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A Cutting-Edge Light-Based System for Confidential Data and Audio Transmission

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ABSTRACT

The objective of this project is to design and develop a reliable, secure, and high-speed wireless communication system using Light Fidelity (Li-Fi) technology. Li-Fi offers several advantages over traditional Wi-Fi, including higher data transfer speeds, improved security, greater energy efficiency, reduced interference, increased safety, high data density, and environmental friendliness. As a form of visible light communication (VLC), Li-Fi transmits data using visible, ultraviolet (UV), or infrared (IR) light, typically through modulated LED bulbs. Unlike Wi-Fi, which relies on radio frequencies, Li-Fi encodes data into light intensity variations, making it especially effective in environments where RF communication is restricted or unreliable. Li-Fi supports bidirectional communication, enabling devices to both transmit and receive data. The proposed system is divided into two main sections: the transmitting (TX) and receiving (RX) units. Data input, including text and audio, is provided to a UART (Universal Asynchronous Receiver and Transmitter) module, which sends the electrical signal to the Li-Fi transmitter. The transmitter converts this signal into modulated light using an LED source, which carries the encoded data across a light beam to the receiver. At the receiving end, a photovoltaic cell detects the incoming light signal and forwards it to a Light-to-Electric (L-E) converter, which transforms it back into an electrical signal. A microcontroller then processes this signal and manages the receiver circuitry. The system's outputs include an audio output module that generates sound from the received electrical signal and an LCD display that shows the transmitted text or images. This Li-Fi-based system ensures a more secure communication channel by reducing risks of interception and hacking, while also minimizing interference from surrounding devices and physical obstacles, making it a dependable and efficient solution for modern wireless communication.

Keywords: Li-Fi Technology, Audio Transmission, Visible Light Communication, LCD, Speaker.

1. INTRODUCTION

Li-Fi Stands for Light Fidelity. In the era of overcrowded (data communication) world, Li-Fi is a new way of wireless communication that uses LED lights to transmit data wirelessly. Transmission of data is one of the most important day-to-day activities in the fast growing world. The current wireless networks that connect us to the Internet are very slow when multiple devices are connected. Also, with the increase in the number of devices which access the Internet, the availability of fixed bandwidth makes it much more difficult to enjoy high data transfer rates and to connect a secure network. Radio waves are just a small part of the electromagnetic spectrum available for data transfer.The idea of Li-Fi was introduced for the first time by a German physicist Harald Hass in the TED (Technology, Entertainment, Design) Global talk on Visible Light Communication (VLC) in July 2011, by referring to it as "data through illumination". He used a table lamp with an LED bulb to transmit a video of a blooming flower that was then projected onto a screen. In simple terms, Li-Fi can be thought of as a light-based Wi-Fi i.e. instead of radio waves it uses light to transmit data. In place of Wi-Fi modems, Li-Fi would use transceivers fitted with LED lamps that could light a room as well as transmit and receive information. Li-Fi can play a major role in relieving the heavy loads which the current wireless system is facing. Thus, it may offer additional frequency band of the order of 400 THz compared to that available in RF communication which is about 300 GHz. Also, as the Li-Fi uses the visible spectrum, it will help alleviate concerns that the electromagnetic waves coming with Wi-Fi could adversely affect

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our health.

By Communication through visible light, Li-Fi technology has the possibility to change how we access the Internet, stream videos, receive emails and much more. Security would not be an issue as data can't be accessed in the absence of light. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

2. LITERATURE SURVEY

Rahul R, et al (2014) Li-Fi stood for Light-Fidelity. Li-Fi was the transmission of data using visible light by sending data through an LED light bulb that varied in intensity faster than the human eye could follow. This paper dealt with the implementation of the most basic Li-Fi based system to transfer data from one computer to another. **[1]**

