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Vehicle-To-Vehicle(V2V) Communication Using ESP32 Microcontroller

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Abstract: Vehicle-to-Vehicle (V2V) communication is a crucial component of Intelligent Transportation Systems (ITS) that enables real-time data exchange among vehicles to improve road safety and traffic efficiency. This paper presents a Wi-Fi-enabled vehicle to vehicle communication system using ESP32 modules for scalable deployment. Conventional vehicle safety systems rely heavily on driver perception and are limited by line-of-sight visibility and delayed human response, increasing accident risks. The proposed system integrates Ultrasonic and Motion Processing Unit (MPU6050) sensors to detect hazards such as obstacles, sudden braking, and abnormal environmental conditions. The processed data is transmitted wirelessly using Wi-Fi to nearby vehicles, enabling early warning alerts. The receiving vehicle providesbuzzer notifications to alert the driver. The system improves situational awareness, reduces reaction time, and minimizes collision risks. It supports future applications in smart cities and autonomous vehicles.

I. INTRODUCTION

The rapid increase in vehicular density due to urbanization has led to a significant rise in road accidents worldwide, primarily caused by human error and lack of situational awareness. Conventional vehicle safety systems are largely reactive and rely heavily on the driver's ability to perceive and respond to road conditions. However, these systems are often ineffective under environmental constraints such as poor visibility, blind spots, sharp curves, and adverse weather conditions.To overcome these limitations, Vehicle-to-Vehicle (V2V) communication enables vehicles to exchange real-time information. This allows drivers to anticipate potential hazards, improve response time, and make proactive decisions. By sharing critical data such as speed, position, and warning signals, V2V systems significantly enhance road safety.In this context, this paper presents a Wi-Fi-based V2V communication system designed to provide reliable and real-time communication between vehicles, thereby improving overall safety and traffic efficiency.

II. LITERATURE SURVEY

Vehicle-to-Vehicle (V2V) communication has gained significant attention due to its ability to enhance road safety, traffic efficiency, and driver awareness. Various research efforts have focused on communication protocols, sensing mechanisms, alert systems, and intelligent vehicular networks.

Smith *et al.* [1] analyzed multiple V2V communication protocols such as DSRC, Wi-Fi, cellular, and Bluetooth, highlighting Bluetooth Low Energy (BLE) as an efficient solution for short-range communication due to low latency and minimal infrastructure requirements. However, scalability and range limitations were noted.

Jones and Wang [2] investigated ultrasonic sensors for proximity detection, demonstrating their effectiveness in short-range measurements and blind spot detection. However, their performance decreases in long-range scenarios and noisy environments.

Chen *et al.* [3] studied auditory alert systems and concluded that audio warnings significantly reduce driver reaction time compared to visual alerts alone, especially under high cognitive load conditions.

Kim and Lee [4] explored I2C communication in embedded systems, showing that it provides efficient, low-complexity communication between sensors and controllers, improving system reliability.

Kenney [5] provided an overview of DSRC technology for vehicular communication, emphasizing its low latency and reliability for safety-critical applications.

Bazzi *et al.* [6] analyzed LTE-based V2X systems and discussed their ability to support large-scale vehicular communication with improved coverage and reliability.

Ali *et al.* [7] proposed cooperative interference management techniques such as ICIC and CoMP in C-V2X systems, demonstrating improved communication performance in dense urban environments.

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III. EXISTING METHODS

Existing Vehicle-to-Vehicle (V2V) communication approaches use a combination of communication protocols and sensing technologies to improve road safety. Studies have explored technologies such as DSRC, WiFi, and Bluetooth, where Bluetooth is suitable for short-range communication but has limited coverage in vehicular environments. Ultrasonic sensors are widely used for accurate obstacle and blind spot detection; however, their range is limited. Driver alert systems using audio warnings help improve reaction time but may cause distraction in certain situations. Additionally, communication protocols such as I2C enable efficient data transfer between internal modules but are restricted to in-vehicle communication and do not support inter-vehicle interaction. Despite these developments, existing methods lack real-time communication capability, integration, and scalability, which limits their effectiveness in dynamic traffic condition.

