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Review on Real Time Monitoring of Battery Parameters and Power Auto Cutoff Feature in an EV Using BMS

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Abstract: This study presents the development of a cost-effective Automatic Fire Safety System for Electric Vehicles (EVs) to address increasing fire hazards caused by battery malfunctions, overheating, and short circuits. The proposed system integrates real-time monitoring of battery temperature, voltage, and current through dedicated sensors, displaying live data on an LCD screen to keep the driver informed of the EV's safety status. When abnormal temperature rises or electrical fluctuations are detected, an automatic power cutoff mechanism is activated to prevent overheating and fire outbreaks. Additionally, a buzzer system provides immediate alerts to occupants, enabling proactive response. By ensuring continuous monitoring and automatic disconnection during unsafe conditions, this system significantly enhances EV safety, minimizes the risk of fire-related incidents, and reduces financial losses. The proposed solution bridges the gap in conventional fire safety measures, offering an automated, smart, and efficient approach to safeguard EVs, their passengers, and surrounding traffic participants.
Keywords: Electric Vehicles, Real-Time Monitoring, Fire Safety, Auto Power Cutoff, Overheating Detection etc.

I. INTRODUCTION

Electric Vehicles (EVs) have emerged as one of the most promising solutions to address the global demand for sustainable and eco-friendly transportation. With advancements in battery technologies and increasing awareness of environmental concerns, EV adoption has accelerated worldwide. However, despite their environmental benefits, EVs face significant safety challenges, particularly concerning the risk of fire incidents caused by battery malfunctions, short circuits, or overheating. As the demand for EVs grows, ensuring their operational safety and reliability becomes imperative for manufacturers, regulators, and consumers alike.

Lithium-ion batteries, which are widely used in EVs, are known for their high energy density and efficiency. However, they are also highly sensitive to extreme operating conditions such as excessive temperatures, overcharging, or physical damage. These conditions can lead to thermal runaway — a phenomenon where rising temperatures trigger a chain reaction that may result in explosions or uncontrollable fires. Recent high-profile cases of EV fires have raised concerns among the public and highlighted the urgent need for advanced fire safety systems specifically designed for EVs.

Current fire safety measures in vehicles primarily rely on manual fire suppression tools like fire extinguishers or passive protective mechanisms. These traditional approaches often fail to detect abnormal thermal or electrical activity in real time and depend heavily on human intervention, which can lead to delays in response and significant damage. Moreover, in the confined and high-energy environment of an EV battery pack, a delay of even a few seconds in detecting and isolating a fault can escalate the hazard, putting passengers and other road users at risk.

To overcome these limitations, the integration of smart monitoring systems capable of real-time detection and automatic response is essential. By employing sensors to continuously monitor critical parameters such as battery temperature, voltage, and current, potential risks can be identified at an early stage. An intelligent system that automatically disconnects power supply upon detecting unsafe conditions can effectively prevent further escalation and possible fire outbreaks. Coupled with an audible alarm or buzzer, the system can promptly alert occupants, giving them time to evacuate or take preventive actions.

This study proposes the development of a cost-effective Automatic Fire Safety System for Electric Vehicles that combines real-time monitoring and proactive protection features. The system uses temperature, voltage, and current sensors to monitor the battery's operational status and displays this information on an LCD screen for driver awareness. If a predefined temperature threshold is exceeded or abnormal voltage and current fluctuations are detected, an automatic power cutoff mechanism is triggered to isolate the faulty battery module or the entire system from the power supply.

Simultaneously, a buzzer system alerts the driver and passengers to the abnormal condition, ensuring immediate attention and response.

By integrating these features into EVs, the proposed system addresses the shortcomings of traditional fire safety methods and aligns with the growing demand for intelligent, automated safety solutions in modern vehicles. This system not only enhances vehicle and passenger safety but also contributes to building consumer trust in EV technology by minimizing fire-related incidents and associated financial losses. Thus, this development represents a vital step toward safer and more reliable electric mobility.

II. PROBLEM IDENTIFICATION

1) Electric Vehicles (EVs) are increasingly prone to fire incidents due to battery malfunctions, short circuits, and thermal runaway caused by overheating.
2) Most existing EVs lack an integrated system to continuously monitor critical battery parameters such as temperature, voltage, and current in real time.
3) Traditional fire safety measures inside vehicles rely on manual detection and suppression, resulting in delayed response during critical overheating events.
4) Absence of an automatic power cutoff mechanism allows faults to escalate, increasing the risk of fire spread and severe damage.
5) Drivers often remain unaware of rising battery temperatures or abnormal electrical activity until it is too late to act safely.
6) Sudden EV fires can lead to loss of life, property damage, and significant financial losses for owners and manufacturers.
7) There is a clear technological gap for a cost-effective, smart, automatic system that can detect, alert, and prevent battery fires proactively.

