Increases Installation Complexity, And Results In Higher Maintenance Costs. Moreover, Wired Systems Are Not Suitable For Flexible Or Temporary Communication Setups.

Some Existing Optical Communication Systems Use Infrared (Ir) Technology For Wireless Transmission. Although Ir Communication Provides Better Security Than Rf, It Has Limitations Such As Low Data Rate, Short Range, And Requirement Of Strict Line-Of-Sight. Most Ir Systems Support Only One-Way Communication And Are Not Suitable For Transmitting Both Data And Audio Simultaneously.

Overall, The Existing Systems Either Rely Heavily On Rf-Based Communication Or Wired Connections, Both Of Which Have Inherent Limitations. These Drawbacks Highlight The Need For An Alternative Wireless Communication System That Offers High Security, Reduced Interference, Efficient Bandwidth Utilization, And Safe Operation In Rf-Restricted Environments. This Motivates The Development Of A Li-Fi Based Two-Way Data And Audio Communication System, Which Overcomes Many Of The Limitations Of Existing Technologies.

- **Proposed System:**

The Proposed System Presents A Li-Fi Based One-Way Communication System That Enables The Transmission Of Both Digital Data And Audio Signals Using Visible Light. The System Is Designed Using Arduino Microcontrollers On Both Communication Sides, Along With Li-Fi Transmitter And Receiver Modules, To Achieve Reliable Bidirectional Communication Without Using Radio Frequency (Rf) Waves. In This System, Each Communication Unit Consists Of An Arduino Microcontroller, A High-Brightness Led Acting As The Li-Fi Transmitter, And A Photodiode Serving As The Li-Fi Receiver. The Arduino Controls The Modulation And Demodulation Of Signals, Allowing Information To Be Transmitted Through Rapid Variations In Led Light Intensity. Since These Variations Occur At Very High Speeds, They Are Not Perceptible To The Human Eye.

For Data Transmission, Digital Information Such As Text Or Sensor Data Is Encoded By The Arduino And Transmitted Using Light Modulation Techniques Like On-Off Keying. At The Receiver End, The Photodiode Detects The Modulated Light And Converts It Into Electrical Signals, Which Are Then Decoded By The Arduino To Retrieve The Original Data.

For Audio Transmission, The Proposed System Uses A Microphone Module To Capture Audio Signals. These Signals Are Processed By The Arduino And Transmitted Via The Li-Fi Led. At The Receiving Side, The Photodiode Detects

The Optical Signal, Which Is Amplified And Reproduced Through A Speaker. This Allows Real-Time Audio Communication Between The Two Units.

To Support One-Way Communication, The System Operates Using A Time-Division Duplex (Tdd) Technique, Where Each Side Alternates Between Transmission And Reception. This Method Avoids Signal Collision And Ensures Reliable Communication Using Simple And Cost-Effective Hardware. Alternatively, The System Can Be Extended To Full-Duplex Communication By Using Separate Transmitting And Receiving Leds And Photodiodes.

The Proposed System Offers Several Advantages Over Traditional Rf-Based Communication, Including Enhanced Security, Immunity To Electromagnetic Interference, And Safe Operation In Rf-Restricted Environments. It Is Particularly Suitable For Indoor, Short-Range Communication Applications Such As Hospitals, Educational Institutions, And Secure Facilities.

Overall, This Project Demonstrates A Low-Cost, Energy-Efficient, And Secure Li-Fi Communication System Using Arduino, Highlighting The Potential Of Visible Light Communication As A Viable Alternative To Conventional Wireless Technologies.

