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A Comprehensive Review on Electric Vehicles Security

Vinay B R[1], Akash K R[2], Manoj S Achar[3], Vaibhava E M[4], Rashmi P[5]
[1, 2, 3, 4]*Department of Electrical and Electronics Engineering, Dayananda sagar Academy of Technology and Management, Bengaluru, India*
[5]*Project Guide, Department of Electrical and Electronics Engineering, Dayananda sagar Academy of Technology and Management Bengaluru, India*

Abstract: ***This paper presents an advanced vehicle security system leveraging an embedded system and GSM module. The proposed system integrates several key security features, including password-protected vehicle ignition activated via GSM, a biometric fingerprint locking mechanism for car doors, and real-time rash driving detection using an ADXL335 sensor coupled with GPS location tracking. The system utilizes an Arduino UNO microcontroller and displays relevant information on a 16x2 LCD. This multi-layered approach aims to significantly enhance vehicle security and driver safety.***
Keywords: Vehicle ignition, gsm, biometric, ADXL 335 sensor, GPS.

I. INTRODUCTION

In today's world, vehicle security has become paramount. With the increasing rate of vehicle theft, traditional security methods such as mechanical locks and alarms are often ineffective. Advanced security systems that integrate embedded systems, GPS and GSM technologies have been developed to improve vehicle security. Embedded systems, typically powered by microcontrollers serve as the core control unit. These systems interface with sensors to detect vehicle insecurity.

This project presents an advanced vehicle security system designed to enhance protection and provide real-time monitoring. Utilizing the power of an embedded system centered around the Arduino UNO and integrated with a GSM module, this system implements several key security features. These include a unique vehicle key ignition system activated by a password received via GSM, a highly secure fingerprint-enabled locking system for car doors using a biometric fingerprint device, and a crucial safety feature for rash driving detection employing the ADXL 335 sensor, which sends real-time location data via GPS. Information and alerts are conveniently displayed on a 16x2 LCD display, offering a comprehensive and intelligent approach to vehicle security.

The system boasts a multi-faceted approach to security and safety. Firstly, it implements a novel vehicle key ignition system based on a password transmitted via the GSM module. This feature eliminates the vulnerabilities associated with physical keys, allowing only authorized individuals possessing the correct remote password to start the vehicle. Secondly, the integration of a fingerprint-enabled locking system for car doors, powered by the biometric fingerprint device, provides an unparalleled level of security against unauthorized entry, ensuring that only registered users can access the vehicle's interior. Recognizing the critical importance of responsible driving, the system incorporates a sophisticated rash driving detection mechanism utilizing the ADXL 335 sensor. This sensor can detect sudden accelerations, decelerations, and sharp turns indicative of reckless driving. Upon detecting such behavior, the system can transmit real-time alerts, along with the vehicle's precise geographical location obtained from the GPS module, potentially mitigating dangerous situations and providing valuable data for vehicle management or emergency response. By synergistically combining these advanced features, this embedded system offers a significant leap forward in vehicle security and safety, providing vehicle owners with enhanced protection, control, and a greater sense of security.

With the rapid adoption of electric vehicles (EVs) driven by environmental concerns and advancements in clean energy technologies, ensuring the security of these vehicles has become increasingly critical. As EVs incorporate sophisticated electronics, battery systems, and autonomous features, they are more susceptible to theft, unauthorized access, and cyber-physical threats.

This paper presents a comprehensive electric vehicle security system that leverages embedded systems and GSM (Global System for Mobile Communications) technology to enhance protection and monitoring. The embedded module integrates various sensors and control units to detect suspicious activities such as unauthorized access, vehicle movement, or tampering. Simultaneously, the GSM module facilitates real-time communication with the vehicle owner via SMS alerts, location tracking, and remote actions such as engine immobilization.

