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Zigbee-based Smart Zone System for Avoiding the Accidents

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Abstract

When it comes to automobiles, safety is of utmost importance in order to minimize accidents in speed-restricted zones and prevent property damage and loss of life. Recent surveys have shown a significant increase in accidents near school zones, hospital zones, and sharp turnings. This rise can be attributed to drivers' eagerness to reach their destination quickly. Consequently, controlling vehicle speed has become a crucial matter that needs attention. This paper aims to propose a practical, compact, and simple design for an automatic vehicle speed control system. The system should be swiftly implemented in school, college, hospital, and sharp turning zones to reduce the number of accidents. The automated speed control system is built using the microcontroller-based platform of the Arduino Uno board. The transmitter circuit is powered by a DC battery, which provides sufficient power for the functioning of the Zigbee device placed near the restricted zones. If the vehicle's speed exceeds the predefined limit, the microcontroller takes control of the vehicle motor by sending a signal to the motor driver. The motor driver then decreases the speed of the electric motor, subsequently reducing the vehicle's speed in that particular zone. In the receiver section, the speed of the vehicle is received through the speed encoder input signal. The receiver unit comprises an ultrasonic sensor, a DC motor, a motor driver, an LCD display, a Zigbee receiver, and an Arduino UNO acting as a microcontroller. Based on the signal received from the transmitter in the designated zone, the speed of the vehicles automatically reduces with the assistance of these devices. The ultrasonic sensor is utilized to detect nearby vehicles and adjust the vehicle's speed, accordingly, thereby preventing accidents.

Keywords: Vehicle speed control system, Zigbee technology, DC motor, L293D driver, Ultrasonic sensor, LCD.

1. Introduction

Accidents are currently a major issue for everyone. Accidents are becoming more common, thus attempts are being undertaken to avoid them and minimize their repercussions. We live in a society where the laws of the road are meaningless to people and are routinely broken. Furthermore, it is human nature to oppose what is placed on them. An rise in population leads to an increase in the number of automobiles parked on the road. As a result, the global number of accidents is increasing. According to a WHO statistic, around 1.25 million people die each year as a result of traffic accidents. Humanity's safety is dependent on us. Collision avoidance systems have demonstrated their worth in recent years, yet their efforts are insufficient. The main goal of this project was to implement a Zigbee smart zone to avoid accidents, which can significantly lower the risk of accidents. The main characteristic of this system is that it automatically reduces the vehicle's speed up to a set limit when a high-speed vehicle enters a safety zone. As a result, we hope that this technology reduces accident rates to some extent. Even if the other vehicles lack the necessary gadget, the user's controller can detect and avoid collisions.

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Human life has gotten easier for an individual with the expanding population and improvement in technology, but the threat to life is increasing due to the reckless use of its application in day-to-day living. Traveling from one location to another has been easier, more pleasant, and faster as the vehicle industry has grown. Nonetheless, this has raised the likelihood of a threat to life on the road. The speed of a vehicle is a crucial aspect that contributes to this. Although though automobiles have many safety features, they cannot guarantee 100% safety for a person's or a pedestrian's life. The advancement of embedded technology has addressed these difficulties by making vehicle speed an advantage rather than a drawback. Cruise control, adaptive cruise control, and other existing embedded technology are examples.

Researchers are still working on developing an efficient algorithm that can inform the motorist and direct him to travel at a safe speed limit. The speed control algorithm is often based on the automatic speed control principle, which works by changing the throttle plate for proper and required fuel flow or by employing a servo motor controlled by the engine control unit (ECU). It is critical to specify suitable input parameters in order for the ECU to function properly. To decrease road accidents and provide a tranquil environment for the people, the Indian Law Commission has issued a recommendation to limit speed in key zones. Because of the rash driving of some drivers, current approaches are unable to reduce accidents. As a result, speed control must be included in all cars.

