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# Vehicle Collision Avoidance at Hairpin Curves Using Ultrasonic Sensor

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***Abstract: Road accidents at hairpin bends are a significant safety concern, especially in mountainous regions where visibility is limited. Traditional safety measures, such as convex mirrors, are ineffective at night and in adverse weather conditions, increasing the risk of collisions. To address this issue, the "Collision Avoidance System for Hairpin Bends Using Ultrasonic Sensors" has been developed to enhance road safety by providing real-time alerts to drivers approaching sharp curves. The proposed system integrates ultrasonic sensors, a Node MCU micro controllers, and LED indicators to detect and warn drivers about oncoming vehicles. The ultrasonic sensors are strategically placed at the curve to monitor vehicular movement within a 10-meter range. Upon detecting an approaching vehicle, the system activates a red LED signal to alert drivers of potential oncoming traffic. Conversely, a green LED signal indicates a clear path, allowing vehicles to proceed safely. Furthermore, the system incorporates an automatic accident detection mechanism. In the event of a collision, the system immediately transmits alert messages to emergency services, ensuring a rapid response to minimize casualties and damage. By leveraging IOT technology, the system ensures real-time monitoring and enhances situational awareness for drivers navigating hairpin bends. This solution offers a cost-effective, energy-efficient, and highly reliable alternative to conventional safety measures. It significantly improves road safety by reducing blind-spot accidents and enabling proactive collision avoidance in challenging terrains. With its simple implementation and scalability, the system can be deployed across various high-risk roadways to enhance driver awareness and reduce accident rates effectively.***

***Keywords*: Accidend prevention, sharp curve Nagivagion, Inclination Detection, Alert System.**

## I. INTRODUCTION

The rapid rise in transportation and vehicle usage has led to a daily increase in road accidents. These incidents are primarily caused by negligence, violation of traffic regulations, and poor road conditions. Among all road design elements, curved segments are especially vulnerable to accidents due to their alignment features. Research shows that curved roads contribute to 10% of total accidents, with 13% of fatalities occurring on these segments. Driving on narrow roads, hill terrains, and ghat sections—especially around hairpin bends—requires constant attention and skill. Over-speeding on sudden curves is a common cause of accidents in such areas. Ideally, vehicles moving uphill on ghats and bends should be given the right of way, but this rule is often ignored, leading to traffic jams and crashes. In current systems, drivers face difficulty in anticipating the arrival of oncoming vehicles at blind curves. To address this issue, we propose a model that assists drivers in safely navigating bends and better predicting oncoming traffic.

## II. EXISTING SYSTEM

Currently, the following methods are being incorporated to negotiate a hairpin bend on a Hilly track, Ghats or any other kind of zero visibility turns.

### *A. Vehicle Horn*

Traditionally, drivers use their vehicle horns to navigate hairpin bends, relying on the sound's intensity to estimate the distance of oncoming vehicles. While this method is simple and widely practiced, it is often inefficient and can lead to significant confusion between drivers

### *B. Headlights*

Flashing headlights at night serves a similar purpose to honking, helping drivers signal their presence on hairpin bends. However, this method is also inefficient and becomes completely ineffective during daylight hours.

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### *C. Convex Mirrors*

Convex mirrors are now commonly used to provide drivers with a view of vehicles approaching from the opposite direction on hairpin bends. However, they come with several drawbacks. In hilly regions, where cold and misty conditions are frequent, keeping the mirrors clean and visible is a constant challenge. Additionally, the time it takes for a driver to locate the mirror, interpret what they see, and react can lead to delayed responses and poor judgment, increasing the risk of accidents.

