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Smart Home Gas Management System

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Abstract: Within the constantly evolving domain of smart home design, the persistent risks posed by gas leaks and fires present significant challenges, especially when crafting a kitchen model that is thorough and secure. Incidents stemming from gas leaks and fires can result in substantial damage to property, underlining the pressing need for sophisticated detection and prevention methods. The potential for flammable gas leaks to ignite fires and cause explosions stresses the necessity of integrating sensor-based initiatives for real-time monitoring. In response to these challenges, a proposed smart management system integrates gas leakage and fire detection through a micro- controller. By utilizing sensors and actuators, this system notifies users of gas detection through SMS alerts. Addressing vital concerns such as gas leak detection, alert systems via SMS and mobile notifications, user interface enhancements, booking functionalities, auditory alarms, and load cells for monitoring consumption, this all-inclusive system seeks to avert property and human losses in addition to warning users of gas leaks and home fires.

Index Terms: detection, alert, notification, real-time monitoring.

I. INTRODUCTION

The rapid development of smart home technology has fundamentally altered how we maintain and engage with our living environments. In the broad field of smart home design, the security and safety of the residents of these spaces remain top objectives. Particularly in the kitchen, which is a busy hub of activity and a popular area for potential hazards like gas leaks and fires, specialized processes must be put in place to properly restrict risks. Smart kitchen layouts run a substantial risk of gas leaks and fires, which can result in significant property damage and even pose a threat to human life. Conventional detection methods sometimes fall short because they are unable to offer timely notifications or proactive intervention [1]. Gas leaks and fires present a serious risk to smart kitchen layouts, with the potential to cause major property damage and endanger human life. Conventional detection methods sometimes fall short because they are unable to offer timely notifications or proactive intervention. As a result, there is an immediate need for creative solutions that seamlessly incorporate cutting-edge sensor technology, enabling quick detection and action in the event of a gas leak or fire [3]. This study presents a thorough smart management system that is carefully adapted for kitchen environments in direct response to these urgent concerns. This state-of-the-art system combines a variety of complex sensors and actuators with the power of micro-controller, including the ESP32. The system's synergistic integration enables prompt and decisive action in response to developing dangers by facilitating real-time monitoring of gas leaks and fire events [2]. Through the implementation of a multimodal approach, the system not only identifies and notifies users of possible risks but also actively works to avert accidents from occurring in the first place. Numerous improvements enable this proactive approach, such as user-friendly interfaces, alert systems for SMS and smart- phone notifications, audible alarms, and thorough consumption tracking features. Through the integration of these cutting- edge technologies, the suggested system seeks to provide homeowners with a deep sense of security, understanding that their kitchen area is constantly monitored for possible threats. This comprehensive system makes a substantial contribution to the continued evolution of smart home technologies through its steadfast commitment to enhancing safety and security in smart kitchen environments [8]. It also serves as a forceful reminder of the fundamental need of proactive risk mitigation measures.

II. LITERATURE SURVEY

Yahaya et.al [1] describes the development of an IoT- based system for monitoring and controlling gas leakage, using sensors, NodeMCU as the controller, and the Blynk application to notify users and trigger fire prevention devices. The system utilizes NodeMCU as the controller and Blynk application as the platform to notify the user when gas leakage occurs, monitor gas concentration, and control fire prevention devices.

The system also provided accurate reading of gas concentration at below 0.5 percentage error if compared to the actual reading.

Sony et.al [2] describes a system uses gas sensors, fire sensors, load cells, GSM modules, and other components to achieve goals. When gas leakage or fire is detected, the system sends SMS and call alerts to the user, activates a buzzer, and notifies the gas cylinder booking agency. The system also continuously monitors the weight of the gas cylinder and alerts the user when it reaches a threshold value. The system employs gas sensors, fire sensors, load cells, GSM modules, and microcontrollers to achieve its objectives. It focuses on detecting gas leakage and fire, notifying users via SMS and phone calls, and facilitating automatic gas cylinder booking when the gas level reaches a critical threshold.

eftekhar et.al [3] system includes features like an exhaust fan that turns on upon detecting smoke, high temperature, or excess gas, a timer system for cooking, and Bluetooth for voice-controlled burner operation. The system ensures safety by preventing accidental gas burner activation through the detection of a flame and a cooking pot, thus reducing gas wastage and enhancing kitchen safety.