Our new proposal is to install an automated speed control system in automobiles, primarily in restricted regions. The device is configured as a transmitter in this case, with numerous devices combining to monitor the speed of the vehicle when it exceeds the prescribed speed and control it by installing a receiver on the vehicle. Interfacing with a microcontroller reduces the vehicle's speed based on the signals sent. The dc motor detects the vehicle's current speed and sends it to the microcontroller, which compares it to the specified limit and adjusts the speed automatically. This system communicates between transmitter and receiver using Zigbee technology, which has a range of up to 10-100 meters. This is less expensive than others. As a result, this system regulates and monitors the total number of cars in its coverage area. Accidents are reduced in our fast-paced world by applying this approach. In both developed and emerging nations. People are inconvenienced by road accidents and vehicle jamming as a result of drivers' dissatisfaction with obeying the laws in the restricted zone, where the speed must be limited as prescribed in that zone by using an automated speed control system to limit the speed automatically using Zigbee technology. Driving too fast is one of the leading causes of traffic accidents worldwide. According to recent studies, one-third of serious traffic accidents are caused by excessive speed as well as changes in the road (like the presence of road work or unexpected obstacles). Consequently, in order to avoid similar accidents, notify drivers, and restrict their vehicle speed in such areas, the highway department has installed signboards.

1.1 Objective

The goals of this project are to create a system that can detect potentially hazardous situations in a specific region and inform people or devices to take appropriate action to prevent accidents. The impetus for this project stems from the real-world issues we confront on the roadways every day. And the project's major goal is to build a smart and safe environment that can aid in the prevention of accidents and the reduction of hazards linked with hazardous settings. And it is to create a smart system that can aid in the prevention of accidents and the improvement of safety in a specific area, such as speed-restricted zones. The system will use Zigbee wireless communication technology to allow devices in the defined region to communicate with one another and work together to detect possible threats and respond to them in a timely and effective manner. It is also to create a comprehensive system that can increase safety and prevent accidents in a variety of settings, such as schools, colleges, factories, or construction sites.

2. Literature survey

Govindraju, et al. presented a system that controls the speed of a vehicle using embedded technology and wireless communication. The authors propose a solution to enhance road safety by implementing wireless technology to monitor and regulate the speed of vehicles. The paper provides details about the design, implementation, and evaluation of the system. It offers insights into the use of wireless technology for vehicle speed control and its potential impact on road safety. Pillai and Supriya focused on a real-time system that monitors and alerts for CO2 levels using wireless sensor networks. The authors discuss the design and implementation of the system, which utilizes wireless sensors to continuously measure CO2 levels and transmit the data to a central monitoring station. The chapter highlights the importance of monitoring CO2 levels for environmental and health considerations and presents the potential applications and benefits of wireless sensor networks in such systems.

Khan et al. (2018a) proposed a Zigbee-based smart zone for accident prevention. The proposed system consists of a Zigbee sensor network, a Zigbee gateway, and a cloud server. The sensor network is used to collect data from the environment, such as temperature, humidity, and gas concentration. The Zigbee gateway is used to transmit the collected data to the cloud server. The cloud server is used to store the collected data and to process it to detect accidents. The proposed system can be used to prevent accidents in a variety of environments, such as homes, offices, and factories.

Al-Fuqaha et al. proposed a Zigbee-based smart zone for fall detection. The proposed system consists of a Zigbee sensor network, a Zigbee gateway, and a cloud server. The sensor network is used to collect data from the environment, such as acceleration, angular velocity, and heart rate. The Zigbee gateway is used to transmit the collected data to the cloud server. The cloud server is used to store the collected data and to process it to detect falls. The proposed system can be used to detect falls in a variety of environments, such as homes, offices, and hospitals.

Khan et al. (2018b) proposed a Zigbee-based smart zone for fire detection. The proposed system consists of a Zigbee sensor network, a Zigbee gateway, and a cloud server. The sensor network is used to collect data from the environment, such as temperature, humidity, and smoke concentration. The Zigbee gateway is used to transmit the collected data to the cloud server. The cloud server is used to store the collected data and to process it to detect fires. The proposed system can be used to detect fires in a variety of environments, such as homes, offices, and factories.