II. LITERATURE SURVEY

[1] Advancements in IoT Enabled Smart Vehicle Security Systems (SVSS) presented by Rishika Yadav, Ishika Gupta, Vikas Chaudhary, Harsh chaukiyal and Vikas Yadav at 2024 1st International Conference on Advanced Computing and Emerging Technologies (ACET) | DOI: 10.1109/ACET61898.2024.10730728. Their system integrates multiple safety features, including Adaptive Headlight Control, an Emergency Support System (ESS), and Ultrasonic Sensor-Based Object Detection. Additionally, they introduce Intelligent Parking Aids to assist in safe vehicle maneuvering and enhance overall driving security through real-time automation and sensing.

[2] Developing Vehicle Security And Comfort: A Remote Car Lock And Ac Control System introduced by Varsha L.K. , Sonu kumar , Aravind Sasidharan Pillai, Santanu Kumar Dash, Prachi Sathe at 2024 Parul International Conference on Engineering and Technology (PICET) | DOI: 10.1109/PICET60765.2024.10716074. Focusing on comfort and security. Their system enables users to remotely lock/unlock their vehicle and control the air conditioning system, offering a convenience-driven approach that also improves the security of unattended vehicles through IoT.

[3] GSM based Vehicle Security Theft Control System presented by Tellapati Anuradha Devi, Gadi Sanjeev, Govardhan Roa, Sai Kalyani, Ramachandra, Kiran kumar
at 2024 3rd International Conference on Computational Modelling, Simulation and Optimization (ICCMSO)
DOI: 10.1109/ICCMSO61761.2024.00043. This system offers real-time vehicle tracking, location-based alerts, and remote engine shutdown capabilities, enabling owners and authorities to respond promptly in theft scenarios using GSM and GPS technologies.

[4] Cloud-Based Biometric Security System for Smart Vehicles introduced by Manjula B M, Nitin Shreepad Kolekar, Sakshi Priya, Raktim Banerjee at 2024 Second International Conference on Data Science and Information System (ICDSIS) | DOI: 10.1109/ICDSIS61070.2024.10594457. The system employs facial recognition for authentication and leverages cloud infrastructure to ensure scalability and real-time IoT integration. This enhances both the security and manageability of vehicle access systems.

[5] Design And Development of Real Time Vehicle Security System introduced by Isha Rajput, Sakshi Chauhan, Ankit Singh, Ayush Yadav, Balveer Singh at 2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE) | DOI: 10.1109/ ICACITE57410.2023. 10182753. A facial recognition-based ignition system was introduced to authenticate drivers before allowing engine ignition, aiming to reduce accidents due to drowsiness and unauthorized access.

[6] Comprehensive e IoT-based Vehicle Security: License Verification and Biometric Authentication presented by Rahul J.T., Sakshi J.C., Sanika N.C., Abhishek B.C., Virupaxi Dalal, Samiksha S.A. at 2025 6th International Conference on Mobile Computing and Sustainable Informatics (ICMCSI) | DOI: 10.1109/ICMCSI64620.2025.10883395. The system cross-verifies driving credentials and uses biometric data to ensure only authorized drivers can access and operate the vehicle, merging digital verification with physical security.

[7] An Automated Smart Centralized Vehicle Security System for Controlling the Vehicle Thefts/Hacking Using IOT and Facial Recognition introduced by Mayank Pathak, Kamta Nath Mishra, Satya Prakash Singh, Alok Mishra at 2023 International Conference on Computational Intelligence and Knowledge Economy (ICCIKE) | DOI: 10.1109/ ICCIKE58312.2023. 10131765. This system uses facial recognition, a key-card entry system, and drowsiness detection. It also includes features for data logging and GPS-based tracking, providing robust protection against theft and driver inattention.

[8] Development of a Two-Factor Authentication System for Enhanced Security of Vehicles at a Carpark introduced by Ezilaan Irraivan and Swee king Phang at 2022 International Conference on Electrical and Information Technology (IEIT) | DOI: 10.1109/IEIT56384.2022.9967804. It integrates Automatic Number Plate Recognition (ANPR) with a QR code system to ensure secure entry and exit, improving access control in shared or public parking environments.