Suma et.al [4] presents a Gas Leakage Detection and Mon- itoring System based on IoT technology. The system automat- ically books a new gas cylinder when the current one is about to empty by sending notifications to the gas agency. An MQ-5 sensor is used to detect various gasses like H2, LPG, CH4, CO, and Alcohol for gas leakage detection.Users can customize the threshold level for gas to be indicated as getting emptied, enabling proactive gas management. This paper demonstrates a high level of accuracy through a thorough review of related works and a detailed explanation of the system's design and benefits.

Sourav et.al [5] provides a low-cost gas leakage and fire detection system using NodeMCU and Machine Learning for accurate alerts and prevention. By incorporating sensors like MQ-2 Gas Sensor, IR Flame Sensor, and DHT11 Temperature Sensor, the system can detect gas levels, fire leakage, and temperature changes, sending alerts via GSM module and NodeMCU. The use of machine learning enhances sensor accuracy, making the system suitable for both residential and industrial applications, offering a practical solution to mitigate potential risks associated with gas and fire incidents.

Afsana et.al [6] have dicussed the issue of gas spillage and fire continues to be a major obstacle in the design of a comprehensive, safe and sustainable kitchen model. The proposed gas leakage detection and smart management system utilizes several components and sensors, including the MQ2 sensor for gas detection, the IR infrared flame sensor module for fire detection, the SIM900A GSM module for wireless communication, the Blynk application for control and moni- toring, the NodeMCU for Wi-Fi connectivity, the LCD display for output visualization, the solenoid valve for water flow, the ventilation fan for smoke and gas extraction, and the buzzer module for notification alerts.

Gavaskar et.al [7] describes a system for LPG leakage detection and control works by utilizing a gas sensor that is highly sensitive to gases like butane and propane. When the sensor detects a gas leak, it sends a signal to the controller, which then automatically shuts off the gas flow using a solenoid valve and turns on the exhaust fan. Additionally, a liquid crystal display (LCD) alerts users about the gas leakage, and an alarm message is sent to the user's smartphone via an application using IoT. The system also includes a fixed load cell to measure the weight of the LPG, enabling automatic booking of LPG when it reaches a low level.The limitations of the existing system for gas leakage detection and control include the lack of an efficient valve system to prevent leakage and the absence of a method to exhaust the leaked gas. These limitations can lead to serious safety issues in the event of a gas leak.

Rahul and Dr Vibha M B [8] discusses a detection system that integrates the MQ2 Gas sensor for accurate gas sensing, displaying concentrations on an LCD, activating indicators like LEDs and fans based on gas levels, and controlling gas flow with a solenoid valve and load cell for quantity measurement. The proposed system ensures safety by shutting off gas valves and sending SMS alerts, leveraging a Wi-Fi module for IoT- based gas leak detection. The methodology involves a network of physical objects for gas detection, a microcontroller-based approach for reservations and detectors, and the utilization of the ESP8266 Wi-Fi module for seamless data transmission.

Marjan Ralevski and Biljana Risteska Stojkoska [9] aims to improve safety in industrial kitchens by detecting gas leaks and house fires using an IoT-based system. It involves three main hardware components: the piGas subsystem, utilizing Rasp- berry Pi 1 Model B, MQ5 gas measuring sensor, logic level converter, and MCP3008 ADC for precise gas concentration measurements. The piTemp subsystem employs a Raspberry Pi 3 Model B and DS18B20 temperature measuring sensor for ac- curate temperature monitoring. The system transitions through different states, including initialization, passive temperature measuring, gas concentration measurement, and gas presence reasoning, utilizing moving average algorithms and advanced sensors to provide early warnings to end users in case of intolerant gas levels, ensuring proactive incident prevention in chaotic kitchen environments.