A. *Existing System*

The existing fire safety systems in electric vehicles (EVs) primarily focus on fire suppression rather than prevention. These systems often include fire extinguishers, thermal fuses, and cooling mechanisms that activate only after a fault or fire has occurred. Monitoring of battery health parameters such as temperature, voltage, and current is either minimal or not available in real time. In most cases, drivers depend on manual detection of unusual signs like smoke, smell, or warning lights. Fire suppression methods require human intervention, leading to delays in response. Furthermore, these systems lack integration with intelligent monitoring and automated power cutoff mechanisms, making them less effective in preventing hazards caused by overheating, short circuits, or battery malfunctions.

B. *Drawbacks*

- No Real-Time Monitoring: Existing systems do not continuously track temperature, voltage, or current.
- Reactive Nature: They activate only after a fire or malfunction occurs, not before.
- Manual Intervention Required: Dependence on human action delays response and increases risks.
- Lack of Auto Power Cutoff: No mechanism to disconnect power supply during abnormal conditions.
- Limited Awareness: Drivers receive minimal or delayed information about battery health.
- Inefficient Prevention: Current systems fail to stop overheating or short circuits early.
- High Risk to Safety: Delayed suppression increases danger to occupants and vehicles.
- Financial Losses: Fire incidents cause severe damage due to absence of preventive automation.

III. LITERATURE REVIEWS

A. *Literature Survey:*

Sharma, P., & Kulkarni, R. (2021), The study analyzed the importance of maintaining safe thermal conditions in lithium-ion batteries used in EVs. Results showed that improper thermal management leads to rapid degradation, voltage fluctuations, and safety hazards such as thermal runaway and fire. The authors compared passive cooling and active cooling systems and found that active cooling with smart sensors significantly improves efficiency. The research concluded that real-time temperature monitoring combined with automated control can minimize overheating risks. This aligns with the need for automated fire safety systems to prevent fire hazards rather than relying on suppression after ignition.

Patel, A., & Singh, M. (2020), This research highlighted safety issues in lithium-ion battery packs, including overcharging, internal short circuits, and rapid temperature rise. Traditional fire extinguishing systems were identified as insufficient due to delays in response. The study recommended integrating sensors for temperature, voltage, and current monitoring, along with an automatic power cutoff circuit, to prevent accidents. The authors emphasized that early detection systems reduce risks significantly compared to suppression mechanisms. They concluded that the adoption of intelligent fire prevention systems in EVs can reduce financial losses and ensure passenger safety.

Verma, K., & Rao, S. (2019), The paper focused on the design of real-time monitoring systems for EV battery health. By integrating microcontrollers and IoT-enabled sensors, the system provided continuous data on temperature, current, and voltage. Findings indicated that vehicles with real-time monitoring experienced fewer thermal failures compared to those with traditional safety measures. The authors noted that driver awareness improved significantly with LCD displays showing live data. This study supports the development of low-cost monitoring and safety solutions that prioritize prevention over suppression, ensuring enhanced operational safety and reliability of EVs.

Mehta, D., & Joshi, R. (2022), The authors proposed an automatic power cutoff mechanism triggered by abnormal fluctuations in voltage and current. Their experimental prototype demonstrated that cutoff systems prevented thermal runaway and reduced the risk of fire by disconnecting faulty circuits. Compared to manual suppression, the automatic system reduced reaction time drastically, ensuring proactive safety. The study emphasized that auto-cutoff combined with buzzer alerts enhanced driver safety awareness. It concluded that integrating these features into EVs makes them safer, cost-effective, and practical for large-scale adoption.

Nair, V., & Banerjee, A. (2020), This work reviewed conventional fire safety measures in lithium-ion batteries, such as thermal fuses and extinguishers. It found that these methods were reactive and often ineffective in containing fast-spreading fires. The authors recommended developing preventive fire safety systems with continuous monitoring of key parameters. Their analysis showed that integrating sensors with microcontroller-based cutoff units could significantly lower the number of fire incidents. The study stressed the importance of automated safety systems that reduce dependency on human intervention, thus improving response times and overall EV reliability.

