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Transmission Line Power Theft

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Abstract: Generation, transmission and distribution of electrical energy involve many operational losses. We can defined the losses in generation technically but distribution and transmission losses cannot be precisely quantified with the sending end information. This illustrates the involvement of nontechnical parameter in transmission and distribution of electricity. Moreover technical losses occur naturally and are caused because of power dissipation in transmission lines, transformers, and other power system components. Technical losses in Transmission & Distribution are computed with the information about total load and the total energy bill. While technology in the raising slopes, we should also note the increasing immoral activities. The system prevents the illegal usage of electricity. At this point of technological development the problem of illegal usage of electricity can be solved without any human control using IoT. With the implementation of this system will save large amount of electricity, and there by electricity will be available for more number of consumer then earlier, in highly populated country such as India, China. Power theft can be defined as the usage of the electrical power without any legal contract with the supplier. To see it, a proposed system (current measurement and comparison) is proposed in which the distribution of family power is done indirectly from the distribution box to each house. Power theft is a persistent issue in many countries, leading to significant financial losses for utility companies and affecting the reliability of power supply. In this study, we propose a novel approach for detecting power theft in transmission lines using NodeMCU ESP8266, a low-cost Wi-Fi-enabled microcontroller, and Blynk IoT platform for remote monitoring and control.The proposed system involves installing current sensors at various locations along the transmission lines to measure the current flow. The NodeMCU ESP8266 is used as a data acquisition unit that collects the current data from the sensors and sends it to the Blynk IoT platform via Wi-Fi for real-time monitoring. The Blynk platform provides a user-friendly interface for visualizing the data and setting up alarms and notifications for abnormal current patterns, which could indicate power theft. The system can also track power consumption trends, identify abnormal usage patterns, and provide insights for optimizing power distribution. The proposed system has several advantages, including low-cost implementation, real-time monitoring, remote access, and easy customization through the Blynk platform. It has the potential to significantly reduce power theft, improve revenue collection for utility companies, and enhance the overall reliability of power supply in transmission lines. Further research and development can be done to optimize the system's performance and expand its applications in different power distribution scenarios.
The Methodology is divided into 8 Parts :
1) ***System Design***
2) ***Component Selection***
3) ***Circuit Design and Schematic Creation***
4) ***NodeMCU ESP8266 Development Board***
5) ***Data Analysis through Blynk IoT Platform***
6) ***Remote Monitoring and Control***
7) ***Customization and Scalability***
8) ***LCD Display Integration***

All these six parts were assembled together and experiments were then performed to build a system that can update the precise fault location and also display on LCD of Kms where the fault correction is to be carried out.
Keywords: Current Sensors, Blynk IoT, Data Analysis, NodeMCU ESP8266.

I. INTRODUCTION

Power theft is the practice of stealing electrical power. Electricity utilities in India lose crores of rupees every year to power theft. According to Section 135 of the Electricity Act 2003, electricity theft occurs when a person taps electricity lines, tampers with electricity meters or transformers or uses a device that interferes with reading or damages equipment such as electric meters or uses electricity for purposes other than authorized. If under the circumstances theft of electricity is detected, then the electric utility can immediately disconnect the supply of electricity.

The punishment for such offence is “three times the financial gain on account of such theft of electricity”. In case the person repeats the offence then the person is debarred from getting electricity supply for not “less than three months but may extend to two years”.

There are various types of electricity power theft and they relate to each part of the electrical equipment namely, a) meters, b) cables, and c) overhead lines. Further, usage of service connection other than for the authorized purpose also falls under the category of theft.

Meters: There can be tampering with meters and seals to stop the mechanical disk from moving. Another method is to bypass the meter by illegally connecting to the fuse thus preventing the rotating disk from moving thus preventing recording of the consumption of energy. Another common method is to damage or remove the meters. Other methods may include opening the meter itself, without damaging its seals and reversing the dials, a complicated procedure that requires expert skill. In the case of electronic meters, a sudden electrostatic discharge can cause either latent damage or permanent damage.

Wires/cables: In the case of wires and cable, theft of electricity occurs due to illegally tapping to bare wires or underground cables. In the case of wires, the circuit wire is disconnected or broken from the circuit terminal block and a triple breaker inserted in the circuit.

Transformers: Theft in this case refers to the illegal terminal tapping of overhead lines on the low voltage side of the transformer. There can be two types of tapping: fish pole connections and flying connections.