Sourabh et.al [10] discusses the design of an industrial monitoring system using Internet of Things (IoT) technology, focusing on gas leakage and fire detection. It highlights the integration of hardware components such as the Raspberry Pi 3 Model B, Gas Sensor (MQ-2), Fire Sensor, and GSM Module SIM900A. The system aims to detect gas leaks and fire hazards efficiently by utilizing sensors interfaced with the Raspberry Pi for data processing and communication.

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SMS alerts are sent to users when gas or fire is detected, enhancing safety measures through remote monitoring and control capabilities.

Metta Santiputri, Muhammad Tio [11] incorporates NodeMCU connected to gas and fire sensors to detect gas content and fire presence. The system utilizes a decision table to determine actions based on sensor readings, aiming to reduce accidents and losses. Successful testing resulted in notifications being sent to users for gas leaks and fire detection, enhancing safety.

Aishwarya et.al [12] incorporates system integrates hard- ware components like the MQ-6 sensor for gas leakage detection, Raspberry Pi 3 Model B as the gateway device, and MCP3008 ADC for analog to digital conversion. In conjunction with these hardware elements, the system employs software components such as an Android application for user interaction and notifications. The primary objective of the system is to swiftly detect gas leaks, notify users through SMS and app alerts, and provide a customizable solution that eliminates the need for additional alarming devices, enhancing overall safety and convenience.

III. PROPOSED METHOD

The lack of real-time monitoring capabilities in current gas leak and fire detection systems causes them to rely on manual intervention and sporadic checks, which delays the discovery of potential hazards. The promptness of emergency alerts may be limited by these systems' incompatibility with contemporary communication technologies. Additionally, they might not have proactive preventive measures, which would leave inhabitants exposed. In contrast, the proposed smart management system uses advanced sensors and cutting-edge parts like the ESP32 to offer real-time monitoring [10].In addi- tion to integrating with mobile apps for remote monitoring and notifications, it provides prompt answers to anomalies. All in all, it's a big step forward, guaranteeing thorough observation, anticipatory avoidance, and improved user experience for safer smart kitchen settings.

IV. IMPLEMENTATION

First and foremost, the gas management system prioritizes the creation of an aesthetically pleasing and user-friendly mobile application interface[12], focusing on gas booking and login functionalities. Users are guided through a seamless authentication process via a secure login page, gaining access to a dashboard upon successful login. From the dashboard, users can easily navigate to the booking section, where they can select their preferred day and time for gas delivery. Clear prompts and intuitive buttons enhance the booking process, ensuring user convenience. Integral to the system's functionality

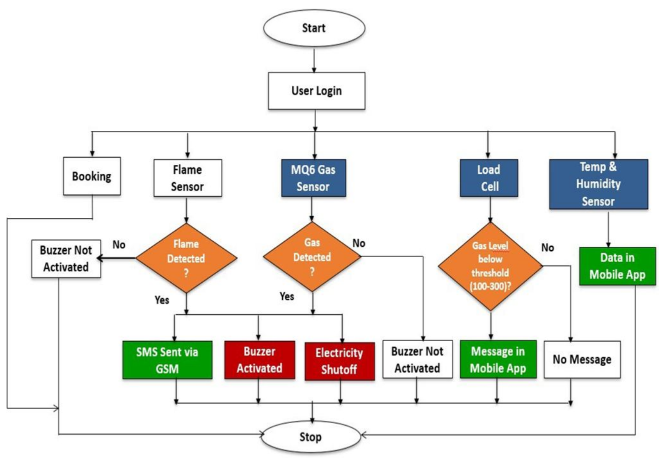

Fig. 1. Flow Chart

is the integration of sensors, such as load cells for real-time gas consumption tracking and MQ6 gas sensors for detecting potential gas leaks. Carefully positioned in high-risk kitchen areas, the MQ6 sensors continuously monitor for flammable gases[5,9] like propane and methane. Upon detecting a gas leak, the sensor alerts the ESP32 microcontroller, triggering notifications on the UI/UX interface and prompting immediate precautionary measures for users via their mobile devices.