[9] High Tech Vehicle Security Structure based on PIC using GPS and GSM introduced by R.Ravi , S.Kannadasan, K.A.Pranesh ,K.L.Jayaprakash, M.Selvapradap, A.Gokulchandar at 2023 International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS) | DOI: 10.1109/ ICSSAS57918.2023. 10331639. Their system supports both online and offline vehicle tracking and includes fuel theft detection, offering a comprehensive tracking solution with proactive theft and misuse alerts.

[10] Advanced vehicle security system introduced by Pritpal Singh; Tanjot Sethi; Bunil Kumar Balabantaray; Bibhuti Bhushan Biswal at 2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS) DOI: 10.1109/ICIIECS.2015.7193276. Featuring dual tracking modes—online and offline—and GSM-based alert messaging to relatives in case of unauthorized access or emergencies. The system enhances tracking reliability and family notification in real-time theft or crisis situations.

[11] Smart Vehicle Security System presented by B Ajay Veneesh Nelson; V Muthulakshmi; Janhavi Doijad at 2024 International Conference on Innovative Computing, Intelligent Communication and Smart Electrical Systems (ICSES) DOI: 10.1109/ICSES63760.2024.10910665. Focusing primarily on enhancing vehicle tracking and monitoring capabilities. The system is designed to ensure continuous surveillance of the vehicle's location and status, thereby deterring theft and enabling timely response in case of unauthorized movement.

III. PROBLEM STATEMENT

Stealing the vehicle is the major threat to car or vehicle owners. Nowadays, it is increasing day by day. So, the increasing rate of vehicle issues, such as vehicle theft , rash driving accidents and unauthorized access are critical challenges in vehicle security system. The Existing traditional security methods such as mechanical locks and alarms are often ineffective. For this, Need for Real-Time Tracking, Monitoring and Advanced security systems is essential. This study aims to develop a advanced vehicle security system using an embedded system, GPS and GSM module to improve vehicle security.

IV. COMPONENTS USED

Major components which are used to develop security model are listed below.

1) Arduino UNO

The Arduino Uno is a low-cost, open-source microcontroller board that's easy to use and can be integrated into many electronic projects. It's based on the ATmega328P chip and was originally released in 2010. The Uno is popular with hobbyists, educators, and professionals for prototyping and developing embedded systems, automation solutions, and more. It's considered the most robust and well-documented board in the Arduino family, making it a good choice for beginners.

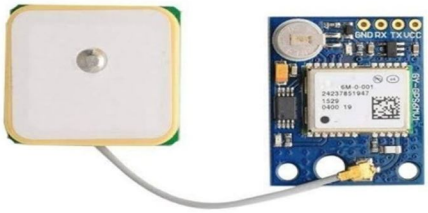
2) ADXL 335 Sensor

The ADXL335 has a measurement range of ±3 g minimum. The output signals are analog voltages that are proportional to acceleration. The accelerometer can measure the static acceleration of gravity in tilt-sensing applications as well as dynamic acceleration resulting from motion, shock, or vibration. The ADXL335 operates based on **capacitive sensing**. Inside the chip is a micro-electromechanical system (MEMS) structure that moves slightly when acceleration is applied. This movement changes the capacitance between tiny plates. These changes are converted into a voltage signal that is output as an analog voltage on three separate pins — one for each axis (X, Y, Z).

3) GSM module

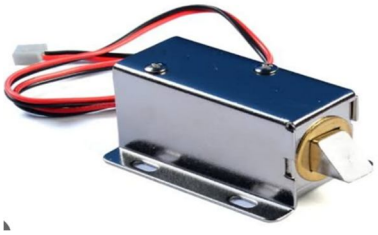
GSM modules are used for a variety of communication applications, primarily leveraging the GSM network to enable devices to send and receive data. These modules are versatile and can be found in remote monitoring and control systems, home automation, vehicle tracking, security systems, industrial automation, and even healthcare systems. They facilitate tasks like sending and receiving SMS messages, making and receiving calls, and data transmission via GPRS.

