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Vehicle to Vehicle Communication using Li-Fi

V. Prathyusha
M.Tech Scholar, Dept of ECE,
Audisankara College of Engineering and Technology, Gudur, Andhra Pradesh,

Dr. N. V. Ramanaiah,
Associate Professor Dept of ECE,
Audisankara College of Engineering and Technology, Gudur, Andhra Pradesh.

N. Ramadevi
Assistant Professor, Dept of ECE,
Audisankara College of Engineering and Technology, Gudur, Andhra Pradesh

Abstract - Vehicle-to-Vehicle (V2V) communication plays a vital role in modern intelligent transportation systems by enabling vehicles to exchange real-time safety information. Traditional wireless technologies rely on radio frequency spectrum, which is increasingly congested and vulnerable to interference. Light Fidelity (Li-Fi) is an emerging communication technology that uses visible light for high-speed data transmission. This paper presents a Li-Fi based V2V communication system designed to transmit safety alerts between vehicles using LED or laser light sources. The proposed prototype consists of a transmitter and receiver module built around Arduino microcontrollers, light sensors, and LCD display units. The transmitter encodes warning messages and sends them through modulated light signals, while the receiver detects and decodes the signals using a light dependent resistor (LDR). Experimental results demonstrate reliable short-range communication with low latency and high security due to line-of-sight transmission. The proposed approach highlights the feasibility of Li-Fi for future intelligent transportation systems and road safety applications.

Index Terms - Li-Fi, Vehicle-to-Vehicle Communication, Visible Light Communication, Intelligent Transportation Systems, LED, Arduino Uno, Laser Communication, LDR Sensor, Embedded Systems, Internet of Things, Real-time Communication, Collision Avoidance, Smart Vehicles, Wireless Communication

I. INTRODUCTION

The increasing number of vehicles on roads has led to a rise in accidents and traffic congestion, creating a need for efficient communication between vehicles. Conventional wireless systems based on radio frequency face limitations such as interference, limited bandwidth, and security concerns. Light Fidelity (Li-Fi) is an emerging technology that uses visible light for high-speed data transmission by employing light emitting diodes and lasers, enabling fast, secure, and interference-free communication. In vehicle-to-vehicle communication, Li-Fi can utilize existing vehicle lighting systems such as headlights and taillights to exchange information in real time. This approach reduces the need for additional infrastructure while improving communication reliability. Furthermore, Li-Fi offers advantages such as low latency, high data rates, and enhanced security since light signals cannot penetrate opaque objects. The proposed system uses embedded components like microcontrollers, sensors, and optical devices to establish communication between vehicles. By enabling instant data sharing related to road conditions and hazards, the system aims to reduce accidents, improve traffic efficiency, and support the development of intelligent transportation

II. LITERATURE SURVEY

Recent studies have explored Light Fidelity as an effective solution for vehicle communication due to its high speed, low latency, and resistance to electromagnetic interference. Researchers have demonstrated that visible light communication can enable reliable data exchange between vehicles using light emitting diodes and photodetectors. Compared to traditional radio frequency systems, this approach provides better security and reduces signal congestion. Several works have also proposed hybrid communication models that combine light-based and radio-based systems to maintain connectivity in challenging conditions. Applications such as collision avoidance, traffic monitoring, and autonomous driving have been widely discussed, showing the potential of this technology in improving road safety. However, limitations such as dependence online-of-sight and sensitivity to ambient ligh remain key challenges, leading to further research on improving system performance and reliability.

III. METHODOLOGY

3.1. EXISTING SYSTEM:

The existing vehicle communication systems are mainly based on Radio Frequency (RF) technologies such as ZigBee, Wi-Fi, and Bluetooth. In these systems, vehicles communicate with each other using wireless transceiver modules connected to microcontrollers. Various sensors, including fire sensors, vibration sensors, and ultrasonic sensors, are used to detect hazardous conditions such as accidents, obstacles, or environmental threats. Once a critical condition is detected, the sensor data is processed by the microcontroller and transmitted to nearby vehicles through RF transmitters.

However, despite their widespread use, these RF-based systems have several limitations. They often suffer from low data transfer rates, limited bandwidth availability, and high signal interference, especially in urban environments with dense traffic. The performance of RF communication also degrades due to obstacles, electromagnetic interference, and network congestion.