Misuse or diverting service connections: Electricity connections must be used for the purpose it is authorized for. For example, if the connection is effected for domestic purposes it is to be used for authorized domestic premises only. The service connection should not be extended to other purposes like commercial purposes, industrial purposes, construction purposes, etc. This constitutes theft of electricity.

II. LITERATURE SURVEY

The literature related to Transmission Line Power Theft Detection focuses on various techniques and technologies used for detecting power theft incidents in transmission lines. Some of the key findings from the literature are:

1) Current sensing techniques: Many studies have proposed the use of current sensors, such as current transformers or Rogowski coils, to measure the current flow in transmission lines for power theft detection. These sensors can provide real-time data on current flow, and abnormal current patterns can be analyzed to detect potential power theft incidents.
2) IoT and Cloud-based solutions: Several research works have utilized Internet of Things (IoT) and cloud-based platforms for transmission line power theft detection. These solutions involve using IoT devices, such as NodeMCU ESP8266 or Arduino, to collect data from current sensors and send it to cloud-based platforms, such as Blynk, for analysis, visualization, and remote monitoring.
3) Data analysis and machine learning algorithms: Many studies have employed advanced data analysis techniques, including machine learning algorithms, for detecting abnormal patterns in current data that may indicate power theft. These algorithms can analyze historical and real-time data to identify patterns or anomalies in current flow, and trigger alarms or notifications when power theft is suspected.
4) Multi-sensor fusion: Some research works have proposed the use of multiple sensors, such as current, voltage, and temperature sensors, in combination to improve the accuracy of power theft detection. Multi-sensor fusion techniques can provide a more comprehensive and reliable approach for detecting power theft incidents in transmission lines.
5) Remote monitoring and control: Literature suggests that remote monitoring and control of the power theft detection system is crucial for timely actions. Many studies have proposed user-friendly interfaces for remote monitoring and control of the system, allowing utility company personnel to access the system through mobile devices or computers, receive real-time alerts, and remotely control the system for further investigation or action.
6) Cost-effective implementation: Several studies have focused on developing cost-effective solutions for transmission line power theft detection, utilizing low-cost components, such as NodeMCU ESP8266 or Arduino, to make the system economically viable for large-scale deployment by utility companies.

III. PROBLEM DEFINATION

The problem of power theft in transmission lines is a significant issue that affects utility companies and power distribution systems worldwide. Power theft refers to the unauthorized consumption or diversion of electricity, leading to financial losses for utility companies, increased electricity prices for legitimate consumers, and reduced reliability of power supply.

Detecting power theft in transmission lines is challenging as it often involves bypassing meters, tampering with transmission lines, or using unauthorized connections, which can be difficult to detect using traditional methods.

The problem of power theft in transmission lines poses several challenges, including:

1) Loss of Revenue: Power theft results in significant financial losses for utility companies, as the stolen electricity is not billed to the rightful consumers. This can impact the financial viability of the utility company and result in increased costs for legitimate consumers to compensate for the losses.
2) Inaccurate Billing: Power theft can lead to inaccurate billing and revenue collection, as stolen electricity is not accounted for in the billing system. This can result in incorrect billing for legitimate consumers, leading to customer dissatisfaction and loss of trust.
3) Operational Challenges: Detecting power theft in transmission lines requires continuous monitoring of current flow at various locations, including before and after the energy meter, and along the transmission lines. Traditional methods may not be efficient or effective in detecting power theft incidents in real-time, leading to delays in identifying and addressing the issue.
4) Security Risks: Power theft incidents can involve tampering with transmission lines, bypassing meters, and other unauthorized activities, which can pose security risks to the power distribution system. Tampering with transmission lines can result in damage to infrastructure, endangering the safety of workers and the public.
5) Complex Detection: Power theft incidents can involve various methods, such as bypassing the meter, tampering with the transmission lines, or using unauthorized connections, making it challenging to detect using conventional methods. Advanced detection techniques and technologies are required to accurately identify power theft incidents and differentiate them from legitimate electricity consumption.
6) Lack of Remote Monitoring: Traditional methods of power theft detection may not provide remote monitoring and control capabilities, making it difficult for utility companies to effectively monitor and manage power theft incidents in real-time, especially in remote or inaccessible locations.

Addressing these challenges requires innovative solutions that utilize advanced technologies, such as IoT, data analysis, and real-time monitoring, to accurately detect power theft incidents in transmission lines, enable remote monitoring and control, and optimize power distribution to prevent power theft and improve the overall reliability of power supply.