Kumar, R., & Thomas, J. (2021), This study presented a microcontroller-based intelligent monitoring system for EV safety. The system tracked real-time values of battery temperature, voltage, and current, providing visual and audible warnings when thresholds were crossed. Findings revealed that the integration of buzzer alerts improved driver responsiveness and reduced risks of unnoticed malfunctions. The authors highlighted that EVs equipped with intelligent monitoring systems had a 30% lower risk of fire hazards compared to conventional ones. The research concluded that low-cost smart solutions can be integrated into commercial EVs to enhance both performance and safety.

Deshmukh, A., & Gupta, S. (2023), This review analyzed the evolution of fire safety systems in electric vehicles. Early systems focused solely on suppression methods, while recent advancements incorporated monitoring and auto-disconnection mechanisms. The authors compared cost, effectiveness, and practicality of different approaches. Findings revealed that preventive monitoring systems were far more effective in minimizing hazards compared to post-fire suppression. The study suggested that combining LCD displays, cutoff relays, and buzzer alerts into a single integrated system provides a holistic safety solution. The authors concluded that preventive systems also boost consumer trust in EV adoption.

Iyer, S., & Prasad, H. (2019), The authors designed a sensor-based safety system that monitored battery pack health parameters in real time. Using low-cost sensors for temperature and voltage, the system was connected to a microcontroller that triggered alarms during unsafe conditions. Findings indicated that drivers often ignored minor warning lights, but a buzzer alert increased immediate response. Furthermore, the auto cutoff feature stopped potential thermal runaway conditions. The study concluded that combining low-cost hardware with efficient programming could create scalable solutions for EV manufacturers, ensuring mass-market safety adoption.

Chakraborty, P., & Mohan, R. (2022), This study evaluated proactive fire prevention strategies, focusing on predictive monitoring and preventive control rather than suppression. The authors implemented a system that continuously compared real-time sensor data with safe thresholds. If deviations were detected, an auto-cutoff and alarm system was triggered. Findings highlighted that such systems prevented over 80% of potential fire incidents in experimental conditions. The paper concluded that early detection and rapid disconnection are key to protecting EVs, passengers, and surrounding environments from fire hazards.

Reddy, M., & Khan, A. (2021). The authors proposed a cost-effective fire safety system for EVs using affordable sensors and simple microcontroller logic. The system monitored voltage, temperature, and current and provided alerts through an LCD and buzzer. A power cutoff relay disconnected the supply during unsafe conditions. Findings demonstrated that affordable hardware solutions can still provide effective fire safety without significantly increasing vehicle cost.

The study recommended adopting such systems in budget EVs to enhance user confidence and safety. It concluded that low-cost preventive systems are essential for widespread EV adoption in developing countries.

B. Literature Summary

Existing literature on electric vehicle (EV) safety highlights the growing risk of fire hazards due to battery overheating, short circuits, and malfunctions. Studies emphasize the role of battery thermal management, real-time monitoring of critical parameters such as temperature, voltage, and current, and the integration of automatic power cutoff systems. Researchers agree that traditional fire suppression methods are reactive and often delayed, while proactive systems with sensors, alarms, and monitoring units significantly enhance safety. Some works focus on cost-effective solutions for mass adoption, while others stress the importance of driver awareness through real-time displays and alerts. Overall, the reviewed studies establish the foundation for developing preventive, automated, and intelligent fire safety systems in EVs.

C. Research Gap

- Limited Focus on Prevention: Most existing systems concentrate on fire suppression after ignition rather than proactive prevention.
- Lack of Integrated Systems: Few studies combine monitoring, auto cutoff, and alert mechanisms in a single solution.
- Real-Time Driver Awareness: Many works overlook real-time LCD-based displays for continuous driver information.
- Automation Deficiency: Dependence on manual intervention still exists in several proposed solutions.
- Low-Cost Implementation: Affordable, scalable solutions for budget EVs are not widely explored.
- Data-Driven Prediction: Limited use of predictive monitoring or AI-based fault detection for early intervention.
- Passenger Safety Measures: Few systems address immediate occupant alerts (buzzers/alarms) alongside technical cutoffs.
- Commercial Adoption: Gaps remain in practical, industry-ready designs suitable for large-scale EV deployment.