4) GPS module



GPS modules are used for a wide variety of applications, primarily focused on location, navigation, and timing. These modules are used in navigation systems, tracking devices, and various other applications requiring precise positioning data.

5) Locking Module



6) Ignition Key Setup

7) Biometric Fingerprint device

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Biometric fingerprint devices are used for authentication, identification, and verification in various applications, including security, banking, and access control. They offer a more secure and convenient way to verify identity compared to traditional methods like passwords or PINs.
Biometric devices are electronic systems that identify individuals based on unique physiological or behavioral characteristics. These devices are widely used in security systems for authentication and access control.

8) LCD Display

A 16×2 LCD display is a liquid crystal display that can show 16 characters in each of its two rows, providing a total of 32 characters of information. It's commonly used to display alphanumeric information in various electronic devices. A 16x2 LCD is a liquid crystal display module capable of displaying 2 rows with 16 characters each. It is widely used in embedded systems to show textual information such as system status, messages, or sensor outputs.

9) Buzzer/Alarm

A buzzer is an audio signaling device that generates sound when powered, typically used for alerts, warnings, or notifications in electronic systems. In security systems, such as vehicle alarms, it acts as an audible alert to indicate events like unauthorized access, motion detection, or other abnormal conditions.

10) 775 DC motor

The 775 DC motor is ideal for use in applications which need high output torsional force in small gadgets or devices. Its high torque features makes it suitable for use in areas of high usage such as; power tools, fans, and even electric vehicles.

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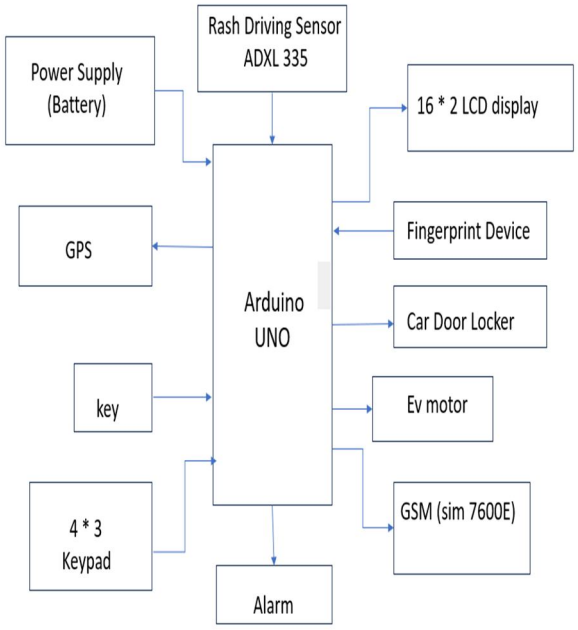
V. BLOCK DIAGRAM



This block diagram illustrates a security and control system for an electric vehicle (EV) centered around an Arduino UNO microcontroller. It incorporates various input devices such as a power supply (battery), GPS, key, 4x3 keypad, and a rash driving sensor (ADXL335). The system also includes security features like a fingerprint device, car door locker, and an alarm. User feedback and system status are provided through a 16x2 LCD display, while communication capabilities are enabled by a GSM (SIM800A) module. Ultimately, the Arduino UNO controls the EV motor based on the inputs and programmed logic.

By combining hardware-level security with mobile communication, the proposed system ensures a robust, scalable, and user-friendly approach to electric vehicle protection. This solution not only aims to deter potential theft but also empowers users with proactive monitoring and control features, making it a significant step toward secure and intelligent transportation.

VI. METHODOLOGY

This system employs a multi-layered security approach, integrating various sensors, identification methods, and communication technologies, all orchestrated by an Arduino UNO microcontroller. The core methodology revolves around continuously monitoring the vehicle's status, verifying user authorization, and providing alerts and control functionalities. Here's a step-by-step breakdown:

1) Powering the System: The system is powered by a battery, ensuring autonomous operation even when the vehicle's main power is off.