Additionally, flame sensors strategically placed near poten- tial fire hazards, such as stoves and ovens, actively monitor for signs of fire, such as flames or sudden temperature increases. In the event of a fire, the flame sensor alerts users through the UI/UX interface and sounds an audible alarm via a buzzer [3]. The ESP32 microcontroller coordinates emergency protocols, displaying the fire's location on the interface and providing evacuation instructions to ensure occupant safety.

Furthermore, the gas management system leverages a com- bination of components, including the ESP32 microcontroller, a server (typically an IoT server), and a GSM module, to facilitate remote system control and enhance monitoring ca- pabilities[2]. However, safety considerations regarding the use of relays for shut-off valve control must be addressed, as gas appliances typically require manual operation to meet safety standards.

Overall, the integration of these elements and functionalities into the gas management system enhances safety and security in the kitchen, offering extensive monitoring and prevention capabilities. For an improved user experience and peace of mind, the companion mobile application guarantees user engagement and responsiveness, offers real-time notifications, and makes it easy to interact with the system's functions.

V. SYSTEM OPERATION

The system is categorized into hardware and software parts. The hardware part comprises of MQ-6 gas sensor, flame sensor, buzzer, load cell, ESP32 , GSM module and the software part comprises of mobile application.

A. Hardware Design

The schematic circuit design of the hardware gathering is centered on an ESP32 microcontroller, which is designed to collect data from several sensors and perhaps manage a load. With built-in Bluetooth and Wi-Fi, [1] the MH-ET LIVE ESP32 DEVKIT serves as the system's central processing unit. Ensuring smooth operation of the entire system is the responsibility of the Power Supply. In order to maximize the efficiency of the circuit, breakout boards are positioned strate- gically to make it easier for electronic components to interface with one another. Within this framework, certain sensors play pivotal roles: the KY-026 flame sensor, which is adept at identifying flames and communicating relevant signals to the microcontroller; and the RHT03 humidity and temperature sensor, which is able to evaluate environmental conditions and communicate pertinent data to the microcontroller. To further enhance the circuit's extensive sensing capabilities, a HX711 Module functions as a crucial load cell amplifier, boosting signals from the load cell sensor, which transforms force into an electrical signal. These parts are carefully connected to

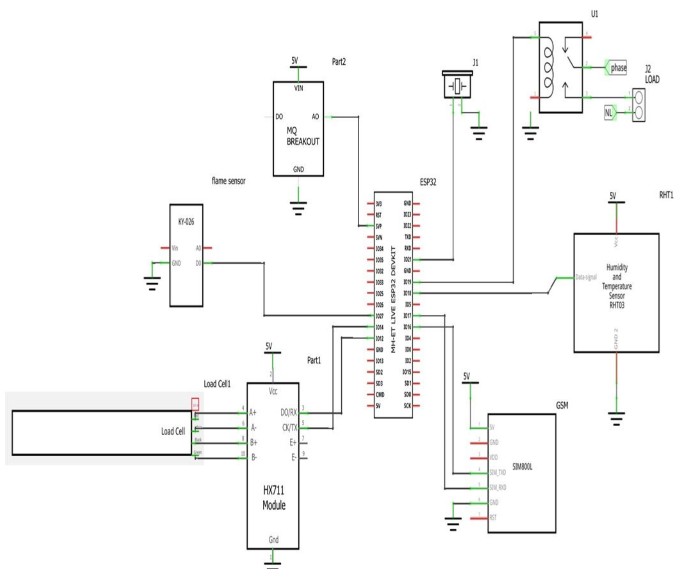

Fig. 2. Hardware Design

each other through a complex web of pins that includes power inputs (B+, E+, E-), ground connections (Gnd), and pins for clock/data transmission (CK/TX) and serial communication (DO/RX). This complex network ensures reliable performance for a wide range of applications by facilitating smooth com- munication and power distribution across the circuit. This circuit design's adaptability allows for a variety of uses. For example, it might be used to build a sophisticated fire alarm system that uses the flame sensor to quickly identify fires and send signals to the GSM [6] modem so that authorities are notified right away. Alternatively, it might be repurposed as a cutting-edge environmental monitoring system that allows temperature and humidity data to be tracked in real-time and