Lamya I , et al (2018) proposed wireless communication technologies like Wi-Fi and Bluetooth used radio waves to transfer information. However, limitations like overcrowding and interference led to exploring alternatives. Researchers conducted studies to improve Li-Fi technology. This paper presented a survey of previous Li-Fi studies and proposed a Li-Fi-based IoT architecture.**[2] Pradip Kumar, et al (2018)** proposed the Internet of Things (IoT) connected humans, things, and environments. IoT applications required dynamicity, heterogeneity, and scalability. This paper proposed with Li-Fi communication for data transmission for one place to another.**[3]**

Emmanuel, et al(2019) This paper proposed a Li-Fi system using off-the-shelf components. The system used an embedded system with an AVR microcontroller, LED, and photodiode. A interface monitored the transferred data, examining speed, efficiency, security, and capacity. The system proved reliable and cost-effective.**[4]**

Sunil L, et al(2023) proposed data transmission speeds were once limited to 50kbps, but eventually reached 100Mbps. Researchers sought even faster speeds, achieving 224 GB per second using Li-Fi. Li-Fi used light as a medium, providing eco-friendly, super-fast data transmission. LED technology enabled easy transfer of text, audio, image, and video files. Visible light had a larger spectrum than radio waves, allowing for enormous capacity. Wi-Fi's inefficiency and security concerns led to the development of Li-Fi as a superior alternative.**[5]**

Ammar Fahim, et al (2019) A proposed Li-Fi healthcare monitoring system was developed and evaluated over different propagation links. The system removed optical background noise and ensured patient mobility up to 4m. The proposed system provided more accurate received data than previous literature.**[6]**

S. Balakrishnan, et al (2015) A proposed prototype Li-Fi system was designed to transfer data and files using VLC. The system used UART serial communication, transmitting data from one PC to another using LEDs and photodiodes. A PIC microcontroller was deployed for LED toggling and binary conversion. The system was tested and could be used wherever LED light sources were available.**[7]**

Yusuf, et al (2017) Proposed people relied on the internet for tasks, but Wi-Fi's speed was insufficient. Wi-Fi's 150 Mbps was not enough for users. To address this, German physicist Harald Haas developed Li-Fi. Li-Fi used light as a carrier signal, transmitting data wirelessly through LEDs. Li-Fi offered faster data rates, up to 10 Gbps, and was more secure since signals couldn't travel through walls.**[8]**

3. PROPOSED SYSTEM

LEDs can be switched on and off faster than the human eye can detect since the operating speed of LEDs is less than 1μs,thereby causing the light source to appear to be continuously on .This invisible on-off activity enables data transmission using binary codes.Switching on an LED is binary '1',switching it off is binary '0'.It is possible to encode data in light by varying the rate at which LEDs flicker on and off to give different strings of 1s and 0s.Modulation is so rapid that humans cannot notice it .A light sensitive device(photo detector) then receives the signal and converts it back into original

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data.

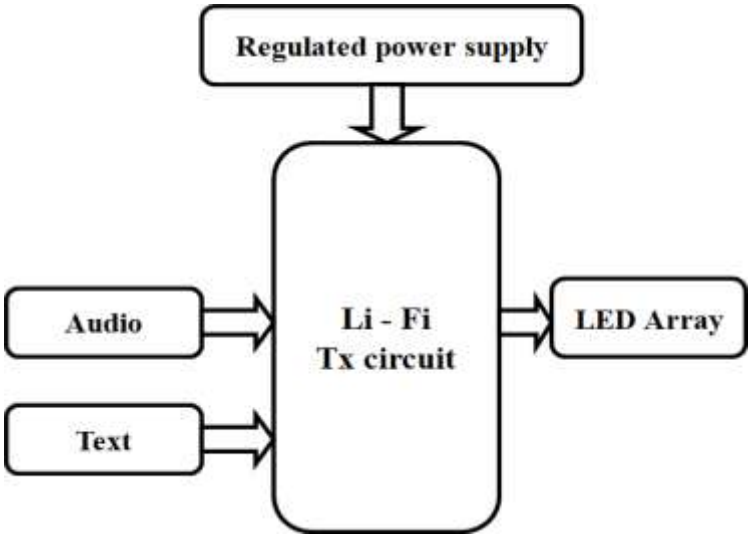

Fig. 1: Block Diagram of TX-ZONE

The system starts with a 230V AC to 12V AC adapter, then regulated to 5V DC. The stabilized voltage powers a UART and LCD module for data transmission and reception. An Arduino board processes the data, sending it to a transmitter circuit with three ICs. The transmitter converts data into electrical signals, sent to an LED array, producing a light source.

