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V2V Communication Using LiFi

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Abstract

The global status report on road safety launched by the World Health Organization (WHO) highlights that the number of annual road traffic deaths has reached 1.35 million. In the USA over 37,000 people die in road crashes each year and an additional 2.35 are injured or disabled. The direct impact of road accidents is loss of life as well as damage to vehicles and property. Accidents might happen due to careless driving, negligence of the driver, over speeding etc. According to research, efficient communication between vehicles and warning systems put in place can reduce or prevent 80% of these crashes. Based on these reasons V2V solutions were expected to provide efficient vehicle communication mechanisms enhancing road safety. V2V has the goal to facilitate efficient and reliable communication without predominantly relying on a global system for mobile communication (GSM) network. The main feature of V2V is that it does not rely on third party networks like cellular networks to communicate. V2V can be used to improve traffic conditions, reduce road accidents and increase the safety of passengers. This paper discusses solutions and adaptations to make LiFi viable in such scenarios, potentially enhancing communication, connectivity, and safety within vehicles. In the proposed project we implement features like sudden brake alert, collision alarms and blind spot warnings to prevent accidents due to vehicles coming in close proximity to another due to carelessness or distraction.

Keywords: Arduino, LIFI, Piezoelectric, ESD, V2V, GSM

INTRODUCTION

In the fleetingly evolving geography of ultramodern technology, the vital part of data transmission harsen to elevation, taking nonstop invention in ways, methodologies, and protocols. As the sheer volume of data expands daily, the critical need for a brisk and more robust transmission system becomes decreasingly apparent. This necessity, still, isn't limited to speed but also encompasses critical considerations of security and trust ability in data transmission. An arising trend addressing these conditions is Light Fidelity (LiFi) technology, exercising optic signals for effective data transmission. This design explores the operation of LiFi in vehicular communication, using its simplicity and appreciation, along with the essential advantages of short-range communication and Eco-friendliness when compared with traditional radiofrequency swells [1–5]. At the core of LiFi-grounded communication lies the double commerce of the ON and OFF countries of LED lights, representing the abecedarian 1's and 0's of double integers. The design's specific emphasis on vehicular communication arises from LiFi's proficiency in short-range scripts, making it particularly suitable for vehicle-to-vehicle relations. Noteworthy is its diminished environmental impact, offering a lower mischievous volition compared to radiofrequency swells without causing discomfort to the girding terrain. The abstract frame of this design settlers a one-way communication scheme, employing straight forward bedded units to seamlessly transmit and admit data. The primary end revolves around mollifying accidents, a critical concern aggravated by contemporary life and population swell, egging

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an increased reliance on vehicles and latterly raising road business. In this acclimatized approach, communication is rigorously limited to the exchange between two vehicles, without the addition of extraneous bumps to the communication topology. In the ever-evolving realm of technology, where data transmission stands as a critical pillar, the pursuit of faster and further flexible ways for vehicle-to-vehicle(V2V) communication

As the volume of data continues to grow, the imperative of icing secure and dependable transmission increases exponentially. Amidst these demands, LiFi technology emerges as a transformative force, employing photonic signals to review the silhouettes of data communication. This paper navigates the uncharted home of LiFi integration into vehicular communication systems, using the double countries of LED lights to establish a one-way communication scheme. The simplicity of LiFi's operation, coupled with its proficiency in short-range communication, positions it as a promising result for vehicle-to-vehicle relations, particularly addressing the raising challenges of accidents in the period of increased vehicle operation [6]. As we claw into the background, methodology, and issues of this innovative approach, the paper aims not only to showcase the present efficacity but also to illuminate the path for unborn developments in reshaping the geography of vehicular communication. LiFi technology, innovated on the transmission of data through photonic signals, represents a contemporary stride in the realm of communication. The simplicity and ease of appreciation, coupled with colorful proposed coding and decoding algorithms, position LiFi as a promising avenue for data transmission. Operating on the double principle of the ON and OFF countries of LED lights, emblematizing 1's and 0's, LiFi presents a straightforward medium with implicit operations in different disciplines [7-8].