Khan et al. (2018c) proposed a Zigbee-based smart zone for gas leak detection. The proposed system consists of a Zigbee sensor network, a Zigbee gateway, and a cloud server. The sensor network is used to collect data from the environment, such as gas concentration. The Zigbee gateway is used to transmit the collected data to the cloud server. The cloud server is used to store the collected data and to process it to detect gas leaks. The proposed system can be used to detect gas leaks in a variety of environments, such as homes, offices, and factories.

Khan et al. (2018d) proposed a Zigbee-based smart zone for flood detection. The proposed system consists of a Zigbee sensor network, a Zigbee gateway, and a cloud server. The sensor network is used to collect data from the environment, such as water level. The Zigbee gateway is used to transmit the collected data to the cloud server. The cloud server is used to store the collected data and to process it to detect floods.

3. Existing system

Before, users used to manually manage the speed of their automobiles with the help of speed brokers in this project's previous system. If speed limit signs are not visible to drivers at night, there is a risk of more accidents, which will contribute to an increase in the death rate. The speed of the vehicle in speed restriction zones is then reduced by employing ultrasonic sensors. The ultrasonic sensors identify obstructions and send signals to the drivers, who reduce the speed of the vehicle. The existing system controls the vehicle's speed based on the speed restriction of the accident zones, which is accomplished via RF transmission. The speed of the vehicle within the smart zones is controlled using this manner depending on the signal received from the RF transmitter, which is fixed at the zone entry point. The RF system is a one-way communication system in which the transmitter only provides the necessary signals. There are a few downsides to RF communication. The cost of the system is lower since it employs a fixed frequency, requires transmitter maintenance, and has a higher installation cost. When compared to RF communication, Zigbee communication is stronger and more reliable; thus, Zigbee communication was chosen for our suggested system.

4. Proposed system

4.1 Working

The project's operations encompass both transmitter and receiver zones. In order to receive and transmit signals, both zones must have a regulated power supply. The transmitter area is the Zone, which includes places like schools, colleges, nursing homes, and hospitals. When the zone is turned on, it continuously sends signals to the receiver portion. The receiving part is the vehicle. When a vehicle enters a zone, the Zigbee transmitter sends a signal from the zone to the receiver, which is the vehicle that has entered the zone. And the buzzer will activate, signalling to the vehicle that it is in a smart zone, and the vehicle's speed will be automatically reduced to a specified limit. In this case, we additionally utilize an ultrasonic sensor to detect obstructions such as vehicles. The ultrasonic sensor has a frequency range of 30-500 kHz. If the vehicle is outside of the zone, it can continue at its original speed. When the ultrasonic sensor detects a vehicle, it produces three types of output: an LCD display, a buzzer, and a motor. As soon as the signal from the transmitter is received, the motor slows down to avoid a collision. And that minimum speed will be maintained until the vehicle exits the smart zone. The display indicates if the vehicle is within or outside of the zone. If the vehicle is out of Zigbee range, it can continue to travel at its original pace.

4.2 Block diagram of Tx vehicle

The transmitter block diagram consists of four main components: regulated power supply, Arduino UNO controller, LCD, and Zigbee transmitter. These components work together to form a smart zone system aimed at avoiding accidents.

The regulated power supply is responsible for providing a stable and regulated voltage to power the entire system. It ensures that all the components receive the required power without fluctuations or voltage spikes, thereby ensuring their proper functioning. The Arduino UNO controller acts as the central processing unit of the smart zone system. It receives input from various sensors, processes the data, and controls the output devices accordingly. It is programmed with the necessary algorithms and logic to monitor and respond to potential accident scenarios. The LCD (Liquid Crystal Display) serves as the user interface of the smart zone system. It provides visual feedback to the users or operators by displaying important information such as warnings, alerts, or status updates. The LCD can show real-time data from sensors or display messages to inform pedestrians, drivers, or authorities about the current conditions within the smart zone. The Zigbee transmitter is a wireless communication module that enables the smart zone system to exchange data with other devices within its range. It utilizes

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Zigbee technology to establish a reliable and low-power wireless network. The Zigbee transmitter communicates with other Zigbee-enabled devices, such as sensors or control units, to exchange information related to accident prevention. This can include data about vehicle speeds, pedestrian presence, traffic signals, or other relevant factors.