IV. PROBLEM SOLUTION

The proposed solution for Transmission Line Power Theft Detection includes the following steps:

1) Installation of Current Sensors: Current sensors will be installed at strategic locations along the transmission lines, including before and after the energy meter and at the theft lead. These sensors will measure the current flow in real-time and send the data to a central monitoring system for analysis.
2) NodeMCU ESP8266 with Blynk IoT Platform: NodeMCU ESP8266, a low-cost and widely used IoT development board, will be used to collect the data from the current sensors and send it to the cloud-based Blynk IoT platform via Wi-Fi for visualization and analysis.
3) Data Analysis and Abnormal Pattern Detection: The data collected from the current sensors will be analyzed in real-time using advanced algorithms to detect abnormal current patterns that could indicate power theft, such as sudden spikes or drops in current, inconsistent current flow, or deviations from expected patterns.
4) Alarm and Notification System: When abnormal current patterns are detected, the system will trigger an alarm and send notifications to relevant authorities, such as utility company personnel, through the Blynk platform. This will enable timely actions to be taken to investigate and prevent power theft incidents.
5) Remote Monitoring and Control: The Blynk IoT platform will provide a user-friendly interface for remote monitoring and control of the system. Utility company personnel will be able to access the system through a mobile device or a computer, allowing them to monitor current data, receive real-time alerts, and remotely control the system for further investigation or action.
6) Customization and Scalability: The proposed solution will be customizable to suit different power distribution scenarios, including different types of current sensors, transmission line configurations, and power theft detection algorithms. It will also be scalable to accommodate additional features or expand to cover more transmission lines or locations in the future

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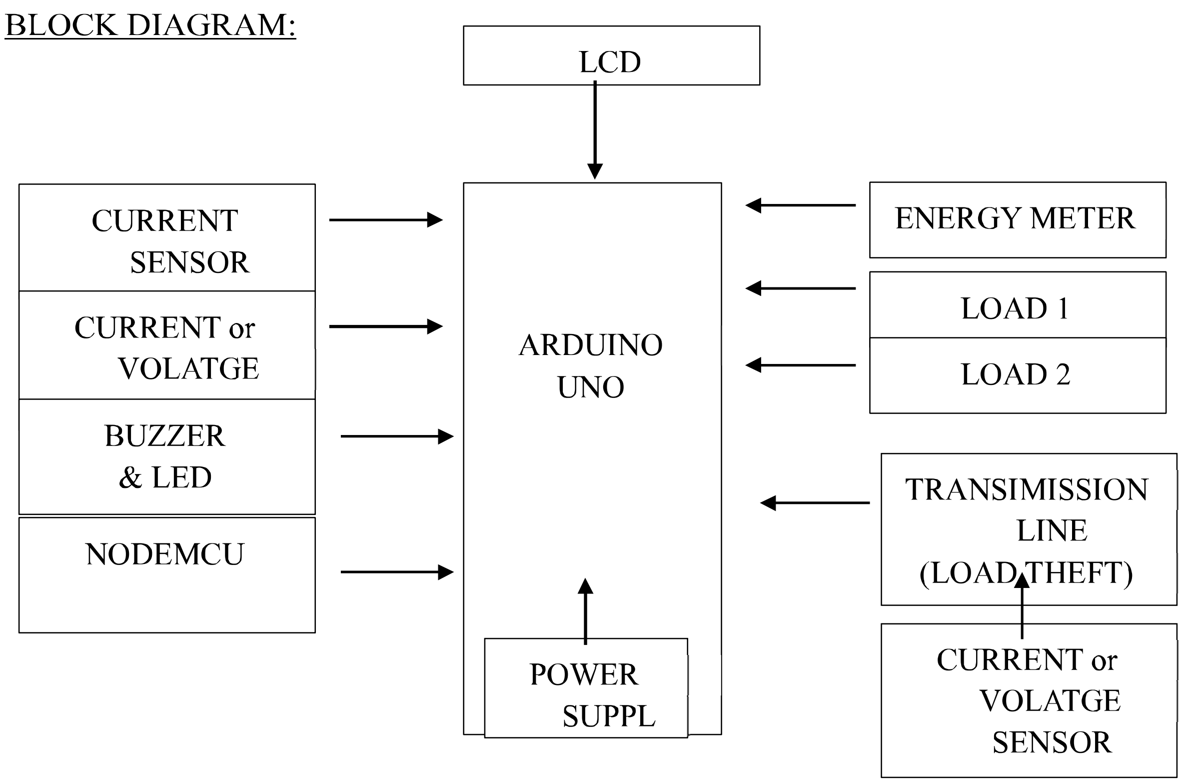
7) Cost-effective Implementation: The proposed solution will utilize low-cost components, such as NodeMCU ESP8266 and current sensors, to make it economically viable for utility companies to deploy and operate on a large scale, ensuring a cost-effective solution for power theft detection.