Literature Survey

1. Rishitha Haridasu et al. [9] propose a Bluetooth-based inter-vehicular communication model to enhance passenger safety by enabling vehicles to communicate directly. This approach aims to prevent collisions, reduce fatalities, and mitigate traffic congestion by empowering vehicles to take proactive control over critical situations.
2. Prakash G Surya et al. [10] introduce a paper detailing the design and prototype of a device for vehicle-to-vehicle (V2V) communication using Light Fidelity (LiFi) technology, specifically Visible Light Communication (VLC), applied for vehicle data transmission.
3. A. Q. Nguyen et al. [11] have created and executed a small WiFi-enabled prototype for two-way and three-way communication in low-speed automobiles. This system supports intelligent transportation systems (ITS) by facilitating the interchange of vital data between cars and infrastructure, including GPS positions, velocities, traffic conditions, and environmental status.
4. Shu-Zhi Liu [12] has developed a vehicle anti-collision warning system comprising a driving environment recognition subsystem and a safety state discrimination subsystem. This system aims to enhance the active safety performance of vehicles.
5. For lateral and longitudinal vehicle-following control in connected autonomous vehicles (CAVs), Jizheng Liu et al. [13]. presented event-triggered model predictive control, or ETMPC, in combination with a multi-target controller. Their simulation results demonstrate that, in comparison to traditional Model Predictive Controllers, ETMPC reduces computing workload by 61.5% while preserving tracking accuracy. Because of its adaptability, this control technique can also be used in vehicle platooning situations.

Design and Implementation

The focus of this design on enforcing LiFi in vehicular communication stems from its essential felicity for short-range relations. With an emphasis on vehicle-to-vehicle communication, the design addresses the pressing issue of accidents. The escalation of road business due to increased cultures and population magnifies the liability of accidents. By establishing a one-way communication scheme through simple bedded units, this design trials to alleviate accidents and enhance road safety. An integral aspect of LiFi's appeal lies in its reduced environmental impact compared to traditional radiofrequency swells. As society substantiations a swell in particular vehicle operation, the design's approach isn't only innovative but also environmentally conscious, icing that the technology stationed doesn't contribute to discomfort in the girding terrain. Block Diagram of Lifi Transmitter is shown in Figure 1.

Block Diagram of the Transmitter

Sensors such as the piezoelectric sensor for collision, HC-SR05 ultrasonic sensor for proximity, and the emergency button provide inputs to the Arduino Nano. Arduino Nano processes the sensor data and determines the status of the vehicle, whether it's a collision, proximity alert, brake alert, or emergency.

The processed data is modulated onto the LiFi signals. This involves encoding the information onto the light signals for transmission. LiFi transmitters emit modulated light signals containing the vehicle status information. These signals propagate through the air and are intended for reception by LiFi receivers on nearby vehicles. If the emergency button is pressed, an emergency signal is generated, modulated onto LiFi, and transmitted immediately to alert surrounding vehicles. Block Diagram of Lifi Receiver is shown in Figure 2.

Block Diagram of the Receiver

LiFi receivers on nearby vehicles capture the modulated light signals from the transmitting vehicle. LiFi technology allows for data reception through light signals, providing a means of vehicle-to-vehicle communication. The received LiFi signals are demodulated to extract the encoded information. This process involves decoding the light signals back into meaningful data. The Arduino Nano on the receiving vehicle processes the received data. Depending on the content of the received signals (collision alert, proximity alert, brake alert, or emergency signal), appropriate actions are taken. The system may display alerts on a dashboard, trigger alarms, or take automated actions such as adjusting the vehicle's speed or notifying the driver. Circuit diagram of Lifi receiver is shown in Figure 3.