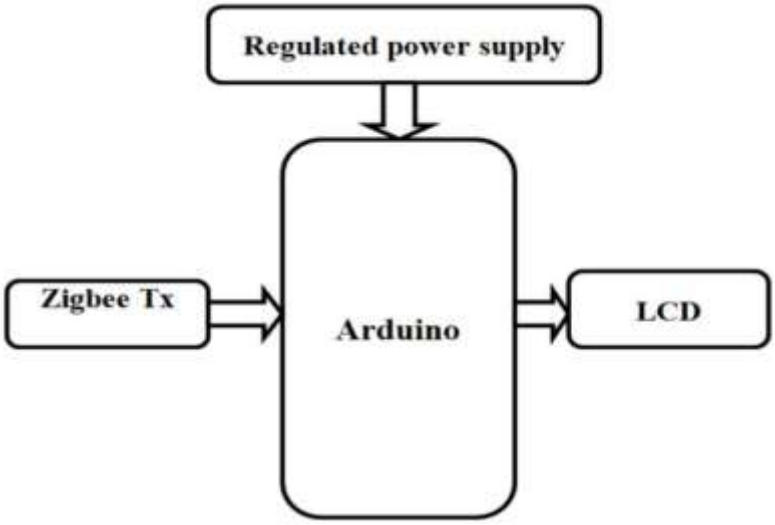

Figure 1: Block diagram of Tx vehicle.

Overall, the regulated power supply provides power to the system, the Arduino UNO controller processes the data and controls the system's behavior, the LCD displays important information, and the Zigbee transmitter facilitates wireless communication for real-time data exchange. Together, these components form a smart zone system designed to prevent accidents by monitoring and responding to potential risks.

4.3 Block diagram of Rx vehicle

The receiver block diagram consists of several components interconnected to create a smart zone system to avoid accidents. Here is an explanation of each component and its role in the system:

- Battery: The battery serves as the power source for the entire system, providing the required electrical energy to operate the components.
- Arduino UNO Controller: The Arduino UNO controller is a microcontroller board that acts as the brain of the system. It processes data, controls the operation of other components, and executes the logic for accident avoidance.
- LCD (Liquid Crystal Display): The LCD display is used to provide visual feedback and information to users. It can display relevant data such as warnings, instructions, or distance measurements from the ultrasonic sensor.
- Ultrasonic Sensor: The ultrasonic sensor plays a crucial role in detecting obstacles or potential accident zones. It emits ultrasonic waves and measures the time it takes for the waves to bounce back after hitting an object. This information is used to calculate the distance between the sensor and the obstacle.
- DC Motor: The DC motor is responsible for actuating a physical mechanism such as a barrier or gate to control the access to a specific zone. It can be triggered based on the sensor readings to prevent vehicles or pedestrians from entering hazardous areas.
- Buzzer: The buzzer is an audible alarm device that emits a sound to alert individuals about potential dangers or to indicate warnings in the system.

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- Zigbee Receiver: The Zigbee receiver is used for wireless communication. It receives signals and data from other Zigbee-enabled devices, such as vehicles or pedestrian tags, to exchange information related to their presence or location.

