

Audio, Image and Text Transmission Using Li-Fi Technology

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Abstract: In this project, a system for transmission of audio, text, and image data using Li-Fi (Light Fidelity) and RF (Radio Frequency) technologies has been developed. For high-speed, short-range data communication, Li-Fi uses visible light while RF is used for long-range audio signal transmission. The combination of these two technologies is a demonstration of a hybrid communication system that enables it to transmit various formats of data at the same time. The project is implemented using Arduino UNO, LED transmitter, LDR/Photodiode receiver, LCD Display, Speaker, and Audio RF module. This system is intended to demonstrate a low cost, energy-efficient and secure method of wireless data transmission for multimedia communication. The demand for high-speed and secure wireless communication has increased to a great extent as the use of internet-based services increases. Traditional wireless technologies like Wi-Fi and Bluetooth depend on radio frequency (RF) spectrum which is facing challenges of congestion, interference and security risks. To solve these problems, Li-Fi (Light Fidelity) technology has emerged as a promising solution to these problems, using the visible light spectrum to transmit data. This project shows a prototype of Li-Fi based Audio, text and image transmission system. The system uses high-brightness LEDs as transmitters and photodiodes as receivers. Audio is transmitted by pulse width modulation (PWM) and text and image information are transmitted by digital encoding techniques. An Arduino microcontroller is used for the modulation, encoding, decoding, and system control. The output is reproduced in the form of sound via a speaker, texts on a 16x2 LCD and images on a 128x64 graphical LCD display. The proposed system shows the success of Li-Fi in providing secure, cost-effective and interference-free multimedia communication. Although the system is limited by line-of-sight requirements and restrictions in range, it provides a basis for further development in highspeed visible light communication systems.

Keywords: Li-Fi, Visible Light Communication (VLC), Arduino, Audio Transmission, Text Transmission, Image Transmission, LED, Photodiode, Wireless Communication, Multimedia Data Transfer

I. INTRODUCTION

As the technology of wireless communication has grown exponentially, so has the need for faster and safer transmission of data. Wi-Fi: Radio waves have their problems, too, such as spectrum congestion, interference, and security concerns. Li-Fi is a technology which was brought to limelight by Prof. Harald Haas, it is a new technology of transmitting information using visible light instead of radio waves. In this project Li-Fi is used for text and image data transmission and RF module is used for audio data transmission to maintain analog communication without any distortion. The integration of Li-Fi and RF is a hybrid wireless communication system which is ideal for multimedia data transmission in short-range setting including classroom, laboratory and IoT applications. In the new era of wireless communication



there is a never-ending demand for more data rates, secure communication channels and efficient bandwidth utilization. Conventional wireless communication systems such as Wi-Fi, Bluetooth and the cellular networks use Radio Frequency (RF) spectrum for data transfer. However, as the number of wireless devices has been exponentially rising, the RF spectrum has become very congested which has reached issues such as limited bandwidth, interference and potential data breach. To try to avoid these limitations, researchers have been exploring other means of wireless communication: one of the most promising technologies is Li-Fi (Light Fidelity) technology. Li-Fi is a high-speed, two-ways wireless communication system, using visible spectrum light, which is emitted from Light Emitting Diodes (LEDs) and this is used for information transmission. Li-Fi first came about in 2011 when Professor Harald Haas gave a presentation about the idea at the University of Edinburgh. Unlike RF waves, there is a humongous amount of spectrum bandwidth of visible light (400-800 THz) - which is expected to theoretically enable much bigger data rates than Wi-Fi. Furthermore, since visible light cannot travel through walls, Li-Fi communication is naturally far more secure and free from interference, which makes the technology ideal for use in environments such as hospitals, airplanes and laboratories where RF signals can cause disruptions. The principle of Li-Fi is Visible Light Communication (VLC) in which the LED light source is utilized to communicate data by modulating its intensity at very high speed - many times faster than the human eye can see. These fluctuations of light intensity are detected by photodiode or LDR (Light Dependent Resistor) at the receiver end and convert it back to electrical signals which is decoded by microcontroller (Arduino) for binary data. This method can be used reliably for the digital data transmission - for the transcription, images and sensor data, for example. This is a hybrid technology where Li-Fi is being used for digital communication like transmission of text information and image information in light and RF communication for audio signals. The Arduino UNO microcontroller is the central processing unit (CPU) which is responsible for encoding, decoding and synchronizing data. The transmitter section consists of LED arrays and RF transmitter and receiver section consist of photodiode sensor, RF receiver, LCD/OLED display unit and a speaker.