2) User Authentication: The system implements multiple layers of user authentication before allowing vehicle operation:

- Key Input: A traditional key serves as a primary mechanical access method.
- Fingerprint Recognition: A fingerprint device provides a biometric authentication layer, offering enhanced security and personalized access.
- Keypad Entry: A 4x3 keypad allows for the implementation of a PIN-based security system, providing an alternative or supplementary authentication method.

3) Driving Behavior Monitoring: A "Rash Driving Sensor" (likely an accelerometer like the ADXL335) continuously monitors the vehicle's movement. This allows the system to detect sudden accelerations, hard braking, or sharp turns, which could indicate unsafe driving.

4) Location Tracking: A GPS module provides real-time location data of the vehicle. This information can be crucial for tracking the vehicle in case of theft or for fleet management purposes.

5) Central Control and Processing: The Arduino UNO microcontroller acts as the central processing unit. It receives data from all the sensors and input devices, processes this information based on pre-programmed logic, and controls the various output components.

6) Security and Control Actions: Based on the input and processing, the Arduino triggers the following actions:

- Car Door Locker: The system controls the car door locks, likely enabling remote locking/unlocking and preventing unauthorized access.
- Engine Immobilization (Ev motor): The system can control the vehicle's engine (indicated as "Ev motor," suggesting it might be for an electric vehicle or generically representing the drive system), potentially immobilizing it in case of unauthorized access or detected theft.
- Alarm System: An alarm is triggered in response to unauthorized access attempts or detected rash driving (depending on the programmed logic).

7) User Interface and Feedback: A 16x2 LCD display provides visual feedback to the user, displaying system status, authentication prompts, or alerts.

8) Remote Communication: A GSM module (SIM800A) enables remote communication. This allows the system to:

- Send SMS alerts to a registered mobile number in case of security breaches, rash driving incidents, or other predefined events.
- Potentially receive commands remotely to lock/unlock doors or immobilize the vehicle (depending on the system's implementation).

In essence, the methodology involves:

- * Multi-factor authentication to ensure only authorized users can operate the vehicle.
- * Continuous monitoring of driving behavior and vehicle location for security and safety.
- * Real-time control over critical vehicle functions like door locking and engine operation.
- * Remote communication to provide timely alerts and potential remote control capabilities.

This integrated approach aims to create a robust and advanced vehicle security system that goes beyond traditional methods.

VII. IMPORTANCE OF THE PROJECT

A vehicle security system using embedded systems, GPS and a GSM module is a crucial innovation in protecting vehicles from theft and unauthorized access.

1) Theft Prevention.
2) Real time monitoring and control.
3) Cost- Effective security solution.
4) Smart Automation and Tracking.

VIII.CONCLUSION

The proposed advanced vehicle security system successfully integrates various embedded components such as an Arduino UNO, GPS module, fingerprint sensor, rash driving sensor (ADXL335), GSM module, and other peripheral devices to ensure a robust and efficient safety mechanism for electric vehicles (EVs).

The system aims to prevent unauthorized access using biometric verification, detect rash driving behaviors, and instantly communicate alerts via GSM. It also includes essential features such as real-time location tracking, vehicle locking control, and driver authentication, all displayed through an LCD interface.

The primary goal of this project is to enhance vehicle safety through automation, reduce the risk of theft, and improve driver accountability. By monitoring driving behavior and ensuring only authorized users can access and start the vehicle, this system addresses both safety and security concerns comprehensively.

The scope of this system extends to both personal and commercial vehicles, offering scalability for fleet management, accident detection, and remote immobilization. Future enhancements may include camera integration, IoT connectivity for cloud data logging, and AI-based behavior analysis for predictive alerts.

In conclusion, this system offers a comprehensive, low-cost, and effective solution for enhancing vehicle security. By combining biometric authentication, GPS tracking, and GSM communication, it ensures real-time monitoring and immediate response to abnormal events like unauthorized access or rash driving. The embedded control through Arduino UNO provides flexibility and ease of implementation.