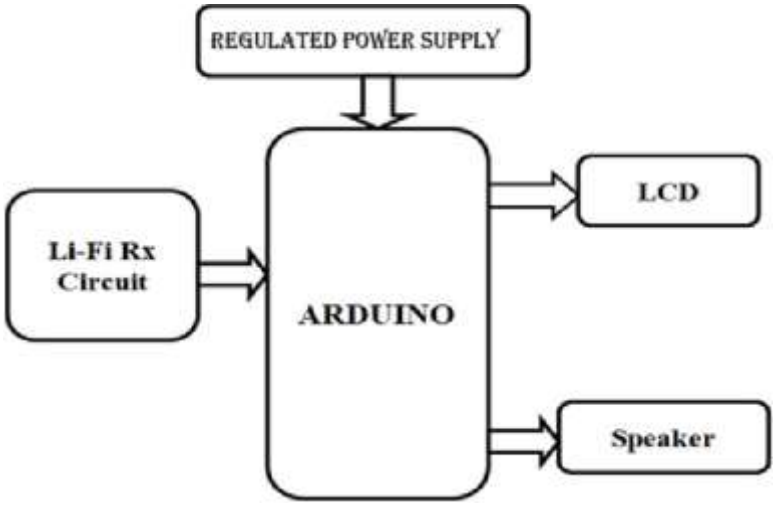

Fig. 2: Block Diagram of RX-Vehicle,

The first module in the transmitter zone is Regulated power supply. The regulated power supply converts the 230 volts AC into 12 volts of DC. The 12 volts of DC power supply gets reduced to 5 volts of DC after the deletion of unwanted noise with the help of capacitors. The 5 volts goes to all components in the system. The second module is input section. The input of the transmitter zone is LIFI Tx. This acts as both input and output. The third module is the output section. The output of the transmitter zone is LCD display. The next module is the Arduino microcontroller which contains the software programming code Embedded C. The main purpose of the microcontroller is, the data can be control by the microcontroller. And the final module is the Arduino IDE software which uploads programs into the Arduino hardware and used to communicate with them.

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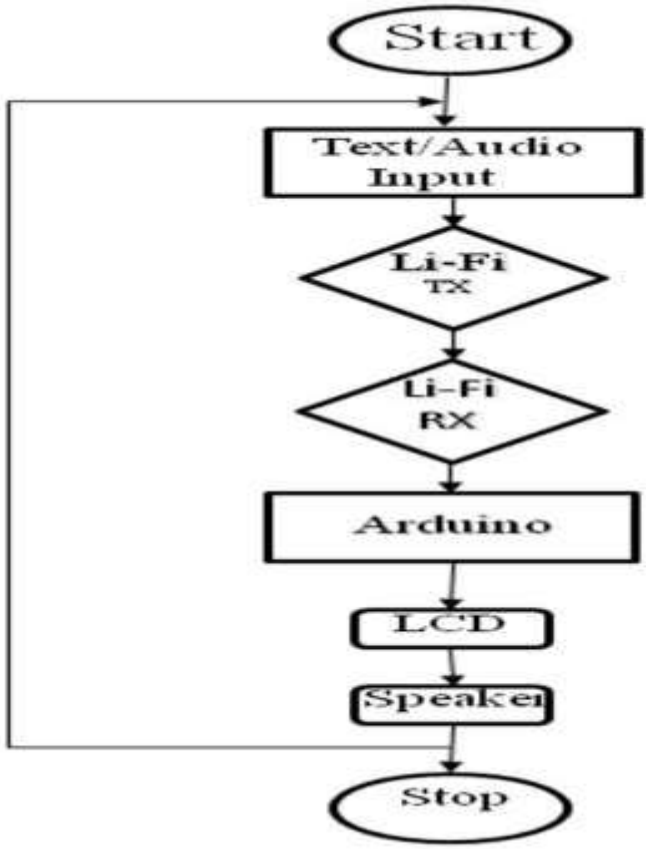