IV. PROPOSED WORK

This paper proposes a Wi-Fi-enabled Vehicle-to-Vehicle (V2V) communication system designed to facilitate real-time data exchange between vehicles for improved road safety. The system utilizes ESP32 microcontrollers with built-in Wi-Fi capability to establish direct communication between nearby vehicles without relying on external infrastructure. The proposed system integrates multiple sensors, including ultrasonic sensors for obstacle detection, gas sensors for monitoring environmental conditions, and vibration sensors for identifying sudden impacts or abnormal vehicle behavior. The sensor data is continuously processed by the microcontroller to detect potential hazards. When a critical condition is identified, the system generates an alert message and transmits it to surrounding vehicles through WiFi communication. On the receiving side, the incoming alert is processed and conveyed to the driver using visual indicators through an LCD display and audio alerts via a buzzer. This enables drivers to take timely action and avoid potential collisions. The proposed approach ensures efficient communication, rapid response, and improved situational awareness in dynamic traffic environments.

V. BLOCK DIAGRAM

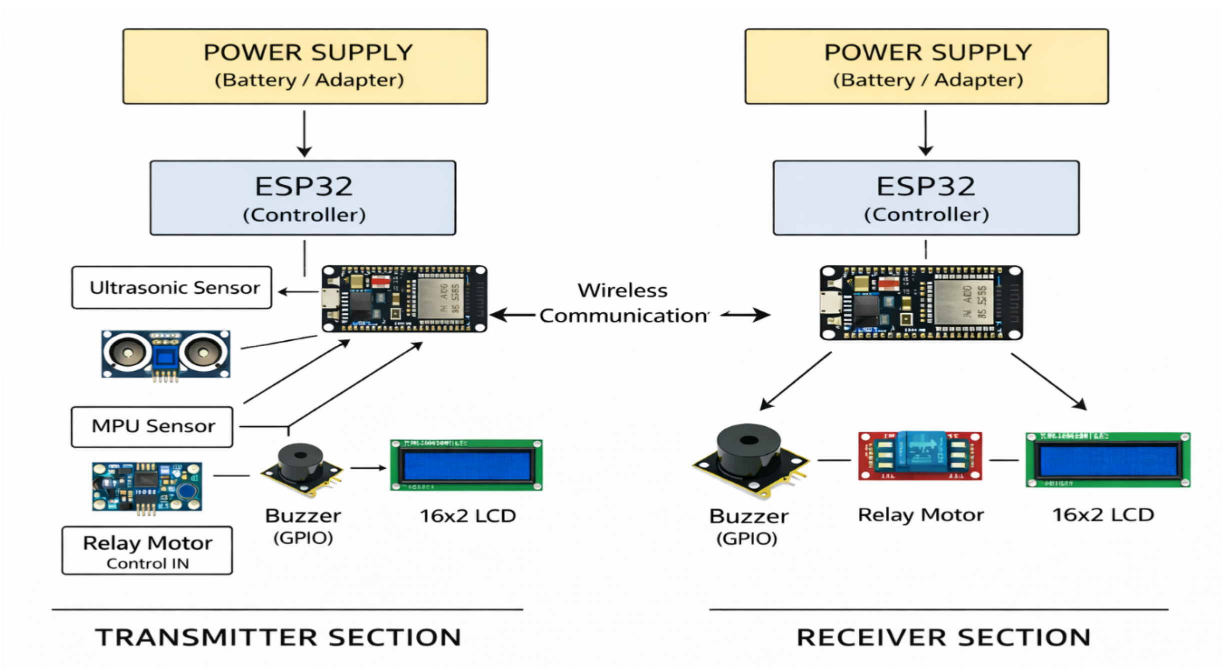

Fig no.1: Transmitter and Receiver of V2V communication

1) Transmitter vehicle:The transmitter unit continuously monitors the vehicle's surroundings and operational parameters using integrated sensors. The ultrasonic sensor measures the distance between the vehicle and nearby obstacles, while the system also evaluates parameters such as vehicle speed.

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The collected data, including speed and distance, is processed by the ESP32 microcontroller in real-time. Based on this analysis, the system determines the current driving condition and prepares the relevant information. Thisprocessed data is then transmitted wirelessly to the receiver unit using Wi-Fi communication, enabling continuous data exchange between vehicles.