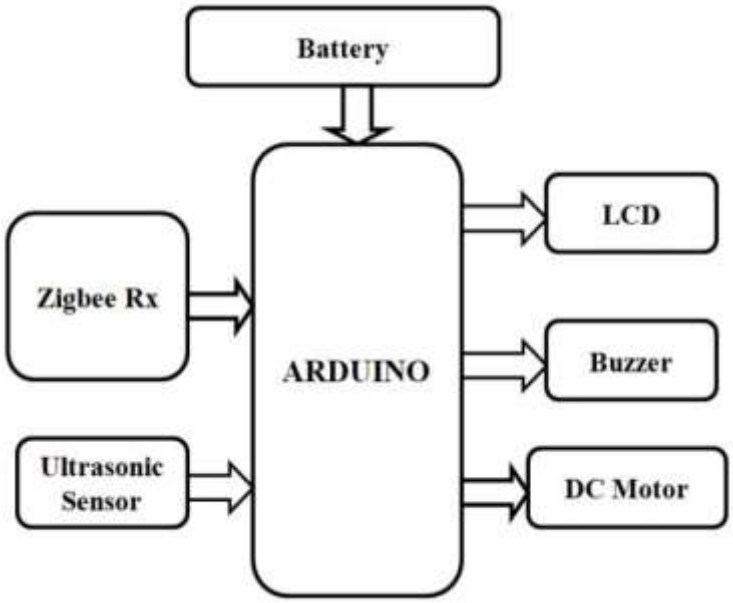

Figure 2: Block diagram of Rx vehicle.

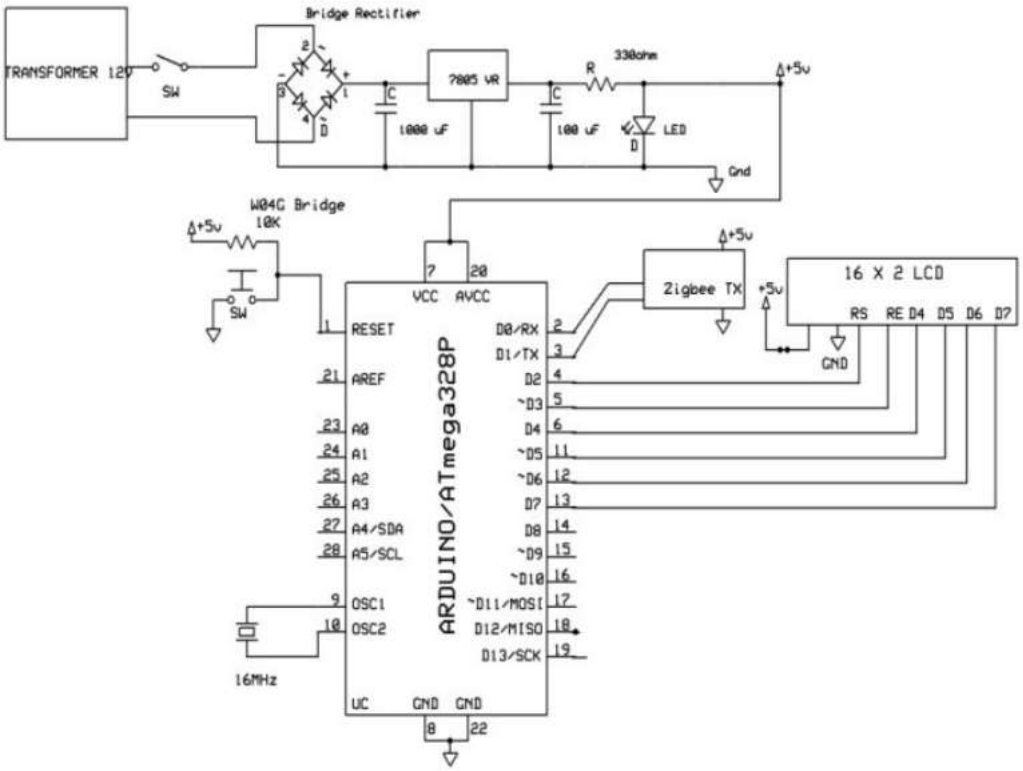

Figure 3: Schematic diagram of Tx vehicle.