II. LITERATURE SURVEY

Zhang et al. 2025 - The authors have come up with an IoT-based Li-Fi system with multiple LEDs and photodiode receivers for indoor data transmission. The design is aimed at decreasing the ambient light interference, while increasing the reliability of the visible light communication for smart home and sensing networks.

Sharma et al. (2025) A prototype system which demonstrates the transmission of multimedia data (audio, text and images) using Valqua the study features performance evaluation under different light conditions, demonstrates the possibility of using this technique for educational and secure communication purposes.

Bansal et al. (2024) - A comprehensive review on the architectures of Li-Fi and its applications was conducted and the focus was given to healthcare, smart cities and industrial automation. The authors pointed out the dual-functionality of LED to be used for illumination and data transfer, which makes LiFi an economical option.

Prakash & Mehta (2024) - Their paper was a survey of high-capacity VLC systems with advanced digital signal processing techniques such as OFDM and MIMO. In this study, the performance capabilities of these techniques on the enhancement of data rate and deterioration of the bit-error performance of indoor optical wireless links were analysed.

Nireekshan et al. (2024) - The authors considered the problem of Li-Fi integration to Internet of Things (IoT) applications. They suggested the energy-efficient smart device's models and explained the benefit of Li-Fi rather than conventional-based IoT communication in terms of bandwidth and security issues.

Patel & Rao (2023) -Research on the standardization, for Li-Fi, of the interoperability level with existing Wi-Fi networks has been presented. Their paper was revealing how Li-Fi is advancing from the laboratory to commercial products through standardization and commercialization.

Deshmukh et al. (2023) -The authors developed a case study on smart classrooms using the concept of Li-Fi for wireless sharing of data. Their use minimized the use of Wi-Fi and increased security, at the same time using LEDs for lighting the room.

Kumar and Singh (2023) - Long range LiFi based on high power LEDs and the use of optical lenses has been presented. Their experiments resulted in better coverage distance showing that free space optical links can be applied to outside and industrial applications.



Hassan et al. (2022) - In this work, a detailed review of VLC technology is published, discussing features of the channel, hardware design and limitations of LED switching speed. The study provided us with an insight on the issues faced in real-life deployment, and also a solution for ambient light interference.

Choudhary & Jain (2022) - The authors talked about the Li-Fi applications in defence and healthcare. Their paper brought much needed attention on the need for secure and interference-free communication systems and demonstrated that Li-Fi can be used to replace or complement RF systems in sensitive environments.

III. METHODOLOGY

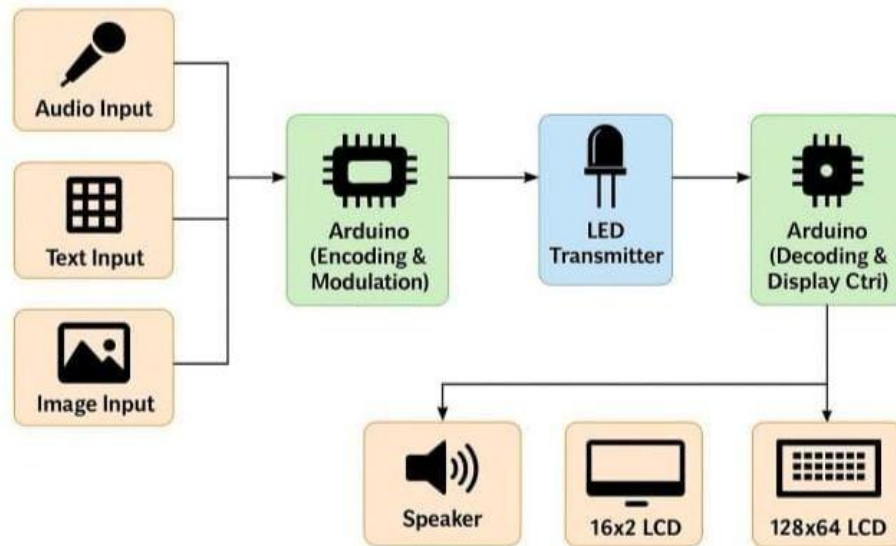


Figure 2.1: Li-Fi Communication System Flowchart

The methodology is described below:

3.1 Data Collection and Preparation

The audio is recorded by a highly sensitive microphone, the text messages are inputted through a serial monitor or keypad interface, and pictures are pre-stored and converted into the binary format to be transmitted digitally over the Li-Fi channel.