### *D. IR Sensor*

An IR sensor (Infrared Sensor) is an electronic sensor that detects infrared radiation, which is emitted by objects in the form of heat. These sensors are commonly used to detect the presence or distance of an object, measure temperature, or detect motion

## III. PROPOSED SYSTEM

This paper presents a straight forward approach to implementing a Collision Avoidance System for hairpin bends on hilly roads,mountain passes (Ghats)or blind turns,utilizing ultrasonic sensor.Fig. 3.1 shows the block diagram of proposed methodology. This system is designed to enhance road safety, particularly on sharp curves like hairpin bends where visibility is often limited. It operates through a sequence that begins with a power supply activating ultrasonic sensors. These sensors continuously monitor a 10- meter range for the presence of vehicles. When a vehicle enters this detection zone, the sensors send data to the NodeMCU, a microcontroller that processes the input in real- time. Based on the processed information, the system reaches a decision point. If a vehicle is detected, the NodeMCU activates a red LED providing both visual and auditory warnings to alert approaching drivers of potential oncoming traffic. This immediate feedback allows drivers to slow down or stop, reducing the risk of collision. On the other hand, if no vehicle is detected, the system activates a green LED, signaling that the path ahead is clear. This simple yet effective cycle concludes after taking the necessary action and then repeats, ensuring continuous monitoring. In case accident occurs tilt sensor activated and the message is send to an team members . Overall, the system provides a cost- effective, real-time safety solution for dangerous curves, helping to prevent accidents and improve driver awareness

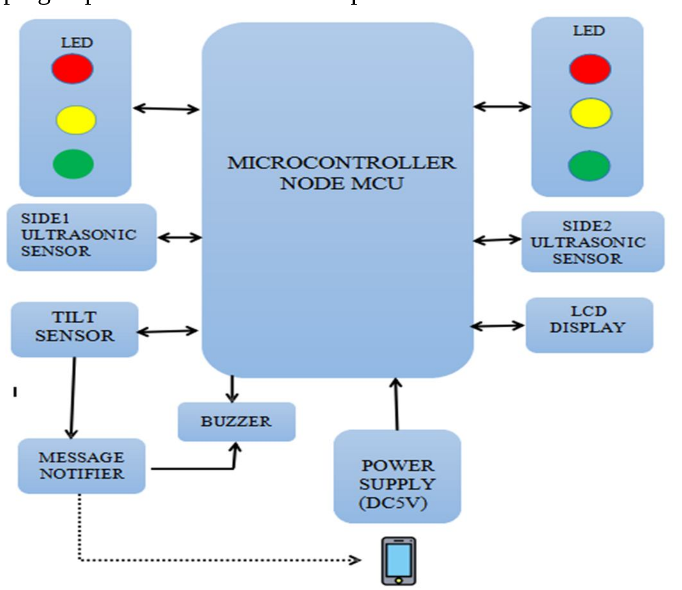


Fig-3.1: Collision avoidance in hairpin bend using ultrasonic sensors

## IV. HARDWARE REQUIREMENTS:

### *A. Microcontroller (NODE MCU-ESP8266)*

The NodeMCU-ESP8266 is a low-cost, open-source microcontroller board widely used for IOT (Internet of Things) projects. It is based on the ESP8266 Wi-Fi SOC (System on Chip) and features built-in Wi-Fi, allowing wireless connectivity without needing an external module. The board is programmable using the Arduino IDE or Lua scripting language, making it accessible for beginners and professionals alike. The NodeMCU supports serial communication protocols such as UART, I2C, and SPI, enabling integration with a wide variety of devices. Its compact size and energy efficiency make it ideal for applications like home automation, weather monitoring, and remote sensing.

The microcontroller runs at 80 or 160 MHz and has built-in flash memory for program storage. It features a micro-USB port for easy programming and power supply. With a strong community and extensive online resources, developers can easily find support and tutorials. Overall, the NodeMCU-ESP8266 is a powerful and versatile microcontroller ideal for wireless IOT development.