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Furthermore, RF signals can be less secure and more prone to unauthorized access. These challenges make RF-based systems less reliable for real-time, safety-critical vehicular communication applications where speed, accuracy, and reliability are essential.

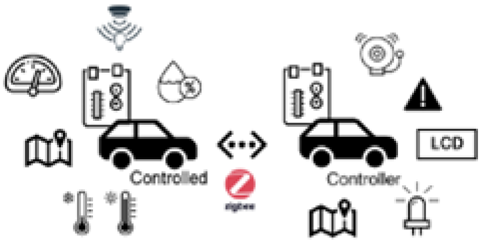


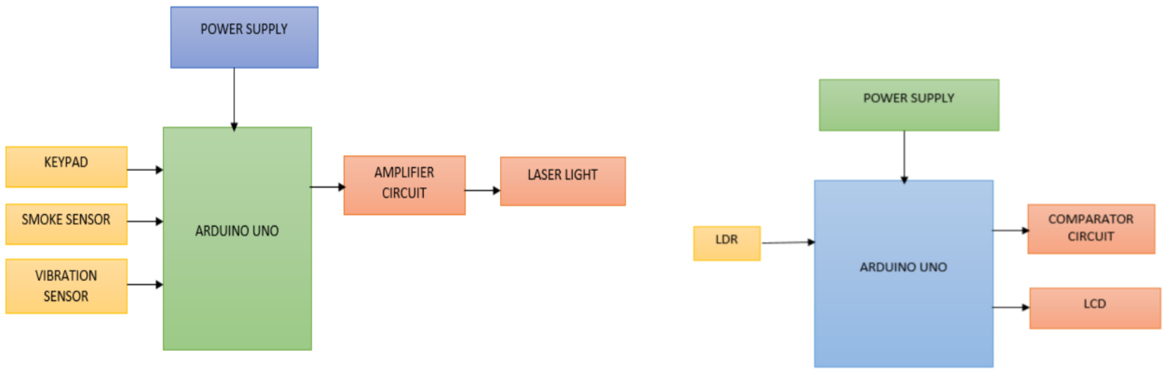
Fig 4.1: Existing System

DISADVANTAGES:
A disadvantage of ZigBee is its relatively low data transfer rate compared to other wireless technologies like Wi-Fi or Bluetooth. Additionally, its range can be limited, especially in environments with many physical obstructions. This makes it less suitable for high-bandwidth applications or long-distance communication without additional network infrastructure.

3.2. PROPOSED SYSTEM:
The proposed system is based on Light Fidelity technology for vehicle-to-vehicle communication using optical wireless transmission. It consists of a transmitter with a microcontroller, sensors such as smoke and vibration sensors, and a laser light source to transmit data when abnormal conditions like fire or accidents are detected. On the receiver side, a light dependent resistor detects the signals, which are processed and decoded by the microcontroller and displayed on a liquid crystal display. This system is cost-effective, provides high-speed and secure communication, and helps in reducing accidents and improving road safety.

Advantages:
1. High-speed data transmission
2. Low latency communication
3. Enhanced security (light cannot penetrate walls)
4. No electromagnetic interference
5. Cost-effective implementation using existing vehicle lights

3.3.BLOCK DIAGRAM:



Transmitter Part   Receiver Part

3.4 HARDWARE REQUIREMENTS:

- ARDUINO UNO
- LDR
- LCD
- POWERSUPPLY
- LM358 COMPARATOR CIRCUIT
- BC547 AMPLIFIER CIRCUIT
- LASER DIODE

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3.5 SOFTWARE REQUIREMENTS:

- ARDUINO IDE
- C-LANGUAGE

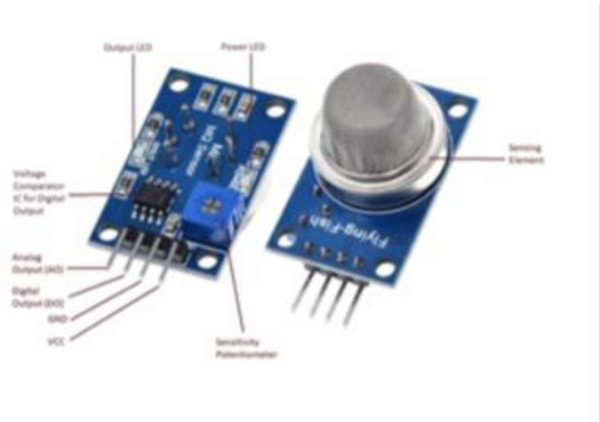
1: ARDUINO UNO:

The Arduino Uno acts as the central controller of the system. It processes input signals from sensors and controls the transmission and reception of data. Based on the ATmega328 microcontroller, it converts sensor data into binary form and controls the LED/laser for Li-Fi transmission. At the receiver's side, it decodes incoming signals and sends output to the display unit.

