Li-Fi is a Resource-Saving, Secure, and Efficient Communication System Solution Based on Lighting Equipment in Buildings

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Li-Fi Prototype Project: Laser Diodes Based Li-Fi Communication System Design

Introduction

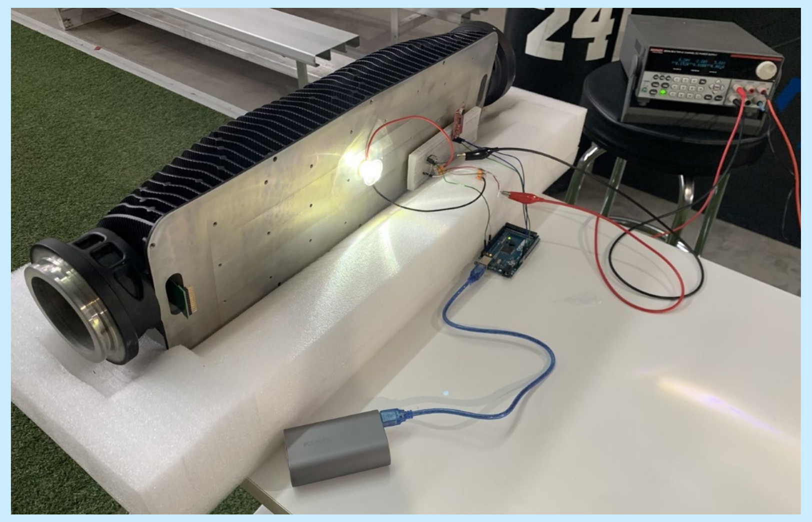
Li-Fi (Light Fidelity) is a revolutionary wireless communication technology that uses light to transmit data. Unlike traditional Wi-Fi, which uses radio waves, Li-Fi employs visible light from laser diodes to provide high-speed data transfer with enhanced security. This technology is particularly advantageous in environments where radio frequency interference is an issue or where there is a need for a secure, high-bandwidth connection. The objective of this project is to build a Li-Fi prototype capable of transmitting both voice and text messages over a distance of more than 3 meters using laser diodes. The project involves designing, simulating, and constructing the transmitter and receiver modules for a functional Li-Fi system. For real-time audio signal transmission, the estimated data rate needs to reach 5 Mbps using PWM modulation, with a focus on blue light (around 450 nm) for data transmission. This project aims to enhance data transmission rates, reliability, and security in various environments by utilizing visible light communication (VLC) technology.

Methods

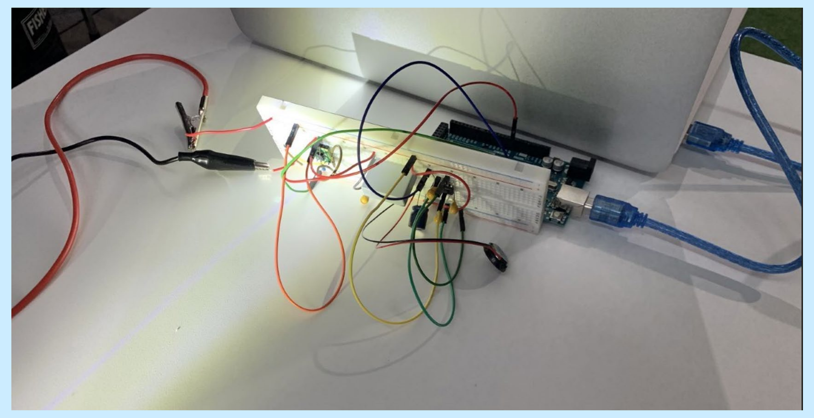
Li-Fi technology leverages light to transmit data, offering high-speed data transfer and enhanced security compared to traditional Wi-Fi. In this project, we developed a Li-Fi communication system to transmit and receive text or audio data using laser diodes and photodiodes. The transmitter circuit included an Arduino board that encoded the data into a PWM signal, modulating a laser diode via a power transistor. The laser diode was powered by a DC power supply. The receiver circuit comprised a photodiode to detect the modulated light, which was then amplified by an operational amplifier to convert the photocurrent to a readable range. The amplified signal was read by another Arduino board to decode the PWM signal back into data. We adjusted the transmission speed and bit rate to ensure reliable communication, and used capacitors for decoupling to minimize noise and ensure signal stability.