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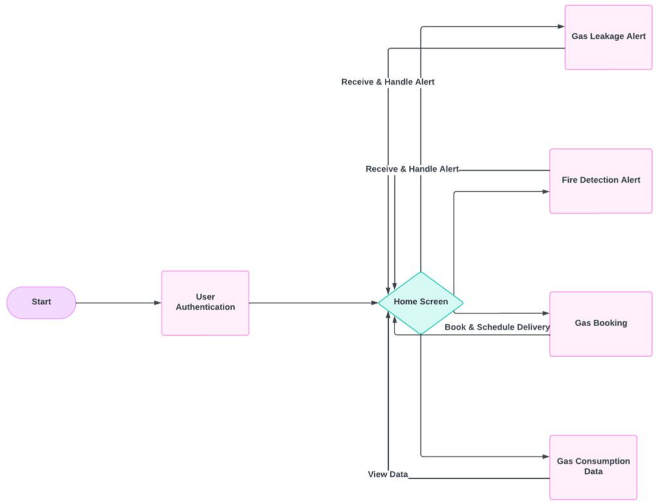

Fig. 3. Software Design

remotely transmitted via a GSM modem [10]. This would enable proactive intervention and informed decision-making in environmental management scenarios. In conclusion, the block diagram does not delve into the finer points of operation, but it does provide a general overview of the circuit's architecture and functionality. However, it captures the spirit of the circuit's creative design approach and offers a thorough grasp of its design principles and its applications.

The sensors or user inputs that detect gas leaks or fires, a smart stove capable of detecting gas leaks and communicating with the home automation system, and a central processing unit responsible for receiving signals from sensors and the stove to determine the presence of a gas leak or fire. Upon detection, the system initiates automated responses, such as shutting off the stove, sounding alarms, to mitigate the risk. Subsequently, the homeowner receives an alert through various means, including alarm notifications, mobile app notifications, or both, prompting them to take necessary actions, such as evacuating the home and contacting emergency services. By continuously monitoring sensor inputs and swiftly responding to potential hazards, the system ensures homeowner safety and enables proactive measures to address gas leaks or fires effectively.

B. Software Design

Fig 3 suggests its primary function is to receive alerts from a gas sensor, analyze them, and then activate an alarm if necessary. However, the presence of the ”User Input” block implies potential additional functionality, indicating the system's ability to receive signals from a smart stove in the event of a gas leak. This block diagram shows that the Gas Sensor/User Input is the main method for detecting gas leaks. It is most likely made up of sensors that can detect natural gas in the air, and the ”User Input” section implies that it is compatible with signals from a smart stove. The central processing unit, labeled the Home Gas Leak Alert System, receives signals from both the gas sensor and potentially the smart stove, utilizing this data to assess the presence of a gas leak. The system's response is then conveyed to the homeowner through the Alert to User block, which may involve triggering alarms, sending notifications to a mobile app, or employing a combination of both methods. In essence, the block diagram outlines a straightforward system tailored to detect gas leaks and promptly notify homeowners, providing a fundamental layer of safety in residential environments.

VI. RESULT AND CONCLUSION

The implementation of a smart home gas management sys- tem yielded promising results, significantly enhancing safety and security in the kitchen environment. Real-time monitoring capabilities enabled the timely detection of gas leaks and fire incidents, leading to prompt responses and mitigating potential hazards effectively. User feedback highlighted the convenience and ease of use provided by the intuitive user interface, allowing for seamless interaction with the system. Integra- tion with mobile notifications and booking functionalities further improved user experience, empowering homeowners to actively manage their kitchen environment. Overall, the smart gas management system demonstrated its effectiveness in enhancing safety, optimizing resource usage, and providing peace of mind to users in smart home environments. Ongoing discussions centered on fine-tuning system parameters, expanding integration with other smart home devices, and leveraging data analytics for continuous improvement.