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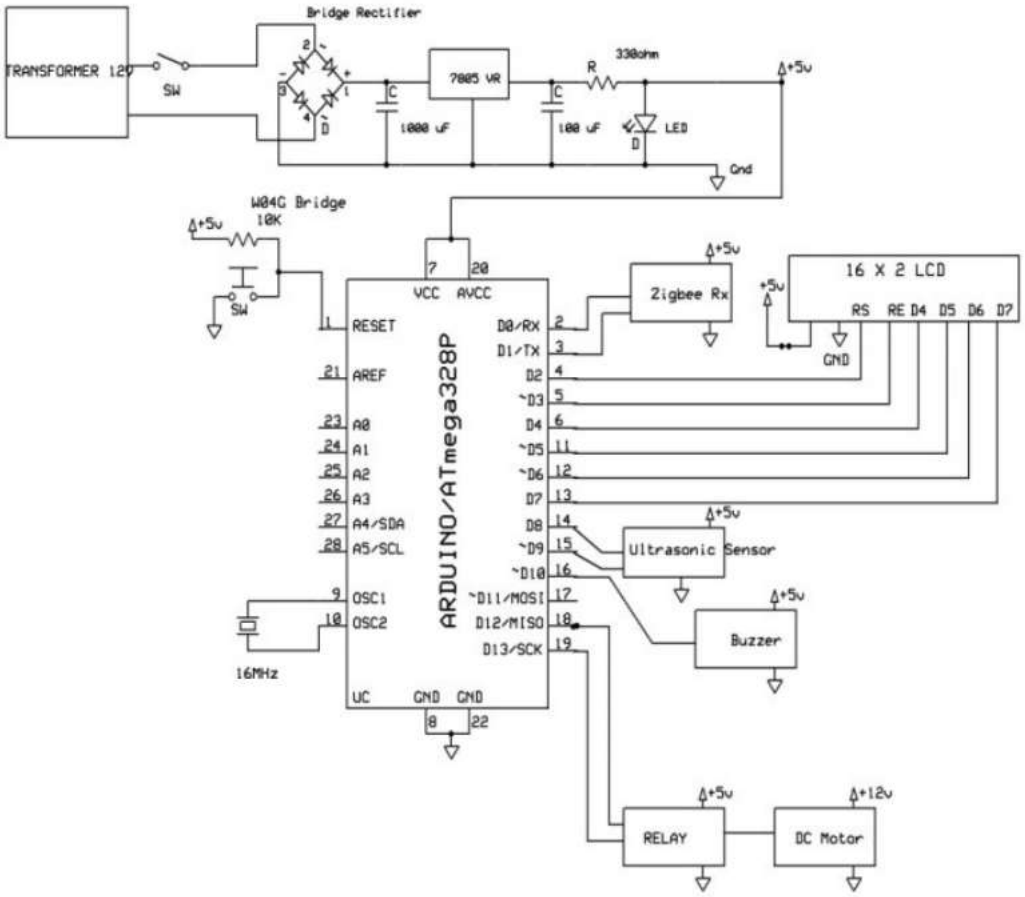

Figure 4: Schematic diagram of Rx vehicle.