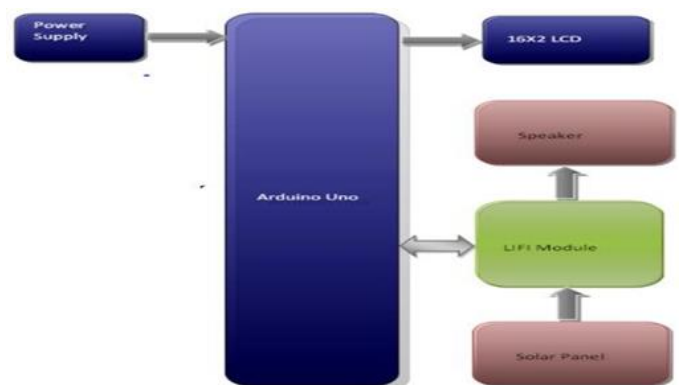


Fig1. Block diagram of transmitter system

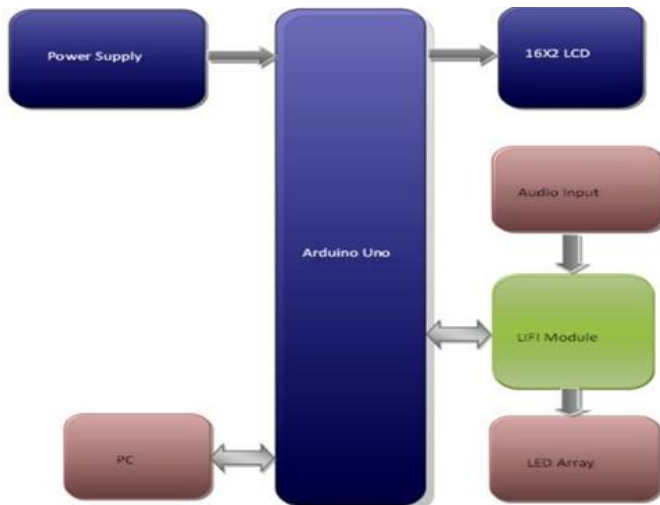


Fig2. Block diagram of receiver system

### III. AIM AND OBJECTIVES

- To Demonstrate Wireless Data Transfer Using Li-Fi (Light Fidelity) Technology As An Alternative To Wi-Fi.
- To Transmit Text And Audio Signals Efficiently Through Visible Light Communication.
- To Transmit Text And Audio Signals Efficiently Through Visible Light Communication.
- To Achieve High-Speed And Secure Communication Through Modulation Of Light Intensity.
- To Develop An Arduino-Based System For Encoding And Decoding Digital Data (Text And Audio).
- To Analyze Data Transfer Performance In Terms Of Speed, Range, And Signal Clarity Under Different Lighting Conditions.
- To Reduce Electromagnetic Interference (Emi) By Using Light As A Data Transmission Medium.
- To Explore The Feasibility Of Li-Fi For Short-Range, Low-Cost, And Energy-Efficient Wireless Communication

### IV. WORKING OF LI-FI

Here There Are Two Sections To Transmit Data And Audio. One Is Transmitter Which Has Lifi Transmitter Connected To Arduino Serial Port. Also It Has Connection With Pc Serial Port To Transmit Data From Pc. When We Enter Data In Pc, Lifi Module Transmits Data Through Led Array In The Form Of Light. At Receiver Side Lifi Module Interfaced With Arduino Serial Port. It Has Solar Panel To Receive Data From

Transmitter And Converts Light Format Data Into Text. This Data Will Be Displayed On 16x2 Lcd Display.

These Lifi Modules Has Audio Communication Modes By Selecting Switches Into Audio Mode. We Can Connect Mobile Phone Audio Pin To Transmitter Lifi Module And It Can Transmit Audio Through Light Format. Lifi Receiver Converts Light Data Into Audio Signals Playing Through Amplifier And Speaker.

#### 1. Power Supply Using 7805:

- Input Voltage: 9V–12V DC
- 7805 regulates it down to +5V DC, supplying all logic ICs, MAX232, and signal processing stages.

#### 2. Transmitter Section: Audio or Data Input

- Audio from a phone or data (TTL or RS232) from a microcontroller/PC is given to the module.
- If input is RS232 ( $\pm 12V$ ), it goes to the MAX232, which converts it to TTL (0–5V) levels.
- The SN74LS14N Schmitt trigger:
  - Cleans up digital signals
  - Removes noise and ensures clean ON/OFF transitions

#### Driving the Light Source

- The IRF630 MOSFET is controlled by the signal output of SN74LS14N.
- It switches the laser diode or LED ON/OFF rapidly based on the input signal.
- This modulates the light beam, embedding the audio or data.

#### 3. Transmission Medium: Light

- The modulated light beam (invisible or visible) carries the encoded signal.
- Needs line-of-sight between transmitter and receiver.
- Distance: Typically 1–5 meters, depending on light intensity and sensor quality.

#### 4. Receiver Section: Light Detection

- A photodiode or solar panel detects the incoming light intensity.
- Converts variations into a corresponding voltage signal.

**Signal Conditioning**

- The signal is weak and noisy → passed through SN74LS14N or an op-amp to clean up.
- If it's RS232 data, the cleaned TTL signal is passed through MAX232 to convert it back to RS232 levels for the PC.

**Output**

- For audio, signal goes to a speaker amplifier (like LM386).
- For data, it's sent to microcontroller RX or PC serial port.