Fig. 3: Flow Diagram.

Input is an analogue audio stream from a smart phone connected to the laser light via an audio connection on the transmitter side. A solar panel is installed at the receiver end to collect the signal, which is then connected to an audio amplifier to amplify the audio data received. Finally, a speaker is attached to the amplifier's output so that the analogue audio output can be heard. We're using the audio port on the transmitter end to send audio from a smart phone, and the audio jack's output is connected to the laser light. When the laser is connected to the audio input, it will begin to glow, and the emitted light will be collected by the solar panel on the receiving end. The output of the solar panel is supplied into the audio amplifier circuit as an input, and the output of the LM386 amplifier is connected to a speaker to allow the amplified analogue audio output to be received. The audio jack is used since the audio is being delivered via a smart phone. This audio jack converts the digital input audio from the phone to analogue. Right, left, and neutral is the three output terminals on this audio jack.

ADVANTAGES

Li-Fi signals are confined to a specific area, making it more secure than traditional wireless technologies. Li-Fi can achieve high data transfer rates, making it suitable for applications that require fast data transfer. Li-Fi can achieve high data transfer rates, making it suitable for applications that require fast data transfer. Li-Fi requires lower power consumption compared to traditional wireless technologies. Li-Fi infrastructure can be less expensive to deploy and maintain compared to traditional wireless technologies. Li-Fi can support a large number of users and devices Li-Fi can provide high-quality audio transmission with low latency and low jitter.

4. RESULTS AND DISCUSSION

The system starts with a 230V AC to 12V AC adapter, then regulated to 5V DC. The stabilized voltage powers a UART and LCD module for data transmission and reception. An Arduino board processes the data, sending it to a transmitter circuit with three ICs. The transmitter converts data into electrical signals, sent to an LED array, producing a light source.

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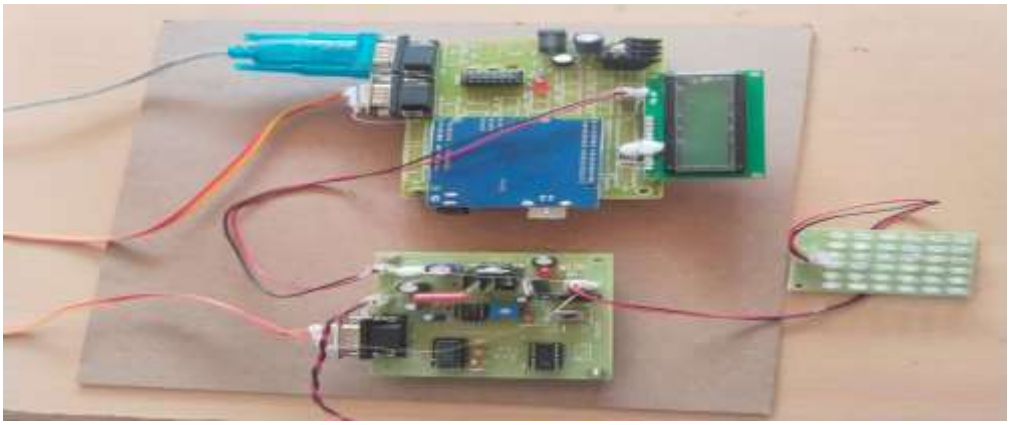