Circuit Diagram of the Lifi Transmitter

Light Dependent Resistor (LDR) Module for detecting signals from the transmitter unit. The transmitter unit utilizes an ultrasonic sensor to detect nearby vehicles in the blind spot. When a vehicle approaches the blind spot, the buzzer activates to alert the driver. A piezoelectric sensor on the transmitter unit detects sudden impacts or collisions. Upon reaching a predefined threshold, an LED on the transmitter blinks for a specified duration. The blinking signal is transmitted via LiFi to the receiver unit, indicating an accident ahead. A push button is integrated into the transmitter unit for emergency situations. When activated, an LED on the transmitter blinks for a designated duration. The blinking signal is transmitted to the receiver unit, signaling an emergency scenario. A brake switch is installed on the transmitter unit to detect brake application. Upon pressing the brake switch, an LED on the transmitter blinks for a set duration. The blinking signal is transmitted to the receiver unit, indicating that brakes have been applied. Circuit diagram of Lifi receiver is shown in Figure 4.

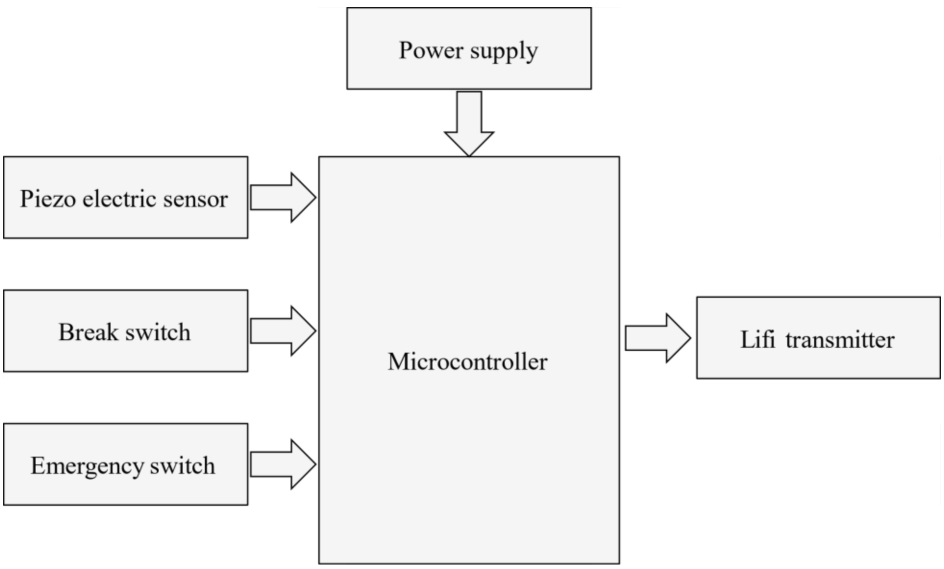

Figure 1. Block Diagram of Lifi Transmitter.