2) Receiver vehicle: The receiver unit is responsible for receiving and processing the transmitted data from the transmitter. Upon receiving the information related to speed and distance, the ESP32 microcontroller evaluates the proximity between vehicles.

If the received distance indicates a critical condition, the system automatically initiates a braking action to prevent a possible collision. Simultaneously, a buzzer sound is generated to indicate system activation, and the LCD displays the status of automatic braking.

VI. EXPERIMENTAL RESULT

Fig no. 2: LCD of Front Vehicle

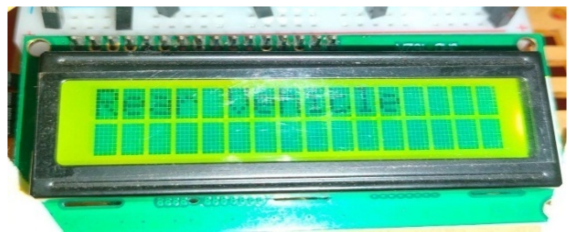
Fig no. 3: LCD of Rare Vehicle

Fig no. 4: Result of Front Vehicle

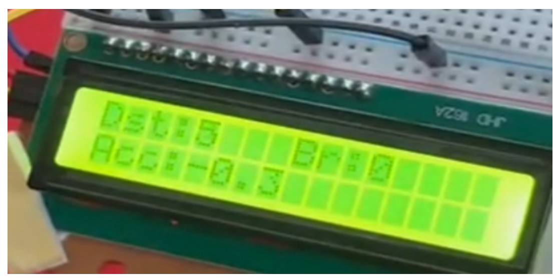

Fig no. 5: Result of Rare Vehicle

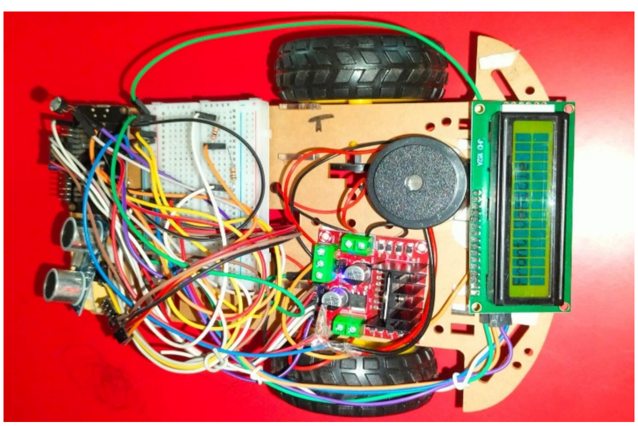
Fig no. 6:Front Vehicle

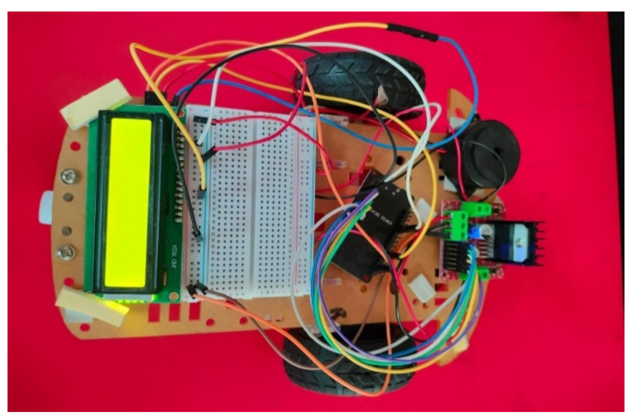
Fig no.7: Rare Vehicle

VII. CONCLUSION

The proposed WiFi-enabled Vehicle-to-Vehicle (V2V) communication system improves road safety through real-time transmission of critical parameters such as speed and distance. The integration of sensors with the ESP32 microcontroller ensures accurate detection and efficient communication between vehicles.

At the receiver side, automatic braking along with buzzer indication and LCD display enables immediate response to critical conditions, reducing the risk of collisions. Overall, the system provides an effective and reliable solution for enhancing vehicular safety and responsiveness.

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