### *B. Ultrasonic sensor (HC-SR04)*

The HC-SR04 is a widely used ultrasonic distance sensor that determines the distance to an object by emitting sound waves. It works by sending an ultrasonic pulse through the "Trigger" pin and listening for the returning echo on the "Echo" pin after the sound bounces off an object. The time delay between sending and receiving the signal is used to calculate the distance, typically measured in centimeters. The sensor can accurately detect objects within a range of 2 cm to 400 cm, with an accuracy of approximately 3 mm.Operating at 5V and consuming minimal power, the HC-SR04 is well-suited for low-power applications. It has four pins: VCC, GND, Trigger, and Echo. Its ease of integration with microcontrollers such as Arduino and NodeMCU makes it a popular choice in fields like robotics, obstacle detection, automation, and general distance measurement. Thanks to its affordability, reliability, and non-contact sensing capability, the HC-SR04 is widely used in DIY electronics, educational projects, and in environments where contact-based sensing isn't practical.

### *C. Led Indicators*

LED indicators are basic electronic components used to visually display the status or condition of a device or system. "LED" stands for Light Emitting Diode, which produces light when an electric current flows through it in the proper direction. They are widely used in electronics projects to show power status, output signals, warnings, or system states. LEDs come in various colors like red, green, blue, and white, each often representing a specific meaning (e.g., red for error, green for OK). They are energy-efficient, long-lasting, and respond quickly to voltage changes, making them ideal for real-time feedback. In microcontroller-based systems like with NodeMCU, LEDs are often used to indicate Wi-Fi status, sensor activity, or system errors. They require a current-limiting resistor to prevent damage from excessive current. LEDs are commonly connected to GPIO pins, allowing the micro-controller to control them via code.

### *D. Tilt sensor*

A tilt sensor is an electronic device that detects orientation or a change in position, commonly used to sense angular movement or tilt. It typically works by using a rolling ball or mercury switch that makes or breaks contact when the sensor is tilted beyond a certain angle. When the sensor is upright, the internal mechanism completes the circuit, sending a signal to the connected micro-controller. If tilted, the circuit breaks, and the output changes accordingly. Tilt sensors are simple, low-cost, and widely used in applications like alarms, motion-activated systems, gaming devices, and robotic navigation. They usually have two pins: one for ground and one for signal output, making them easy to interface with micro-controllers like Arduino Node MCU.

### *E. Buzzer*

A buzzer is an electronic device that emits sound when an electric current flows through it, commonly used for signaling or alerting in various applications. There are two primary types of buzzers: active and passive. An active buzzer can produce sound on its own when power is supplied, while a passive buzzer needs an external signal, such as a square wave, to generate sound. Typically, buzzers have two pins—one for power (VCC) and one for ground (GND)—making them easy to connect with microcontrollers like Arduino or NodeMCU.

## V. SOFTWARE REQUIREMENTS

### *A. Arduino IDE*

Used to program and upload control logic to the Node MCU.Provides an easy-to-use interface for writing, debugging, and uploading embedded C/C++ code. Facilitates integration with various sensors and IOT platforms.

### *B. IOT Platform (Blynk)*

Manages emergency notifications and remote monitoring. Stores and visualizes sensor data for analysis and system performance tracking. Allows remote control of the system via a mobile application or web interface Blynk is a cloud-based Internet of Things (IOT) platform that allows users to develop, monitor, and control IOT devices remotely using a smartphone or web dashboard. It supports various microcontrollers like Arduino, ESP8266, ESP32, and Raspberry Pi.

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## VI. WORKING PRINCIPLE

The system operates through a sequential process to detect vehicles, alert drivers, and send emergency notifications. The working principle can be divided into the following steps:

### A. *Vehicle Detection*

The Node MCU processes the received sensor data and activates LED indicators accordingly If a vehicle is detected approaching the bend .The Red LED is activated, serving as a visual warning for drivers to slow down and proceed with caution.

### B. *Alert Activation*

The Node MCU processes the sensor input and activates the appropriate LED indicators.If a vehicle is approaching Red LED turns on, warning the driver about oncoming traffic.If no vehicle is detected Green LED turns on, indicating a safe passage.