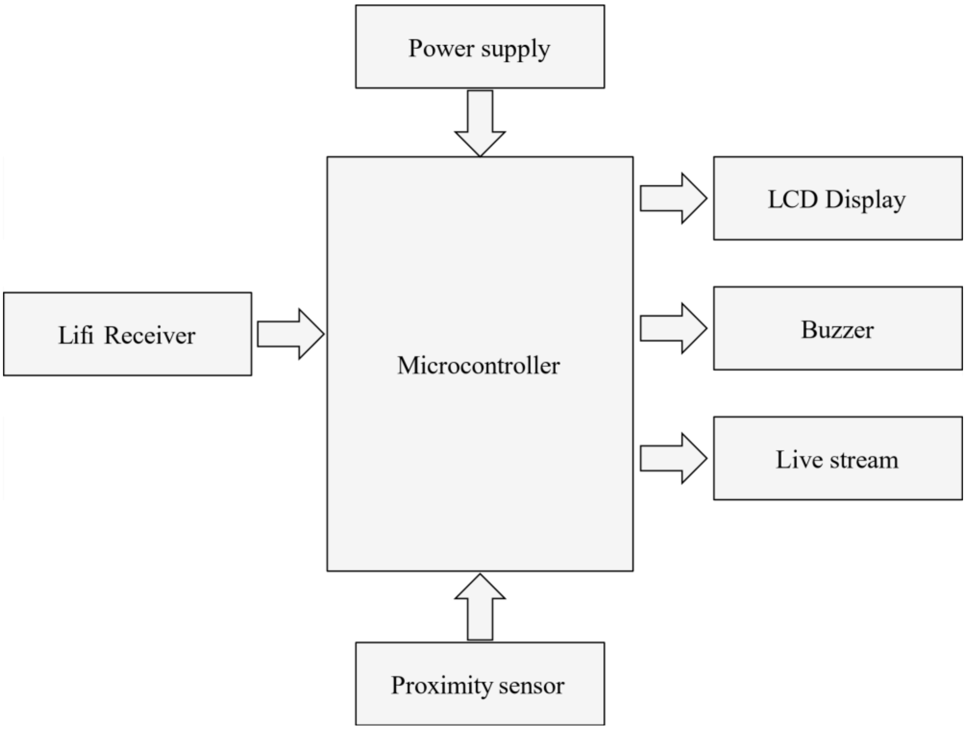

Figure 2. Block Diagram of Lifi Receiver.

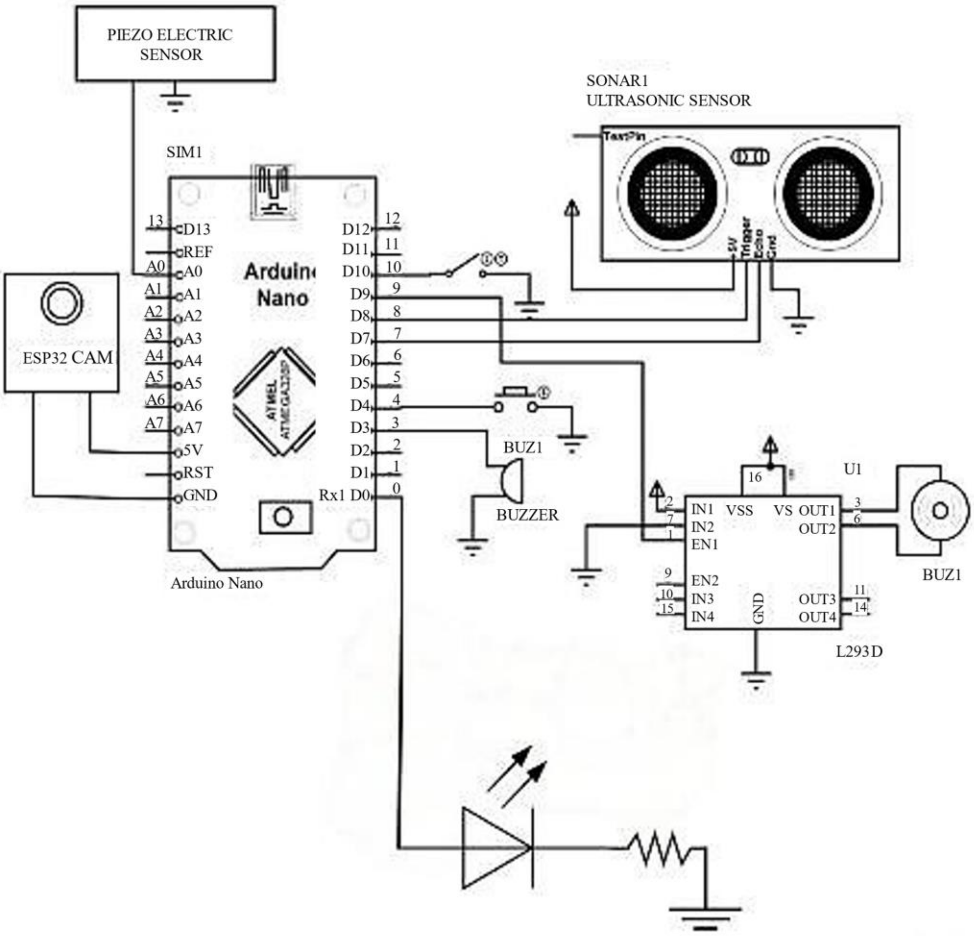

Figure 3. Circuit diagram of Transmitter.