5. Results and discussion

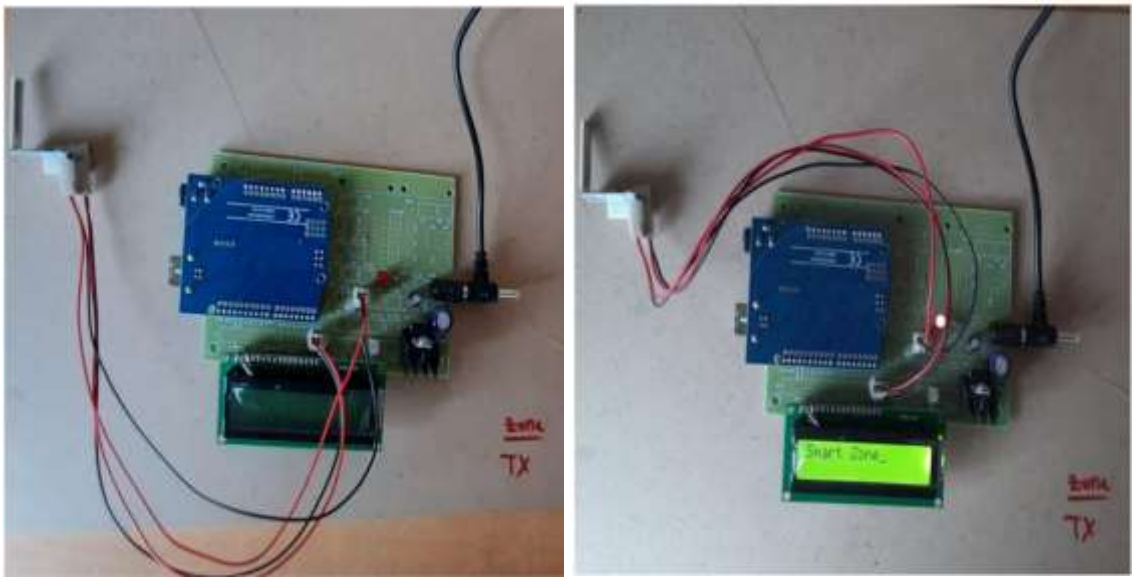

Figure 5: Smart zone Tx zone hardware and its On condition.

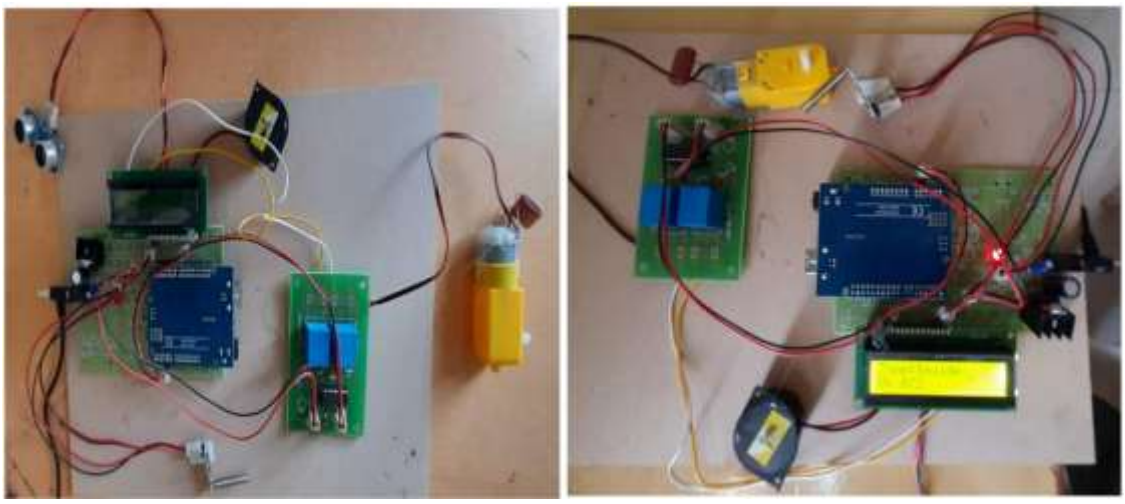

Figure 6: Zigbee smart zone receiver vehicle (left). Vehicle is inside the zone (right).