### C. *Accident Detection and Emergency Notification*

An Accident Detection and Emergency Notification System is designed to identify road accidents and promptly alert emergency responders, ensuring quick assistance to victims. The system typically consists of sensors such as accelerometers and gyroscopes that detect sudden impacts, abrupt deceleration, or rollovers. A GPS module determines the accident location, while a communication module (such as GSM, LTE, or IOT) sends emergency alerts to predefined contacts, nearby hospitals, or authorities. Once an accident is detected, the system processes the data and automatically transmits the vehicle's location and severity of impact.

## VII. HARDWARE SETUP

Ultrasonic sensors are securely mounted at critical locations to provide comprehensive vehicle detection.LED indicators are placed at driver-visible points to ensure immediate awareness of road conditions.The Node MCU is encased in a weatherproof enclosure to prevent environmental damage.A stable power source, such as a regulated DC supply, ensures the system operates without interruption.Proper wiring and circuit protection mechanisms are implemented to prevent short circuits and power surges.


Fig 7.1

## VIII. RESULT

The working of proposed system setup in various real life scenarios are shown below using Fig. 8.1, 8.2, 8.3, 8.4, 8.5, and 8.6.

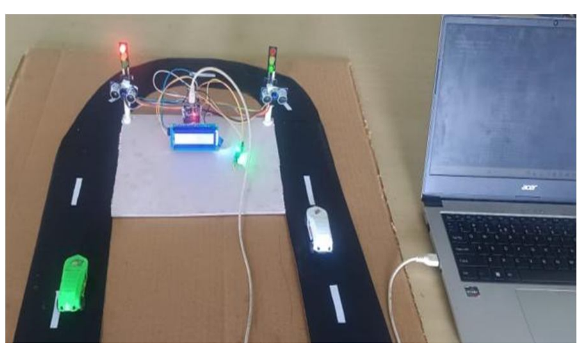

Fig 8.1 Indicate that the lane 2 vehicle approached maximum distance so lane 2 can go and lane1 incidated the red signal so the vechical can stop.

 

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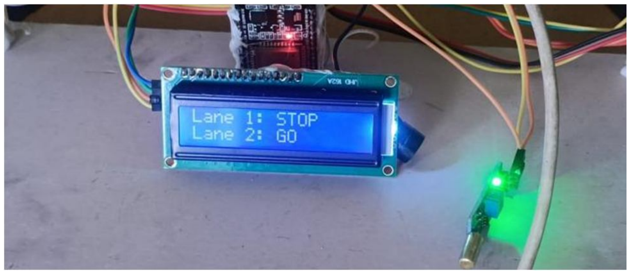


Fig 8.2 Indicate Lane 1 stop and Lane 2 can go displayed in the LCD.

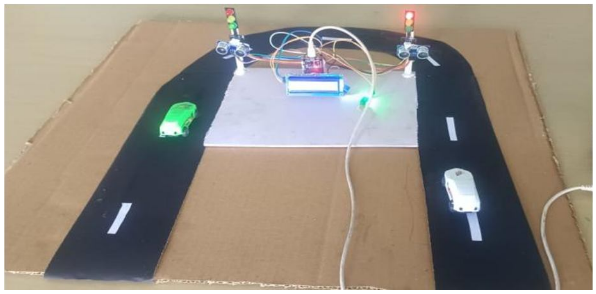

Fig 8.3 Indicate the lane 1 vehicle approached maximum distance so lane 1 can go and lane2 incidated the red signal so the vechical can stop.