Fig. 4: Final view of the project transmitter block

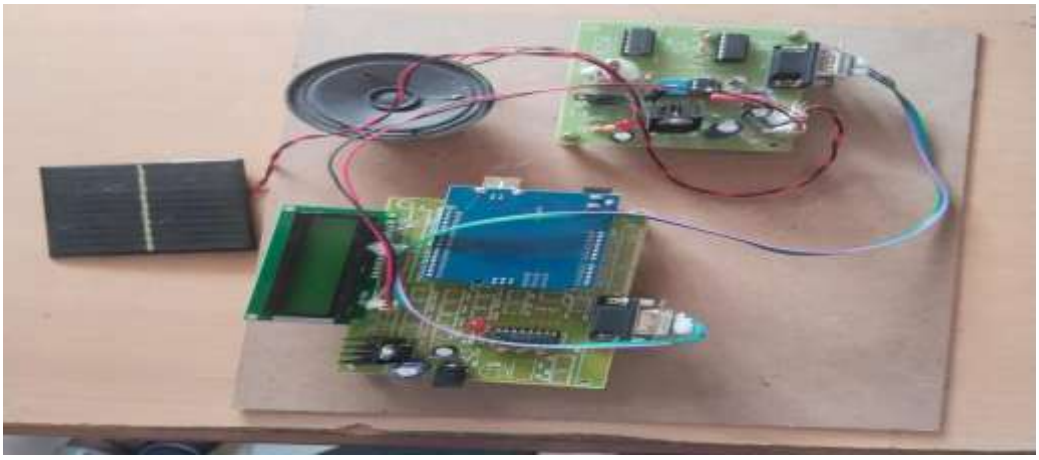

Fig. 5: Final view of the project Receiver block

In the receiver section, the LED array's light is absorbed by a solar panel, converting it back into electrical energy. The energy is transferred to a receiver circuit with a single LM386 IC, which processes the signal, separating audio and text data. Audio data is played through a speaker, while text data is displayed on an LCD screen via an Arduino board.

Fig. 6: The Title of the project

When the project is powered on, the 16x2 LCD display will automatically show the title of the project. The default message, which is predefined in the code, will be displayed in two rows, when the power supply is ON. The first row will display "Li-Fi Based" and the second row will display "Data and Audio", providing a clear and concise title for the project.

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Fig. 7: Final OUTPUT of the project

The system transmits data through a Li-Fi transmitter, converting electrical signals into light. The light is received by a solar panel, converting it back into electrical energy. The receiver circuit processes the signal, separating text and audio data. The text data is displayed on an LCD screen via an Arduino board, while the audio data is played through a speaker. The final output is presented in a way that both text and audio can be displayed or played simultaneously, with connections made as shown in the diagram.

5. CONCLUSION

The purpose of this project is to develop a potential alternative wireless communication in this the two-sided transmission system can transmit text and pictures successfully with Li-Fi technique. Baud rate possible for this circuitry is limited to certain Kbps. Beyond that limit the photo diode will not detect the incoming signals. Transmission of black and white images is not possible since we use random encoding in 3 layers. The baud rate of transmitter and receiver should be the same and the improvements can be made by adding focusing lens between the transmitter and the receiver. This document provides a thorough overview of the audio transmission system that employs LI-FI technology. The concept of LI-FI is currently generating a lot of buzz all around the world. This system is frequently used with this infrastructure and does not require significant adjustments. Within the sphere of wireless communications, visible light communication may be a rapidly emerging technology. The VLC is still in its early phases, but with the great advances in technology being made step by stage, it will soon be integrated into our daily life. LI-FI is a quick and low-cost wireless data transport technology. The rising need for higher bandwidths, quicker and safer data transfer, as well as technology that is both ecologically and demonstrably human friendly, heralds the start of a huge wireless revolution. This type of recent invention is frequently promoted as a safe and environmentally friendly technology. It can also be used in hazardous environments, such as thermal and atomic power plants, without creating electromagnetic interference. As a result, LI-FI can take the place of Wi-Fi.

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