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VEHICLE TO VEHICLE COMMUNICATION USING LI-FI TECHNOLOGY

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***Abstract*—** The road traffic is getting really terrible day by day. That is why we require better communication systems. These systems should be able to share information and develop communication between vehicles in time to make the roads safer and prevent accidents. This paper is about a Vehicle-to-Vehicle communication system that uses Li-Fi technology. Li-Fi is a way of sending data through light using high-intensity LEDs instead of using radio frequency signals.
This system is very prominent and accurate because it is safer, fast and does not get interrupted. It lets vehicles share information like how far away they are and if there is a fire, distance or emergency. The system uses Arduino Uno microcontrollers, ultrasonic sensors, fire sensors, and accident sensors in both the vehicle that sends the signal and the one that receives it. It also has a voice alert module.
When we tested this system ,it worked well. It sent emergency alerts in time using Li-Fi and it detected every hazard correctly. This module is a good choice because it is trust worthy does not cost too much and can be used by a lot of people. It is an alternative, to the traditional radio frequency based intelligent transport system.
***Keywords*—** Light Fidelity (Li-Fi), Visible Light Communication (VLC), light emitting diodes (LEDs)

I. INTRODUCTION

The number of cars on the road are increasing sharply that leads to the increase in road accidents. Latest traffic systems are trying to use communication between vehicles in time to overcome these issues.Vehicle-to-vehicle communication usually uses radio waves like Dedicated Short-Range Communication, ZigBee, Bluetooth and Wi-Fi.These systems have some disadvantages which led to the introducing some new technologies[7].
They can be disrupted by radio signals don't have enough bandwidth can be jammed and have security issues, especially in urban areas.Li-Fi or Light Fidelity, is a way to send data using light. This was first introduced by Haas in 2011. It uses the light that can be visible as a medium to send data forth really fast. Li-Fi is very unique technology from systems that use radio waves. It changes the brightness of lights really quickly to send data. The human eye cannot see these changes.Li-Fi is more secure than systems because it uses light. Light cannot go through things that're not transparent. This makes Li-Fi really good for things, like cars talking to each other. [1],[2],[6]
This project proposes an efficient multi-mode alert system for vehicles using Li-Fi technology. The system enables two vehicles to communicate hazard information — including accidents, fire,emergency situation and distance.The ultrasonic sensors are used as a distance measurement device for this system, a low power, high-performance microcontroller is used to control the overall operations systematically. Accident sensor is used to detect the accidents, fire sensor is used to detect the fire and emergency button is used to send the voice alert in panic situations. Li-Fi technology is used to send the data using light waves and intake the data using solar wirelessly.It helps better communication system between two vehicles by calculating distance and vehicle status like accident, gas, fire, emergency of other vehicles will be display on LCD and also voice alert will be coming from speaker. The main controlling device of the project is Arduino UNO, to achieve this task microcontroller loaded program written in embedded C++ language.

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II.RECENT WORKS:OVERVIEW

Vehicle-to-vehicle communication using Li-Fi technology which uses light from car LEDs to send data like distance alert, accident alert,emergency alert and fire alert.This method has many advantages like data transfer, fast response and better security compared to traditional radio frequency systems.

Haas, Yin, and Chen introduced the concept of Li-Fi in 2016, stating that it as a paradigm using visible light communication for high-speed wireless data transmission via LED modulation. Their work established the theoretical basis upon which subsequent vehicular applications have been built.[1]

At the application level, Singh et al. (2017) demonstrated the use of Li-Fi for a wireless toll collection system, confirming the technology's viability in real outdoor vehicular environments.[5]

Early studies from 2019 to 2020 checked if LiFi communication could work.They made systems using LEDs and light sensors to show basic data transmission.These studies laid the groundwork for LiFi communication. Explored basic system designs.Recent studies from 2024 to 2025 focused on safety systems.They enabled alerts for braking, obstacles and lane changes to prevent accidents.[3],[4]

III.METHODOLOGY

This module mainly uses the lifi technology.It can transmit data at high speed and more accurately. It uses hardware components like arduino, buck converter, VCB tracker, 12v batteries, LEDS and some sensors like ultra sonic, fire, panic button and accident sensors in the transmitter and the receiver side the components included are speaker, APR33A3 voice module, arduino, LCD display, photo diode, solar panel and 12v battery. This system helps in detecting the threat in advance and alert the driver so that it can prevent the accidents .