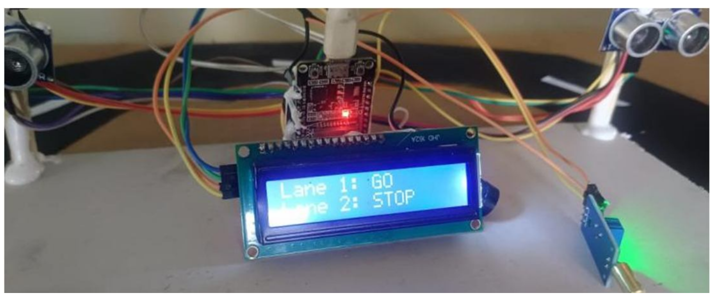


Fig 8.4 Indicate Lane 1 can go and Lane 2 stop displayed in the LCD.

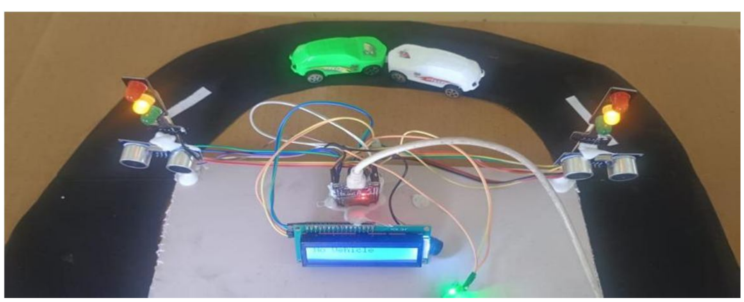

Fig 8.5 shows vehicle get accident.

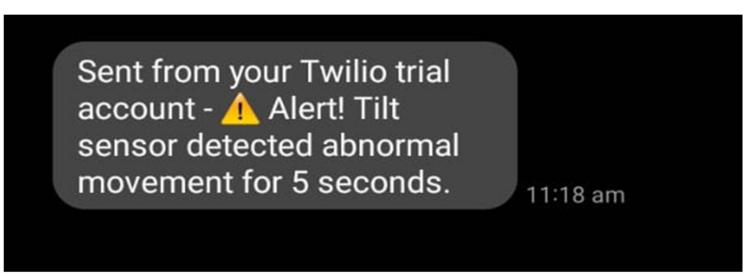


Fig 8.6 shows vehicle get accident tilt sensor activated and send a message to an recurited team.

 

## IX. CONCLUSION

The Collision Avoidance System for Hairpin Bends Using Ultrasonic Sensors was developed to address the critical safety challenges posed by sharp road curves, where visibility is significantly limited. In such locations, drivers often struggle to anticipate oncoming vehicles, leading to a higher risk of accidents. Traditional safety measures, such as convex mirrors and signboards, while useful, frequently fail to provide sufficient real-time alerts, particularly during nighttime or adverse weather conditions like heavy fog and rain. These limitations necessitated the development of a more advanced and responsive safety mechanism to mitigate the risks associated with blind curves and hairpin bends.

## X. FUTURE SCOPE

To further enhance the system's performance and effectiveness, the following improvements can be considered:

### *A. The integration of Artificial Intelligence (AI) and Machine Learning (ML)*

The transforming industries by improving automation, decision-making, and operational efficiency. These AI-powered systems can analyze large volumes of data, identify patterns, and make real-time decisions, resulting in more intelligent and adaptive technologies.

### *B. Extended Detection Range*

Combining LIDAR sensors with ultrasonic sensors enhances detection accuracy and extends the sensing range beyond 10 meters. Meanwhile, Extended Detection and Response (XDR) marks the next step in cybersecurity, offering a more cohesive and automated method for identifying and responding to threats. As cyberattacks grow more advanced, XDR delivers a unified defense by integrating multiple layers of security into a single, comprehensive solution.

### *C. Solar-Powered Implementation*

Incorporating solar panels to make the system energy-independent and sustainable. Solar-powered implementation involves installing solar panels or other solar technologies to convert sunlight into electricity. The electricity can be used immediately or stored in batteries.