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Fig 4 displays the hardware components integral to the smart home gas management system, encompassing the GSM module, temperature sensor, flame sensor, humidity sensor, MQ6 gas sensor, buzzer, load cell, relay bulb, and ESP32 microcontroller. The temperature sensor serves to monitor temperature fluctuations, while the flame sensor identifies the presence of flames, triggering a beep from the buzzer upon detection. Similarly, the MQ6 gas sensor is responsible for detecting gas leaks, prompting an alert from the buzzer. The load cell plays a crucial role in measuring the container's weight, facilitating gas consumption monitoring. Upon gas leak detection, the relay bulb blinks as an additional visual indicator. The ESP32 acts as the central hub, orchestrating the interconnected functionalities of all components. Additionally, the GSM module, equipped with a SIM card, enables commu- nication by sending SMS notifications to users in the event of fire or gas leak detection. Within the relay bulb, upon gas leak indication, automatic electricity shutoff occurs, extinguishing the bulb.

Fig 5 illustrates the software components of a smart gas management system, designed to enhance user safety and efficiency. The system features a user authentication page, ensuring that access is securely managed. Key functionalities include a gas leak detection page that alerts users to potential leaks, alongside a flame alert system for immediate notification in the event of fire. The software also integrates environ- mental monitoring, displaying temperature, humidity, and gas levels in real-time. For user convenience, there is a booking

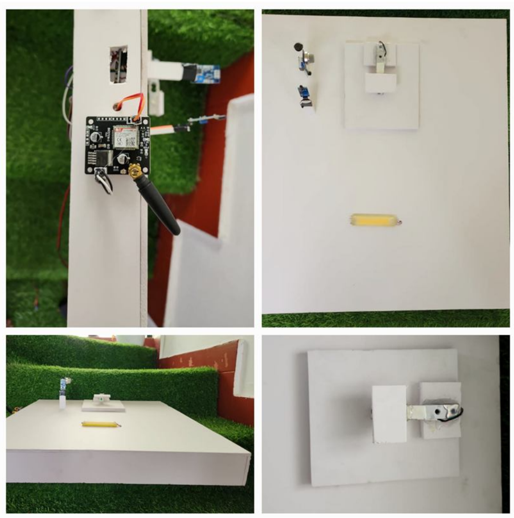

Fig. 4. Hardware Configuration

Fig. 5. Software Configuration

page for scheduling gas deliveries or maintenance services. Additionally, the system provides detailed gas consumption analytics, allowing users to monitor their usage patterns and optimize consumption through a user-friendly app interface. This comprehensive approach combines safety, convenience, and efficiency, streamlining the management of gas utilities in smart homes or businesses.

The system significantly enhances safety and operational efficiency in the kitchen by offering real-time monitoring of gas leaks and fire incidents. Its intuitive user interface and mobile notifications make it user-friendly and accessible, allowing homeowners to easily manage their kitchen environ- ment. Key features include automatic alerts via SMS, visual indicators through a relay bulb, and precise gas consumption monitoring facilitated by a load cell. The system integrates seamlessly with other smart home devices and utilizes data analytics for continuous performance enhancement, providing homeowners not only with safety and efficiency but also peace of mind. Future enhancements aim to expand its functionality and integration, promising to make it an even more essential component of smart home ecosystems.

In conclusion, the emergence of smart home gas manage- ment systems signifies a significant advancement in protecting kitchen environments from potential dangers like gas leaks and fires. Traditional systems often prove inadequate due to their lack of real-time monitoring, limited incorporation of mod- ern communication technologies, and insufficient proactive measures. However, the proposed smart management system, harnessing state-of-the-art technology such as microcontrollers and advanced sensors, presents a comprehensive solution. With features like real-time monitoring, immediate response capa- bilities, integration with mobile applications for remote access, and proactive prevention measures, this system effectively addresses existing shortcomings. Ultimately, the adoption of smart home gas management systems not only enhances safety and security but also showcases the transformative potential of innovative technologies in safeguarding our living spaces.