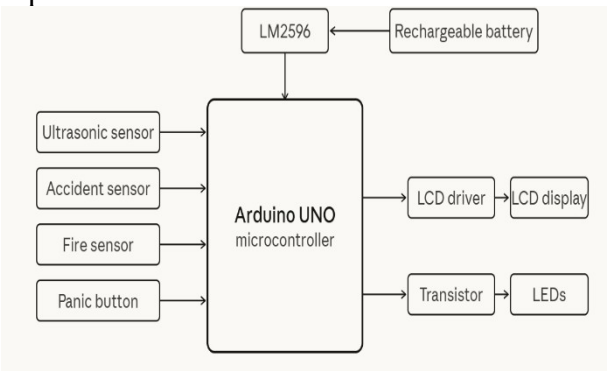

Fig:1: Transmitter

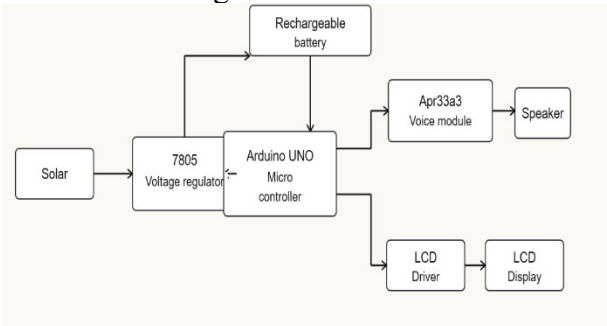

Fig:2: Receiver

The sensors in the transmitter gets triggered based on the situation and sends the signals to the arduino. Arduino process thetype of signal it received and trigger the transistor. Whenever the tansistor is triggered by the arduino the LED'S emmits light.

The solar panel is connected to th arduino. Photo diode is glued on top of the solar panel and parallely connected to the arduino.The solar panel absorb the voltage from the signal received from

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the transmitter LED'S and the photo diode detects the intensity of light . The received electric signals will be sent to the arduino. The arduino process the type of alert it received and sent the signals to the voice module which simultaneously rigger the speaker for voice alert.

IV.MATERIALS AND METHOD USED

Table I: Transmitter Hardware Components

Component	Specification	Function
Arduino Uno	ATmega328P, 16 MHz	Main MCU – reads sensors, encodes data, drives LED
12V LED Array	12V DC, High Intensity	Li-Fi optical transmitter – OOK modulation
LM2596 Regulator	3.2-40V in / 1.25-35V out	Step-down DC-DC; 5V supply to Arduino
HC-SR04 Ultrasonic	5V, 40kHz, 3cm-3m	Proximity / collision distance measurement
SW-420 Vibration	3.3-5V, adj. threshold	Detects collision-level vibration events
Fire Sensor	760nm-1100nm, 60 deg FOV	Flame / high-heat detection
Panic Button	Momentary switch, 5V	Manual driver-initiated distress signal
LCD 16x2	5V, HD44780	System status display on transmitter vehicle
12V Battery	12V, 1Ah rechargeable	Primary power source for LEDs and modules

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Component	Specification	Function
Arduino Uno	ATmega328P, 16 MHz	Decodes received light signals, drives alert outputs
Solar Cell / LDR	Photodiode-based receiver	Captures modulated light from transmitting vehicle
7805 Regulator	7-35V in / 5V stable out	Regulated 5V supply to receiver Arduino
APR33A3 Voice	Flash analogue, 256 sections	Pre-recorded voice alert playback
Speaker	8 ohm, 0.5W	Audible alert output inside vehicle cabin
LCD 16x2	5V, HD44780	Displays decoded emergency type and distance
12V Battery	12V, 1Ah rechargeable	Power source for receiver vehicle system

Table II: Receiver Hardware Components

1. System Design

The system is made using vehicle headlights and taillights as senders and special parts called photodiodes as receivers. A small computer like Arduino is in charge of sending and receiving information between vehicles.