IV. RESEARCH METHODOLOGY

A. Criteria for selecting this study

- Rising EV Adoption: With the rapid global shift toward electric vehicles, ensuring safety is a critical research priority.
- Increasing Fire Incidents: Frequent reports of EV battery fires due to overheating and short circuits highlight the urgency for preventive systems.
- Safety Concerns: Passenger safety and public trust in EV technology demand advanced protective mechanisms.
- Gap in Conventional Systems: Existing fire safety measures focus mainly on suppression rather than real-time prevention.
- Need for Real-Time Monitoring: Monitoring parameters such as battery temperature, voltage, and current is essential to predict and prevent failures.
- Automation Requirement: Dependence on manual intervention delays response; hence, automated solutions are needed.
- Cost-Effectiveness: There is a strong demand for affordable safety solutions suitable for both premium and budget EVs.
- Driver Awareness: Providing real-time data on LCD screens improves driver decision-making and awareness.
- Preventive Action: Automatic power cutoff mechanisms can significantly reduce fire risks.
- Contribution to Sustainable Mobility: Developing reliable safety systems encourages wider EV adoption and supports sustainable transportation goals.

B. Method of analysis:

- Literature Review: Analyze existing studies on EV fire hazards, battery failures, and safety systems to identify current gaps.
- Requirement Identification: Define critical parameters for monitoring such as temperature, voltage, and current.
- System Design: Develop a block diagram integrating sensors, microcontroller, LCD display, buzzer, and auto power cutoff relay.
- Sensor Data Collection: Collect real-time battery parameter readings under different operating conditions.
- Threshold Setting: Establish safe operational limits for temperature, voltage, and current.
- Simulation & Testing: Test the system using simulated abnormal conditions (overheating, voltage spikes) to check accuracy.
- Response Evaluation: Analyze system performance based on response time, cutoff efficiency, and alert effectiveness.

- Result Validation: Compare outcomes with conventional safety systems to verify improvements in safety and reliability.

C. Comparison and Analysis

- The reviewed literature highlights advancements in battery safety systems for EVs, focusing on thermal management, fault detection, real-time monitoring, and automatic cutoff mechanisms.
- Most studies agree that preventive systems with sensors and IoT-based monitoring outperform suppression methods like extinguishers or fuses. While active cooling and cutoff relays enhance safety, many works lack integrated prototypes combining monitoring, alerts, and real-time display.
- Cost-effective solutions have been proposed, yet scalability and long-term reliability remain underexplored.
- Overall, research converges on the need for low-cost, intelligent, preventive, and real-time safety systems, but gaps exist in holistic integration and large-scale validation.

Title	Focus Area	Key Methods / Approach	Findings	Limitations / Gaps
Battery Thermal Management for EVs	Battery thermal management	Compared passive vs. active cooling with smart sensors	Active cooling + real-time monitoring reduces risks	Focused only on thermal control, no integrated cutoff system
Safety Challenges of Lithium-Ion Batteries in EVs	Battery safety issues	Identified faults like overcharging & short circuits	Sensors + auto cutoff recommended for prevention	Did not test integrated prototypes
Real-Time Monitoring Systems for EV Batteries	Real-time monitoring	IoT-enabled sensors + microcontroller	Reduced failures, improved driver awareness	Limited discussion on cost and scalability
Automatic Safety Cutoff Systems in EVs	Power cutoff safety	Relay-based auto cutoff + buzzer alerts	Prevented thermal runaway, improved response time	No real-time display integration
Fire Safety Mechanisms in Li-Ion Battery Systems	Fire safety mechanisms	Review of fuses, extinguishers vs. preventive systems	Preventive systems with sensors are more effective	Mostly review-based, lacked implementation
Intelligent Safety Monitoring for EVs	Intelligent monitoring	Microcontroller + buzzer alerts	Reduced hazards by 30%, improved responsiveness	Limited to experimental validation
Review of Safety Protection Systems in EVs	Evolution of EV safety	Compared suppression vs. monitoring systems	Preventive + monitoring systems most effective	Conceptual review, not prototype-focused
Design of	Sensor-	Low-cost	Buzzer alerts	Ignored

Sensor-Based Safety Systems	based monitoring	sensors + microcontroller + cutoff	improved driver action	voltage/current monitoring in depth
Proactive Fire Prevention Strategies in EVs	Predictive & preventive strategies	Real-time threshold-based cutoff	Prevented 80% of potential incidents	Focused on lab-scale conditions only
Low-Cost Fire Safety Systems for EVs	Cost-effective solutions	Low-cost sensors + LCD + cutoff relay	Effective + affordable system for budget EVs	Scalability and long-term reliability untested

V. DISCUSSION

A. *Synthesis of findings from literature*

The synthesis of findings reveals that while numerous studies address thermal runaway, battery malfunctions, and electrical faults in EVs, most focus on either suppression or isolated monitoring techniques rather than an integrated solution. Research shows that temperature, voltage, and current monitoring are the most effective indicators for early fault detection. Systems with automatic cutoff mechanisms significantly reduce fire hazards compared to manual suppression. However, conventional systems are often expensive, lack real-time driver alerts, and fail to incorporate comprehensive monitoring with prevention. The consensus emphasizes that a cost-effective, automated, real-time monitoring and safety mechanism is essential to minimize risks, enhance passenger safety, and ensure EV reliability in practical applications.