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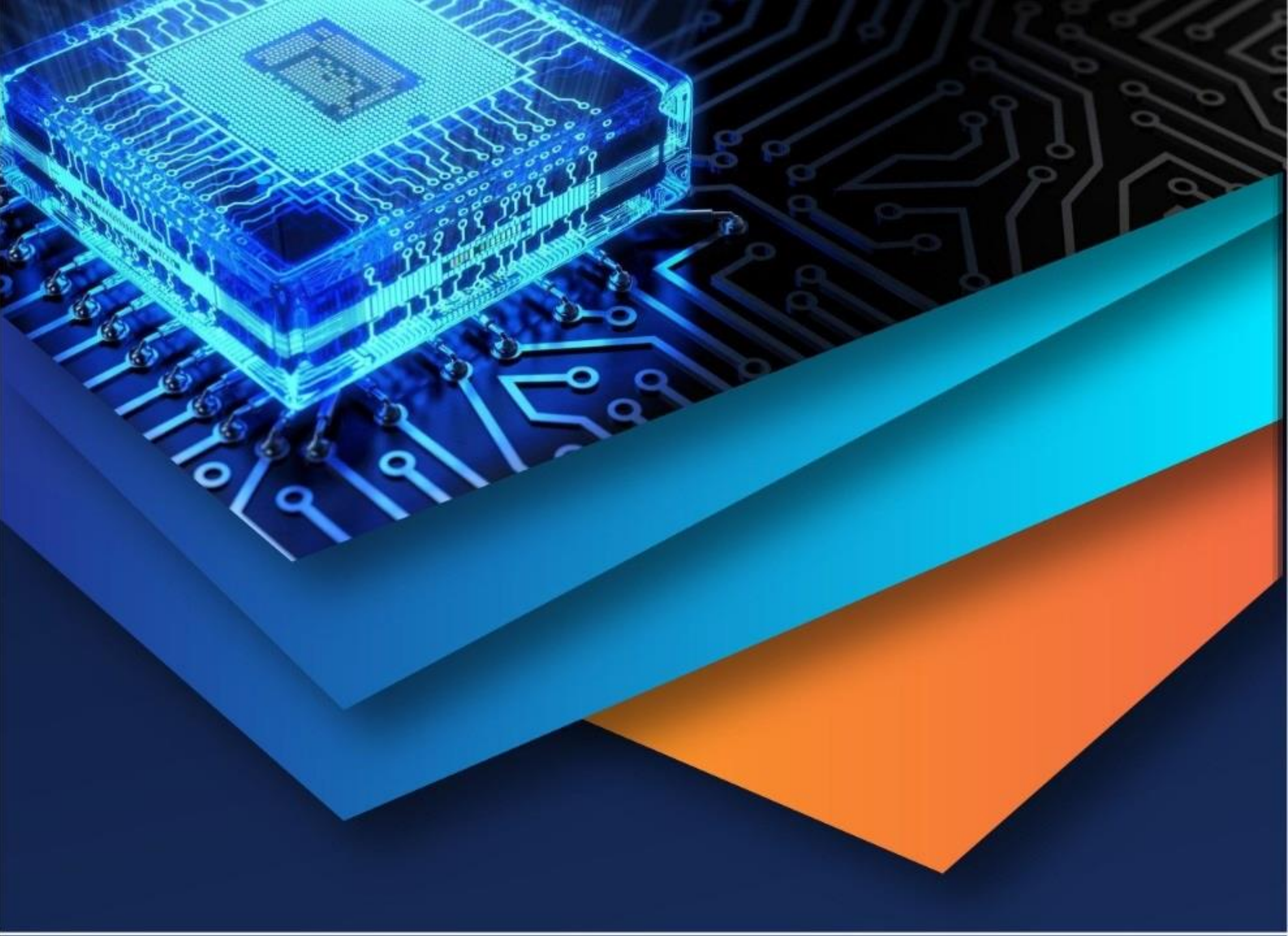


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