- Working Flow Summary
- Transmission

Audio/Data In → MAX232 → SN74LS14 → IRF630 Gate → LED/Laser Diode → Modulated Light Output

□ Reception

Photodiode → SN74LS14 → MAX232 (if needed) → Microcontroller RX / Speaker

□ Use Case Examples

Mode	Example
<b>Audio Transmission</b>	Stream music via light to a speaker
<b>Data Transmission</b>	Send UART/RS232 data between two Arduinos or PC ↔ Arduino
<b>Wireless Sensor Node</b>	Transmit sensor values using Li-Fi to a gateway

**Summary**

Component	Function
<b>IRF630</b>	Modulates LED power with data/audio signal
<b>7805</b>	Regulates 5V supply
<b>SN74LS14N</b>	Cleans signal with Schmitt trigger logic
<b>MAX232</b>	Converts TTL ↔ RS232 for serial communication
<b>LED/Laser</b>	Transmits data via light
<b>Photodiode</b>	Receives light signal and converts to voltage

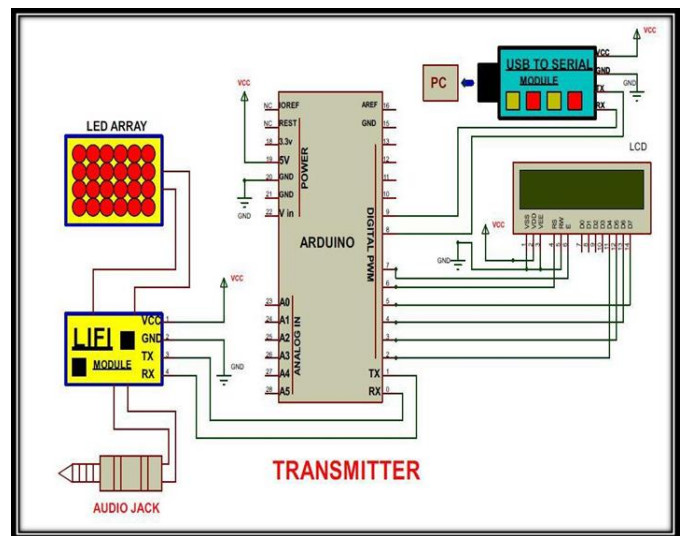
<b>Amplifier (opt.)</b>	Boosts received signal for speaker or processing
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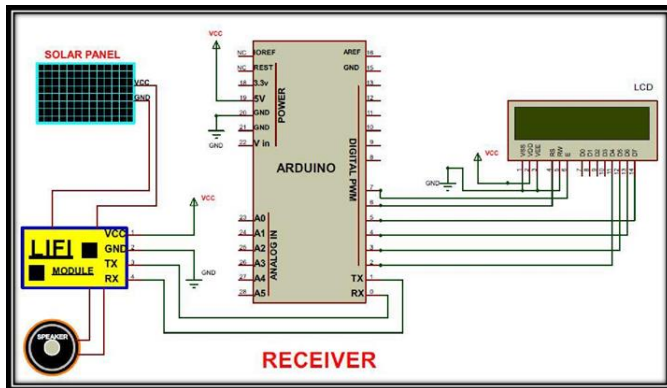
**V. ADVANTAGES:**

- Simple and low-cost Li-Fi system
- Can transmit both audio and serial data
- Good for educational demonstrations of light-based communication
- Avoids RF interference

□ Here is a detailed explanation of the working of a Li-Fi module designed for data and audio transmission, using the components:

- IRF630 (MOSFET for light control)
- 7805 (Voltage regulator for power supply)
- SN74LS14N (Schmitt trigger hex inverter for digital signal shaping)
- MAX232 (RS232 to TTL level converter)
- LM386 (Audio amplifier)





## VI. SCOPE FOR FUTURE WORK

### Range improvement

develop advanced modulation techniques and optical components to increase transmission distance and overcome current range limitations.

### Non-line-of-sight communication

research methods like reflection-based transmission and hybrid systems to reduce dependency on direct line-of-sight

### Integration with wi-fi (hybrid systems)

combine li-fi with wi-fi to create hybrid communication systems for seamless connectivity and wider coverage.

### High-speed data enhancement

improve led switching speed and signal processing to achieve ultra-high data rates for real-time audio and text communication.

### Mobility support

design systems that support user movement (handover mechanisms) without signal loss.

### Security enhancement

implement advanced encryption and secure protocols for highly sensitive communication (e.g., defense applications).

### Iot and smart systems integration

expand li-fi use in smart homes, smart cities, and iot devices for efficient communication.

### Multimedia expansion

enhance capability to transmit not only audio and text but also high-definition video and images efficiently.

### Cost reduction & commercialization

focus on low-cost implementation and mass production to make li-fi widely accessible.

### Real-time applications

develop practical systems for healthcare, underwater communication, aviation, and border security.

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