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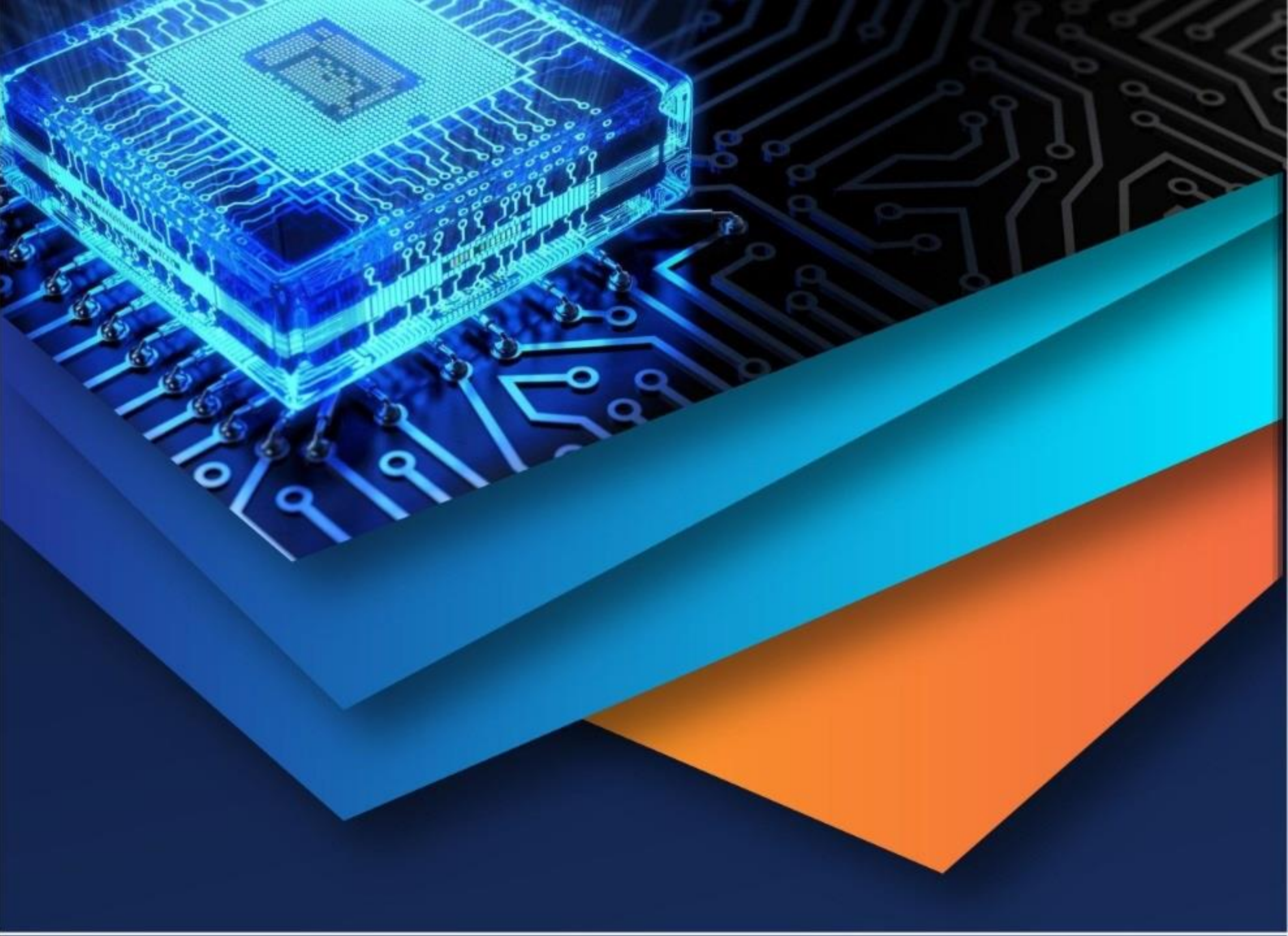

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