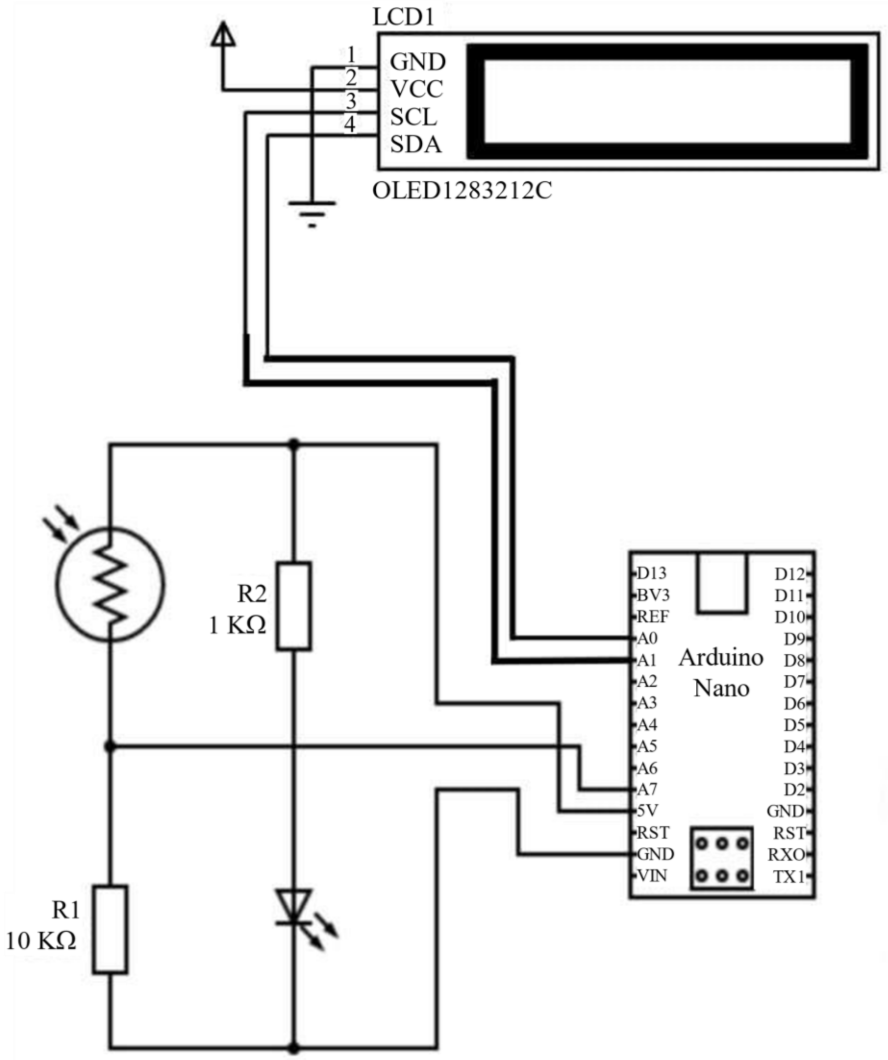

Figure 4. Circuit diagram of Receiver.

Circuit Diagram of the Lifi receiver

The receiver unit consists of an LDR module to detect signals transmitted by the transmitter unit via LiFi. Upon receiving signals, the LDR module processes the data and triggers corresponding alerts or messages on the receiver side.

Challenges and Future Directions

LiFi V2V communication has potential, but it also confronts several obstacles:

Mobility Management: Maintaining seamless transitions between LiFi cells when cars are traveling at high speeds is still a major difficulty. To reduce connectivity disruptions, researchers are investigating adaptive transmission strategies and predictive handover algorithms.

Regulation and Standardization: To create compatible LiFi protocols and legal frameworks that guarantee dependable and secure vehicle-to-vehicle communication, standardization activities are crucial. To expedite commercial deployment, cooperative efforts between regulatory agencies and industry players are essential.

Security and privacy: It's critical to address cybersecurity risks and safeguard private vehicle data. In order to protect LiFi-enabled V2V communications from malicious assaults, research is concentrated on putting encryption algorithms, authentication techniques, and intrusion detection systems into practice.

Case Studies and Pilot Projects

Global campaigns and experimental programs have shown LiFi's viability and usefulness in real-world driving situations. Experiments conducted in urban and highway settings have confirmed LiFi's capacity to enhance communication dependability, minimize latency, and facilitate advanced driver assistance systems (ADAS) and autonomous driving features.