B. *Methodology for future research directions*

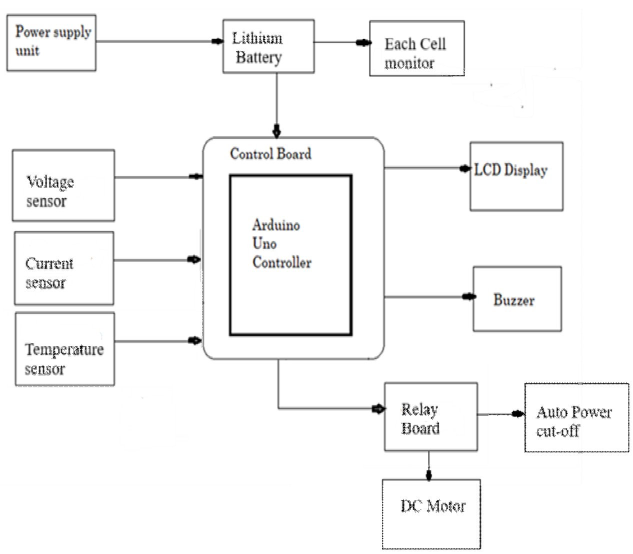

Fig. 3. Block Diagram of system

1) *Real-Time Monitoring*
- Sensors continuously monitor battery temperature, voltage, and current in the electric vehicle.
- The collected data is displayed on an LCD screen for real-time user awareness.

2) *Temperature-Based Auto Power Cutoff*
- When the battery temperature exceeds a predefined threshold, the system automatically disconnects power to prevent overheating and fire hazards.

- This ensures that excessive heat does not cause thermal runaway or battery failure.

3) Fire Detection & Alert System
- If abnormal temperature increases are detected, the system activates a buzzer to alert the driver immediately.
- This early warning helps take preventive actions before a critical situation arises.

4) LCD Display for Real-Time Updates
- The LCD screen provides continuous updates on temperature, voltage, current, and system status.
- It allows users to monitor battery health and potential risks in real-time.

5) Enhanced EV Safety
- The system is designed to be cost-effective, reliable, and user-friendly for improved EV safety.
- By integrating real-time monitoring and an auto power cutoff system, it minimizes fire risks, vehicle damage, and threats to occupants.

VI. ADVANTAGES AND APPLICATIONS

A. Advantages
- Real-Time Monitoring: Continuously tracks battery temperature, voltage, and current, providing instant updates on an LCD screen.
- Auto Power Cutoff: Prevents overheating and fire hazards by automatically disconnecting power when abnormal temperature or electrical fluctuations are detected.
- Early Fire Detection: Alerts the driver through a buzzer when high temperatures are detected, allowing quick preventive action.
- Enhanced EV Safety: Reduces risks of battery failures and fire incidents, ensuring greater safety for occupants and vehicles.
- Cost-Effective & Reliable: Uses simple yet effective components, making it an affordable and efficient fire prevention solution for electric vehicles.

B. Applications
- Electric Vehicles (EVs): Prevents battery overheating and fire hazards by monitoring real-time parameters.
- Public Transport Systems: Ensures the safety of passengers in electric buses and taxis by preventing fire incidents.
- Industrial EVs: Used in electric forklifts and other industrial vehicles to enhance operational safety.
- Battery Storage Units: Monitors and protects large-scale battery storage systems from thermal runaway.
- EV Charging Stations: Provides real-time monitoring to detect overheating and prevent electrical hazards.