2. Data Encoding & Modulation

Things like how apart vehicles are or if there is an accident or emergency are turned into a digital format. This information is then added to the signal using a method called On-Off Keying.

3. Data Transmission

The vehicle headlights send information by turning on and off fast which represents simple computer language. This way of communicating with light is not something people can see.

4. Data Reception

The photodiode gets the signals and turns them into electrical signals. The small computer then looks at these signals to figure out what they mean.

5. Demodulation & Decoding

The signals that are received are looked at again. Turned back into the original information, like alerts or what is going on with the vehicle.

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6. Testing & Implementation

The system is tried out in situations like when there is an accident or something is, in the way to make sure vehicles can talk to each other correctly using vehicle headlights and photodiodes and the small computer.

V:RESULTS AND DISCUSSIONS

The hardware model was put together using two model cars. We did a series of experiments to check how well the emergency alert system worked and how long it took for alerts to get through. The results show that alerts got through fast in under 200 milliseconds in all the situations we tested. The Li-Fi connection worked well even when the cars were 10 to 15 centimeters apart.

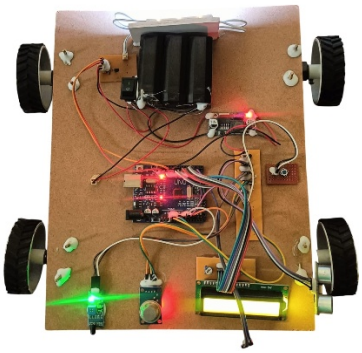

Fig:3: prototype of proposed system Transmitter

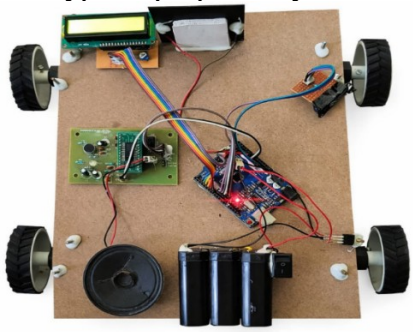

Fig:4: prototype of proposed system Receiver

When an emergency situation occurs in a vehicle (e.g., accident, gas leak, fire), a specialized Li-Fi transmitter module installed in the distressed vehicle is activated. The transmitter module encodes information about the emergency into light signals. This encoding could use techniques such as modulation of light intensity. The Li-Fi transmitter emits modulated light signals containing data about the type and location of the emergency. These signals propagate in all directions from the distressed vehicle. Vehicles equipped with Li-Fi receiver(solar), capture the transmitted light signals. The received light signals are connected to the arduino, which interprets the emergency information. The interpreted information, such as the type of emergency, accident, gas leak, fire and the distance to the distressed vehicle, is displayed on an LCD screen. Simultaneously, the onboard computer system generates voice alerts based on the received emergency information. Upon receiving the emergency alerts, drivers can take appropriate actions, such as slowing down, changing lanes, or preparing to assist the distressed vehicle. Drivers may also relay the information to emergency services or take other necessary steps to respond to the situation.

The developed system has many advantages. The use of LEDS in this project will decrease the usage of RF transceivers which results in reducing the cost. Using of multiple sensors helps in detecting wide range of problems and helps in preventing them. The usage of APR33A3 voice module helps in alerting the driver when he is not visually engaged with the road or the display .

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VI: CONCLUSION

This paper talks about a vehicle to vehicle communication system that uses Li-Fi technology. The system uses Arduino Uno microcontrollers, special sensors, LED lights and solar cells to send emergency alerts between vehicles. We tested the system. Found that it can send alerts in less than 200 milliseconds with perfect accuracy in all the scenarios we tested. The system is cheaper more secure and works better than systems that use radio waves. Li-Fi technology can help make transportation systems safer and smarter. It has the potential to reduce accidents and improve traffic safety. The system is an option for future transportation systems. Li-Fi technology is an option for Intelligent Transportation Systems. It offers benefits, including low cost and high security. The use of Li-Fi technology in vehicles can make roads safer.

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