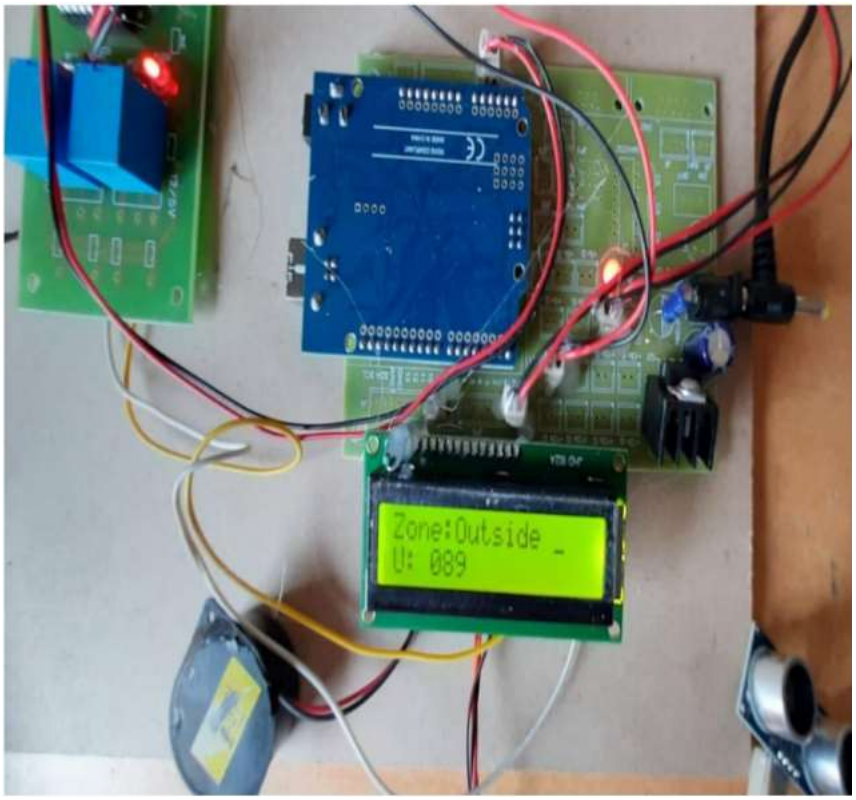

Figure 7: Vehicle is outside the zone.

6. Conclusion

The Zigbee-based smart zone system for accident avoidance, comprising a transmitter vehicle and a receiver vehicle, demonstrates the potential for enhancing road safety. By utilizing wireless communication and intelligent control mechanisms, the system enables real-time information exchange between vehicles, allowing for timely warnings and proactive measures to prevent accidents. The integration of components such as Zigbee transmitters and receivers, Arduino UNO controllers, LCD displays, ultrasonic sensors, DC motors, and buzzers enables efficient and effective accident detection, localization, and communication. The system's transmitter vehicle, equipped with a power supply, Arduino UNO, Zigbee transmitter, and LCD, serves as a source of critical information regarding the vehicle's status, location, and speed. The receiver vehicle, equipped with a battery,

Arduino UNO controller, LCD, ultrasonic sensor, DC motor, buzzer, and Zigbee receiver, acts as a recipient of this information and responds accordingly to avoid accidents. The ultrasonic sensor detects obstacles in the proximity of the receiver vehicle, and the DC motor and buzzer provide necessary alerts and automatic braking actions.

7. Future Scope

- Advanced Collision Avoidance Techniques: Enhancing the collision avoidance capabilities of the smart zone system can involve integrating additional sensors, such as radar or LiDAR, to improve detection accuracy and enable more robust collision avoidance techniques.
- Vehicle-to-Infrastructure Communication: Expanding the system to include communication with infrastructure elements, such as traffic lights or road sensors, can provide additional data for accident prevention. This integration could facilitate intelligent traffic management and optimize the flow of vehicles within the smart zone.
- Integration with Autonomous Vehicles: As autonomous vehicles become more prevalent, integrating the Zigbee-based smart zone system with autonomous driving technology can enhance safety by enabling seamless communication and coordination between autonomous and non-autonomous vehicles.
- Data Analytics and Machine Learning: Leveraging data collected from the smart zone system, advanced analytics and machine learning algorithms can be employed to identify patterns, predict potential accidents, and optimize system performance. This could lead to more efficient accident prevention strategies and improved decision-making capabilities.
- Scalability and Standardization: Ensuring the scalability and interoperability of the smart zone system by adhering to standard protocols and frameworks, such as IEEE 802.15.4 for Zigbee communication, can facilitate widespread adoption and integration with existing transportation infrastructure.

By further exploring these avenues, the Zigbee-based smart zone system can continue to evolve as a comprehensive and effective solution for accident prevention, contributing to safer road environments and reducing the risk of accidents.

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