Arduino Uno Board

2: SENSORS (SMOKE & VIBRATION):

Sensors are used to detect hazardous conditions such as fire, gas leakage, or accidents. The smoke sensor detects harmful gases or fire presence, while the vibration sensor detects collisions or sudden movements. These sensors provide input signals to the Arduino, enabling real-time monitoring and alert generation.



Fig(b): Sensors (Smoke & Vibration)

3: Li-Fi TRANSMITTER (LED/LASER):

The Li-Fi transmitter consists of an LED or laser diode used to send data through visible light. The Arduino rapidly switches the light ON and OFF to represent binary data (1s and 0s). This high-speed modulation allows wireless communication between vehicles without using radio frequencies.

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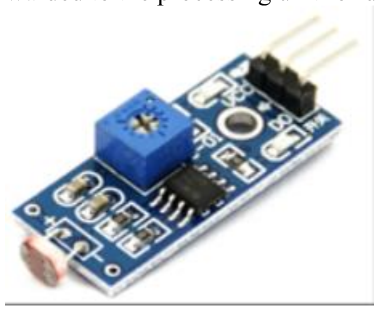
Fig(c): Li-Fi Transmitter

4: Li-Fi RECEIVER (LDR/Photodiode):

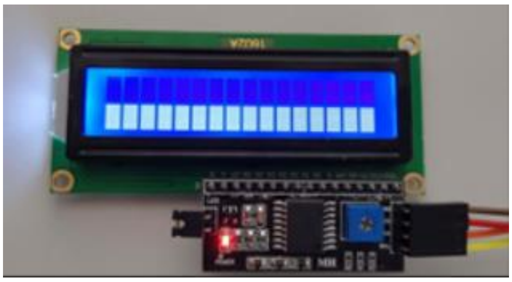
The receiver module uses an LDR or photodiode to detect incoming light signals. The intensity variations in light are converted into electrical signals. These signals are then forwarded to the processing unit for decoding.



Fig(d): Li-Fi Receiver

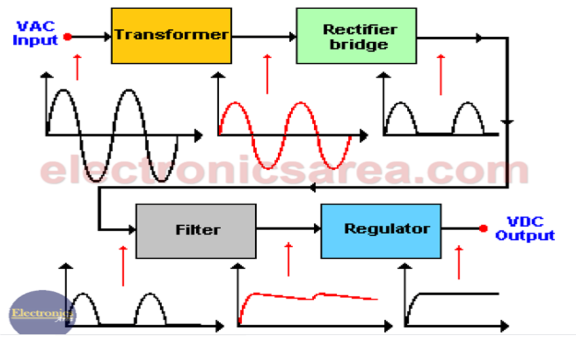
5: LCD Display:

The LCD display (16x2) is used to show the received information to the driver. It displays messages such as accident alerts, fire warnings, or other vehicle data. The Arduino sends decoded data to the LCD, providing real-time visual output.



Fig(e): LCD Display

6: Power Supply – Provides necessary electrical power to all components in the system.



7: Software (Arduino IDE):

The Arduino Integrated Development Environment (IDE) is the primary software tool used for programming and controlling the Arduino Uno microcontroller in the proposed system. It provides a user-friendly interface for writing, compiling, and uploading

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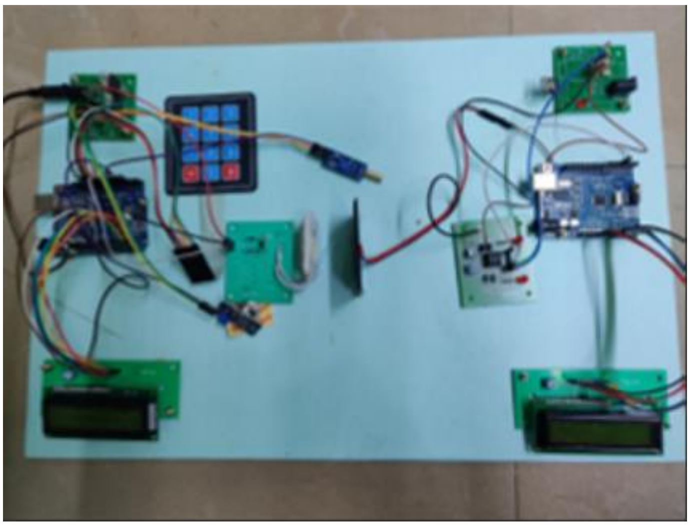
code to the hardware. The programming is done using C/C++ language, which allows efficient control of input and output operations.