3.2 Encoding and Modulation of Data

The data received is processed by the Arduino microcontroller which encodes audio signals by pulse width modulation (PWM) and text and image data where the data is converted to binary data. This is to ensure that all types of data are ready to be reliably transmitted by light.

3.3 Transmission via LED

The encoded data is then used to drive a high-brightness LED, which conveys the information via visible light signals. The light transmits the audio, text, and image data along a line-of-sight route to the receiver.

3.4 Reception and Decoding at the Receiver End

A photodiode then receives the incoming modulated light signals and reverts them back to electrical signals. These signals are then interpreted by a second Arduino microcontroller, which reconstructs the audio, text and image data perfectly.



3.5 Output Display and System Testing

The generated audio is output via a speaker, text is shown on a 16×2 LCD, and images are displayed on a 128×64 graphical LCD. These are all subjected to rigorous testing to guarantee that all multimedia data is transmitted reliably, accurately, and of high quality in varying light conditions, distances, and angles.

3.7 Features of Components Arduino Uno

The system's main microcontroller and processing unit is the Arduino Uno. It handles all encoding and decoding of information for both Li-Fi and RF modules. It digitizes the sensor signals and drives the display and speaker modules. Due to its simplicity, open-source environment, and reliable performance, the Arduino Uno can handle various digital and analog inputs and outputs that can be used for data transmission, automation, and embedded communication.

LED

The LED is the transmission element in Li-Fi technology. The LED's light output intensity is modulated at a high frequency in accordance with the digital data provided by the Arduino. While this rapid modulation does not alter the light output that human beings can see, it can be detected by the photodiode at the receiving end of the Li-Fi system. The advantages of using an LED, in addition to its low-energy consumption, are that it is compact and can change its light output intensity with a rapid frequency that is suitable for Visible Light Communication. In this project, text and image data packets are sent over the LED through the control of light pulsating on and off.

Photodiode

The photodiode acts as the receiving sensor of the Li-Fi communications system. It converts variations in the intensity of light into equivalent electrical signals. These are in an analog form and are fed to the Arduino board for decoding to readable digital data. The photodiode has a high sensitivity, a quick time response and a linear output, which are favourable when large modulation frequency from the LED must be detected. Important for the Li-Fi link ensuring error free and noise free receipt of data.

RF Module

The RF module provides the ability for radio wireless transmission of the audio signals between the transmitter and the receiver. The RF transmitter modulates the audio signal input onto a carrier wave of high frequency (in most cases 433 MHz). The RF receiver demodulates the received signal back to the audio form. This module gives the advantages of a relatively large distance, reliability in its operation, and real time communications, without line - of - sight. It operates in conjunction with the Li-Fi transmission, providing a medium of transmission for the continuous analog signal, in this case voice, thereby giving clear and undistorted audio sound output.

LCD Display (16x2) or LED Display

The display module used to show received text and image data transmitted by the Li-Fi system. The 16x2 LCD displays or the 0.96-inch OLED displays are used, providing an elementary visual output to check the success of the transmission. They are light in weight, and low power consuming, also easily interfaced with the Arduino by the use of either parallel or the I²C method of communications. They act in this application as the user-interface to monitor in real time the data transmitted.

Jumper Wires and Breadboard

Connecting Wires and the Perforated Circuit Board Jumper wires create temporary electrical connections between the different modules and sensors placed on the perforated circuit board. They make the entire circuit modular, flexible and easy to modify during the testing and troubleshooting phases. The provision of the perforated circuit board allows to prototype without soldering, thus allowing a quick layout of the circuit, that will be easily modified during the development phases.



Microphone Module

The microphone module is able to pick up the sound waves in the form of acoustic waves and convert them into analog electrical signals which can thus be fed to the RF transmitter for transmission without wire. The module will use an electret condenser microphone which is well known for its sensitivity in output, small size and requires minimum current. This will ensure, an audio input which will be of great clarity for transmission and at the same time be able to pick up even low sounds, thus making it suitable for voice type of wireless communication systems.