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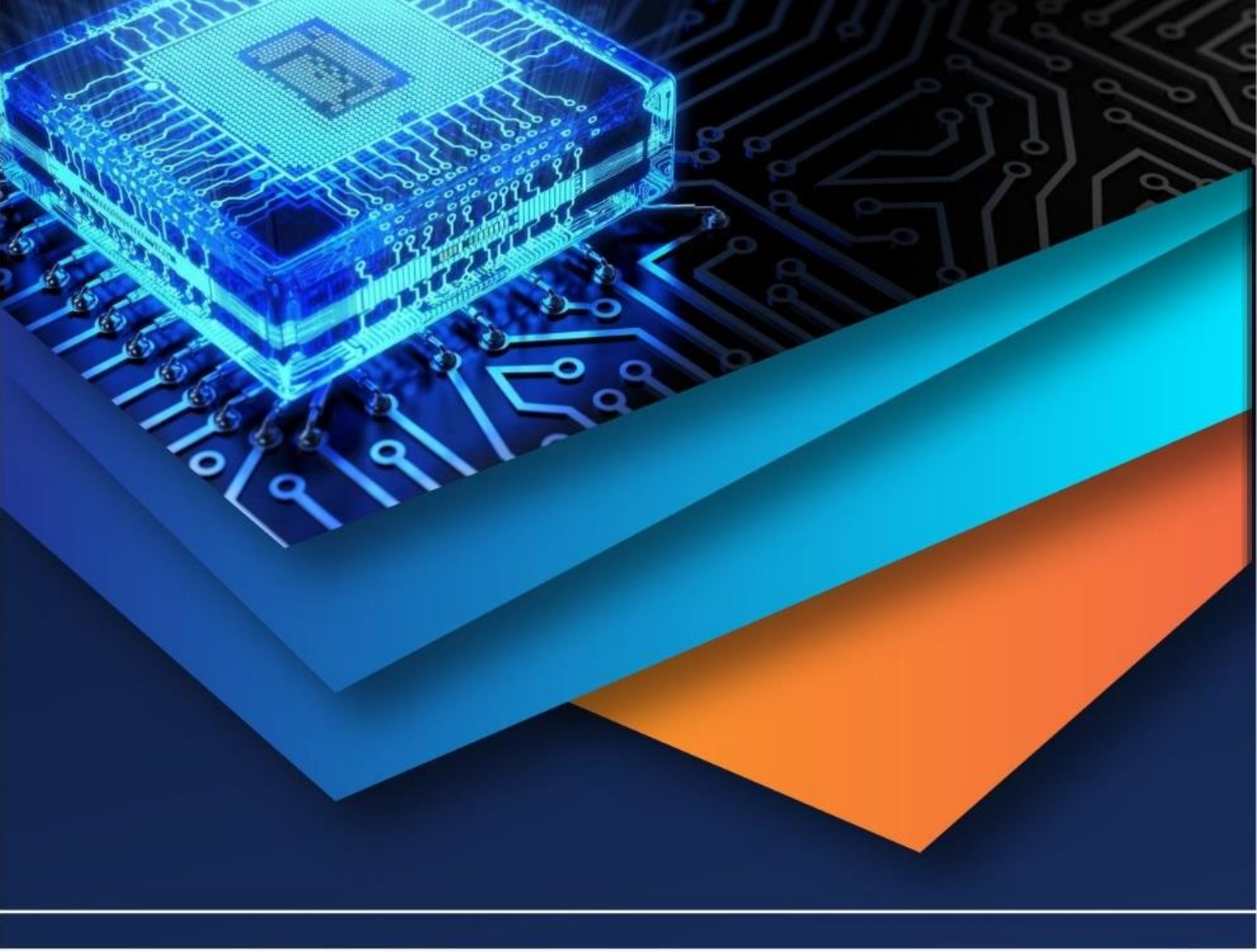

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