Arduino IDE: Uploading Blink

The software also manages the encoding and decoding of data during communication between the transmitter and receiver modules. It ensures proper synchronization of signal transmission using LED or laser sources and accurate reception using LDR or photodiode sensors. Additionally, the Arduino IDE offers debugging tools such as error messages and a serial monitor, which helps in testing and analyzing system performance. These features make it an effective and reliable platform for implementing embedded system applications.

3.6 PROJECTED IMAGE

The experimental prototype successfully demonstrated the feasibility of Li-Fi based vehicle-to-vehicle communication under controlled conditions. During testing, the system achieved reliable and stable data transmission over approximately 1–2 meters in indoor environments with clear line-of-sight between the transmitter and receiver units. The transmitted messages, including hazard alerts and sensor data, were accurately received and displayed on the LCD with minimal delay, indicating efficient real-time communication capability. The system showed consistent performance with low error rates, even when subjected to minor environmental disturbances.



Hardware Implementation

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IV. CONCLUSIONS

This study presented the design and implementation of a Li-Fi based vehicle-to-vehicle communication system using Arduino microcontrollers. The developed prototype demonstrates that visible light communication can effectively transmit safety messages between vehicles. Although the system requires line-of-sight communication and may be affected by ambient lighting conditions, it offers significant advantages including high security, low interference, and efficient bandwidth utilization. Future work can focus on increasing communication range, improving modulation techniques, and integrating Li-Fi with existing vehicular communication technologies.

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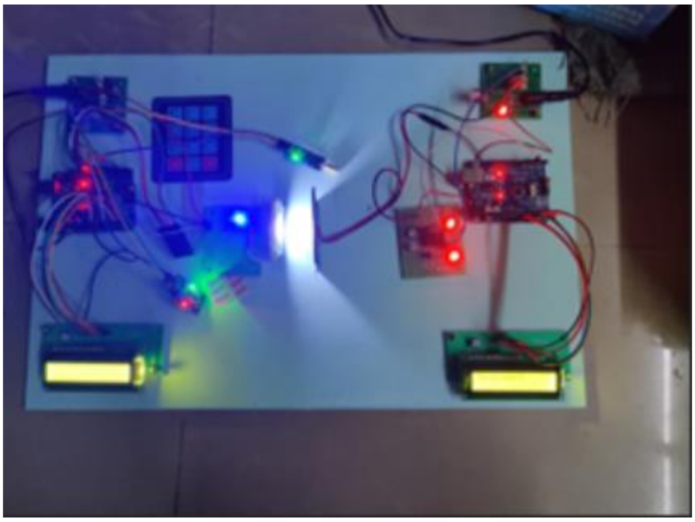
VI. RESULTS



Data transferring from one vehicle to another vehicle

The proposed Light Fidelity based vehicle-to-vehicle communication system was successfully designed and implemented. The system effectively transmitted data between the transmitter and receiver using laser light, demonstrating reliable communication. Sensor inputs such as vibration and smoke were accurately detected and converted into optical signals, which were then received and decoded correctly at the receiver's end. The output was displayed on the liquid crystal display without significant delay, confirming real-time data transmission.

The system maintained stable performance over short distances and showed consistent signal detection under normal lighting conditions. It was observed that communication was fast and free from electromagnetic interference, unlike traditional radio frequency systems. The use of simple hardware components made the system cost-effective and easy to implement.

Furthermore, the system demonstrated good accuracy in detecting hazard conditions and transmitting alerts instantly to nearby vehicles. The communication process was reliable if a proper line-of-sight was maintained between the transmitter and receiver. Although performance may reduce in the presence of obstacles or strong ambient light, the system still proved to be efficient under controlled conditions. Overall, the results confirm that the proposed system is a practical and effective solution for improving road safety, reducing accidents, and supporting advanced vehicular communication systems.