Despite its Potential, LiFi V2V Communication Faces Several Challenges

Mobility Management: One of the biggest challenges still facing LiFi cell operators is ensuring seamless handovers while cars are traveling at high speeds. Adaptive transmission strategies and predictive handover algorithms are being investigated by researchers to reduce connectivity disruptions.

The establishment of interoperable LiFi protocols and regulatory frameworks that guarantee dependable and secure connection between vehicles are contingent upon standardization initiatives. The acceleration of commercial deployment necessitates cooperative efforts between regulatory bodies and industry stakeholders.

Safety and confidentiality: Preventing cyberattacks and safeguarding private automobile information are critical. Research focuses on putting intrusion detection systems, authentication procedures, and encryption algorithms into practice to protect LiFi-enabled V2V communications against malevolent attacks.

RESULT AND DISCUSSION

The V2V communication system utilizing LiFi technology has been successfully implemented with the following functionalities. The ultrasonic sensor accurately detects vehicles in the blind spot, triggering the buzzer to alert the driver on the transmitter side. The piezoelectric sensor effectively detects sudden impacts or collisions, activating the LED on the transmitter side to signal an accident ahead. The push button enables drivers to communicate emergency situations, with the LED blinking on the transmitter side to notify nearby vehicles. The Brake Alert switch detects brake application, causing the LED on the transmitter side to blink and alert other vehicles about the brake being applied. The Lifi receiver side and Lifi transmitter side view of the project is shown in Figures 5–6.

Figure 5. Lifi Receiver side.

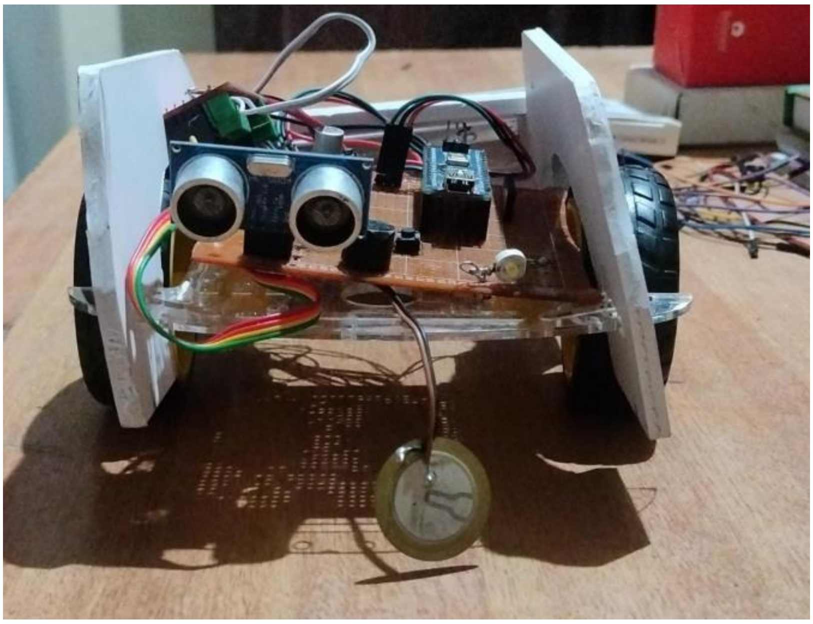

Figure 6. Lifi Transmitter side.

CONCLUSION

This V2V communication system with LiFi technology enhances vehicle safety by providing real-time alerts for blind spots, accidents, emergencies, and brake applications. By integrating various sensors and components, the system facilitates effective communication between vehicles, thereby reducing the risk of accidents and improving overall road safety. This technology's capacity for high-speed, secure data transmission via light signals can facilitate instantaneous communication between vehicles, thus reducing accident risks and enabling more effective traffic management. However, widespread implementation may encounter obstacles such as standardization, infrastructure deployment, and the mitigation of potential interference. Continuous research and development efforts are imperative to address these challenges and fully realize the advantages of LiFi in V2V communication.

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