Figures

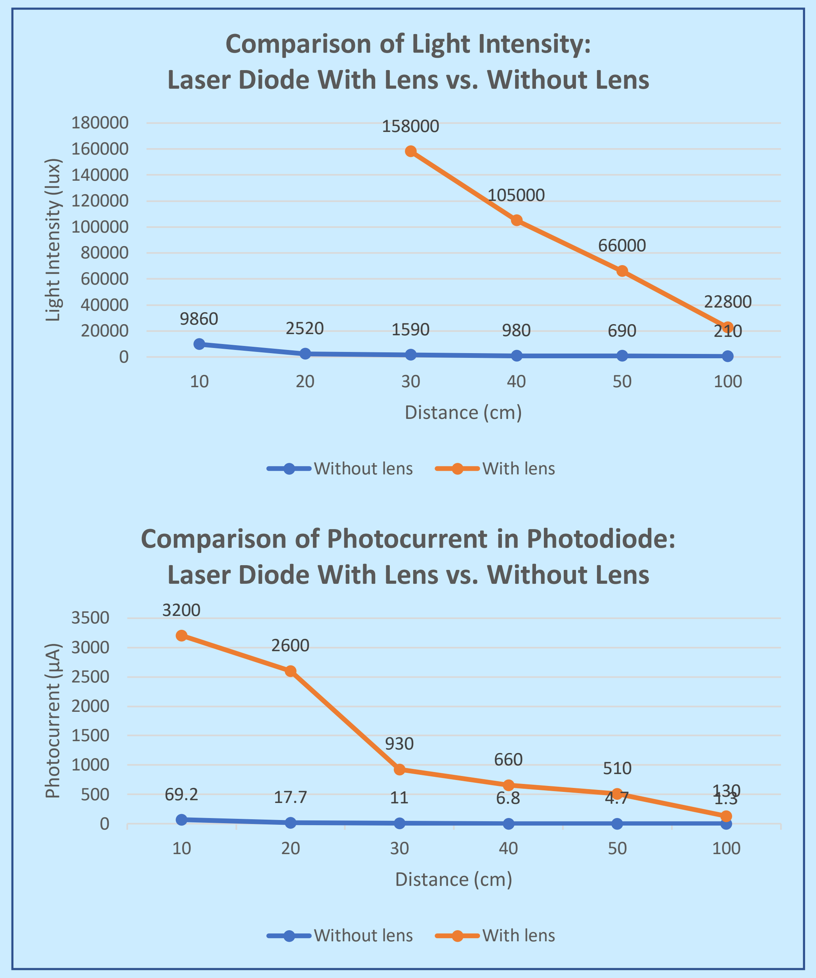
Scan Me for Project Demo!