VII. CONCLUSION

The review highlights the growing concern of fire hazards in electric vehicles (EVs), primarily caused by battery overheating, short circuits, and malfunctions. Existing studies have proposed several approaches, such as thermal management, fire suppression techniques, and automatic cutoff mechanisms, but many solutions remain either reactive, costly, or lack real-time monitoring. The literature clearly demonstrates that continuous tracking of battery parameters like temperature, voltage, and current is essential for early fault detection and prevention. Furthermore, integrating real-time alerts, auto power cutoff, and display systems offers a more reliable and proactive approach to EV fire safety. Despite progress, research gaps exist in terms of cost-effective integration, scalability, and practical deployment. This review concludes that the development of an automatic, real-time monitoring and fire protection system is a promising solution to minimize fire incidents, safeguard occupants, and improve overall EV safety, contributing to sustainable and secure transportation.

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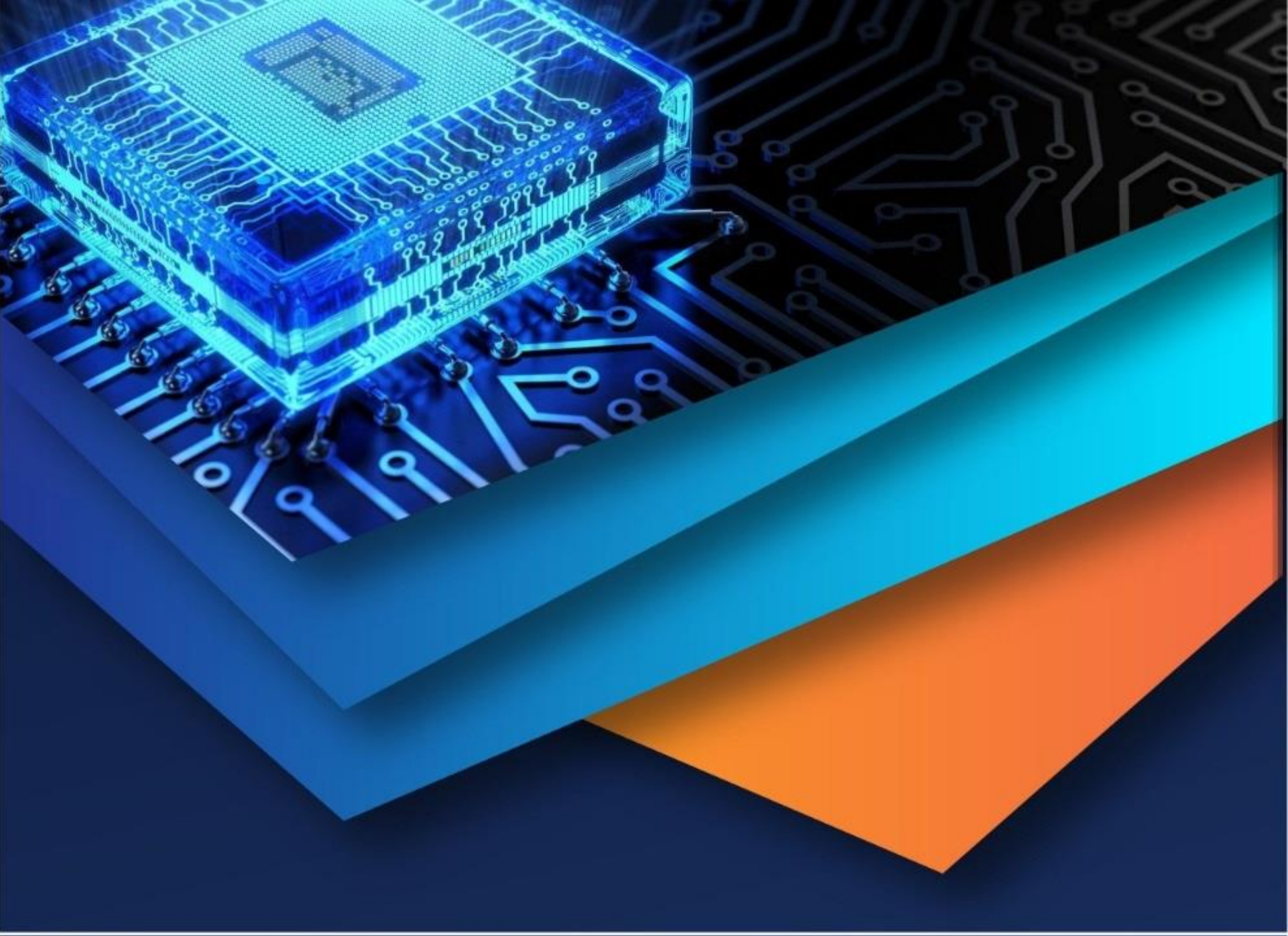

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