Speaker

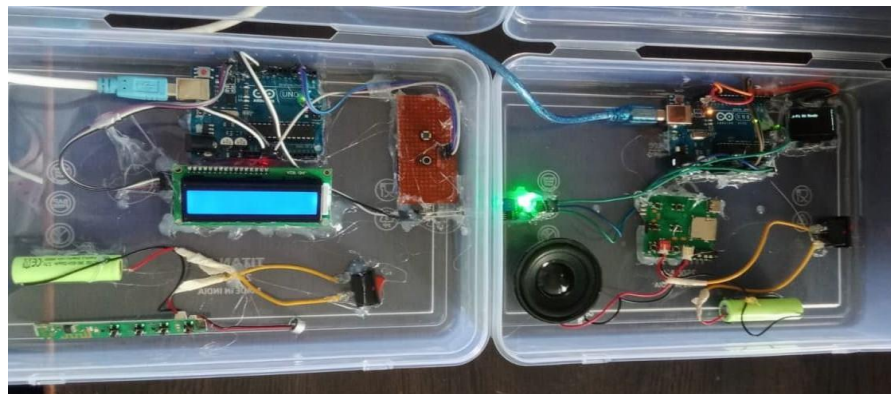
The speaker will be used at the receiver end to decode the electrical audio signals received back to the audible sounds. It will pick up the output of the RF receiver and amplifier circuit. The speaker used will be normally 8Ω , 0.5W, which will give a good clarity due to speaker at low voltage. The speaker will give back the real time audio transmission thus showing the successful operation of the wireless RF communication link.

Power Supply Unit

The power supply provided will give a regulated supply of 5V DC which is required for Arduino & LEDs, RF modules, etc. This can be powered through an USB port, battery pack and also through external adapter. The DC powered supply is guaranteed to be a stabilized supply, which will give a smooth operation of the whole circuit in operation and also eliminate any noise or fluctuations within the voltage level, which will affect in the transmitting or receiving of the signals.

IV. RESULT

This project brings together the principles of Li-Fi and RF to demonstrate that wireless transmission of data can be made to apply to various methods of data generation. In the Li-Fi section a potent LED is used as the transmitter and a photodiode as the receiver. The digital data, which was in the form of texts and pictures, is modulated in the LED by the Arduino so that the information is sent in the form of modulated light. The receiver photodiode picks up the signal which is dependent on the degree that the intensity of light changes and converts it into an electrical signal which is given as output to an LCD or an OLED. For the audio transmission the RF module is used. The microphone registers sound and converts the sound into other electrical signals which are sent to the RF transmitter. These signals are converted into radio waves which are transmitted wireless and the transmitter picks up these signals and gives the output sound through a loudspeaker. This continuous communication gives rise to clear sound being broadcast between transmitter and receiver units. The system has been successfully tried. The Li-Fi link has been found to be successful over distances of 1-2 meters with the two photodiode and LED properly aligned. The text and picture data were properly picked up with-out distortion to speak of. The RF link skilfully gave the reliable transmission of signal for audio. transmission up to 15–20 meters, even when obstacles were present.



The research results clearly indicate that Li-Fi technology can be utilized in local short distance and large volumes of data and secure transmission, while the RF communication technology can be used for the transfer of continuous analog signals such as voice signals. Therefore, these technologies can be combined in order to guarantee an efficient wireless communication system which could be used for transmission of audio, text and image data.

V. CONCLUSION & FUTURE SCOPE

In this project, audio, text, and image data were successfully transmitted using Li-Fi and RF technology. The Li-Fi system uses visible light as the medium for data transmission and the RF system wirelessly transmits audio in the form of radio signals. The main controller in the project is the Arduino Uno, which will control the transmission and the successfully detected reception of the required data. It has been experimented that the data provided by Li-Fi is transmitted at a faster rate and provides better security. The dependent RF work provides stable audio for a longer range. It is shown that Li-Fi can be made as an alternate mode for transmission of information as in place of the conventional Wi-Fi power which is preferred in short distances where data transfer is to be speed and secured. The combination of both can lead to a hybrid communication system which may be used for the transmission of all types of information. The work may be extended to improve the range and data rates by substituting high power LEDs or most sensitive photodiodes connected to the Arduino. The system may further be developed for the bi-directional communication to allow both to send and receive signals through light. The integration of the Internet of Things gadget may prove to be a viable integration for smart home and industrial applications. Advanced modulation techniques can be employed for the signals to achieve high data transfer rates and better noise immunity. This project presents to be an easy, effective and a low-cost utility for the further application of the wireless communication systems having light and radio frequency used together.

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