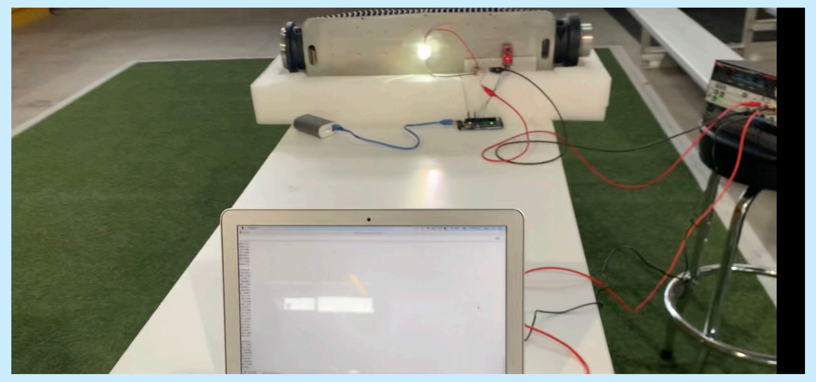
Transmitter



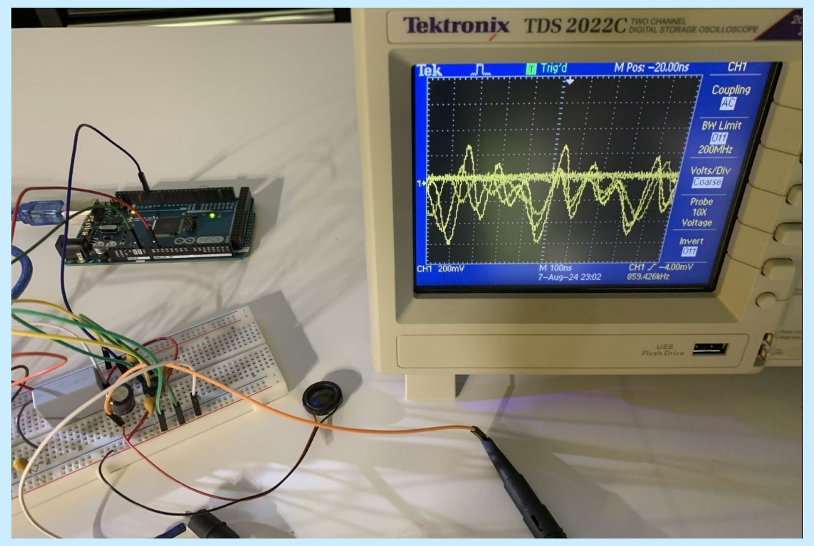
Receiver



Dark Box Test



Text Transmission



Audio Transmission

Technology embedded in the Li-Fi system utilizes a Laser Diode for precise light modulation.
The modular setup ensures efficient data transmission and reception, with performance metrics targeting high data transfer rates over a specified distance.

Results / Discussion

This prototype can communicate text and voice over Li-Fi, showcasing its versatility and demonstrating the potential of light-based communication technology. Initial modules using an Arduino board for the transmitter revealed that the board's PWM frequency limitation restricted the data transmission rate to approximately 500 bps. However, the other components of the circuit, such as the laser diode, transistor, and photodiode, can support a transmission rate of 5 Mbps for distances over 5 meters, meeting the text transmission functionality. To achieve audio transmission, we decided to use an operational amplifier to create an AM signal by adding the audio signal to a DC bias. A power transistor then controls the current flowing through the laser diode, modulated by the AM signal from the operational amplifier. This method successfully enabled audio transmission. Additionally, by replacing the Arduino board with a microcontroller that supports higher PWM frequencies, we can continue using PWM for audio transmission while significantly improving performance.
Light intensity and photocurrent measurements reveal that using a lens significantly enhances performance, with light intensity starting at 158,000 lux and photocurrent at 3,200 μA at 10 cm, compared to 9,860 lux and 69.2 μA without a lens. The lens greatly improves signal reception and data transmission at shorter distances, though the effect diminishes with distance.
The prototype can be installed in various environments, including residential, commercial, and specialized environments like sports facilities. The potential integration with the MAKO Sports Lighting System could revolutionize data communication and control in these settings, offering enhanced performance and new functionalities.

Impact on Low-Moderate Income Communities

Li-Fi technology can significantly impact low-moderate income communities by providing high-speed internet access without the need for extensive and expensive infrastructure. By leveraging existing lighting systems, Li-Fi can offer a cost-effective solution to bridge the digital divide, enabling access to educational resources, remote work opportunities, and improved communication for underserved populations.

Impact on Public Health

Li-Fi technology enhances information security, a critical aspect for public health applications such as remote surgery and telemedicine. With light-based communication being more secure and less susceptible to hacking than traditional radio frequency-based communication, Li-Fi ensures the integrity and confidentiality of sensitive health data. This security is paramount in scenarios like remote surgery, where real-time data transmission without interference or breaches is crucial for patient safety and successful outcomes.

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