By implementing this solution, utility companies can effectively detect power theft incidents in real-time, receive timely alerts, and take appropriate actions to prevent power theft, improve billing accuracy, and enhance the overall reliability of power supply in transmission lines.

V. PROPOSED SYSTEM



Proposed system architecture

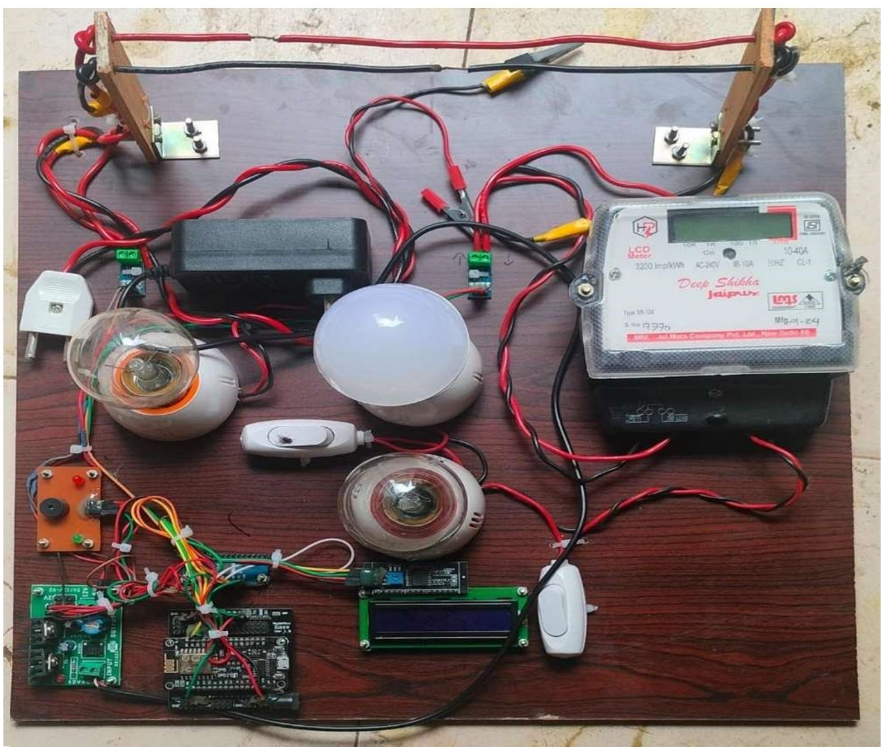
The proposed system for Transmission Line Power Theft Detection involves the use of current sensors, NodeMCU ESP8266 development board, Blynk IoT platform, and advanced data analysis algorithms for real-time and automated detection of power theft incidents. The key components of the proposed system are:

1) Current Sensors: Current sensors will be installed at strategic locations along the transmission lines, including before and after the energy meter and at the theft lead. These sensors will measure the current flow in real-time and send the data to a central monitoring system for analysis.
2) NodeMCU ESP8266 Development Board: NodeMCU ESP8266, a low-cost and widely used IoT development board, will be used to collect the data from the current sensors and send it to the cloud-based Blynk IoT platform via Wi-Fi for visualization and analysis.
3) Blynk IoT Platform: Blynk is a popular cloud-based IoT platform that provides a user-friendly interface for data visualization, analysis, and remote monitoring and control. The data collected from the current sensors will be sent to the Blynk platform for real-time visualization, analysis, and alerting.
4) Data Analysis and Abnormal Pattern Detection: The data collected from the current sensors will be analyzed in real-time using advanced algorithms to detect abnormal current patterns that could indicate power theft incidents. This may involve comparing the current data with expected patterns, identifying sudden spikes or drops in current, inconsistent current flow, or other abnormal patterns that may indicate power theft.

5) Alarm and Notification System: When abnormal current patterns are detected, the system will trigger an alarm and send notifications to relevant authorities, such as utility company personnel, through the Blynk platform. This will enable timely actions to be taken to investigate and prevent power theft incidents.
6) Remote Monitoring and Control: The Blynk IoT platform will provide a user-friendly interface for remote monitoring and control of the system. Utility company personnel will be able to access the system through a mobile device or a computer, allowing them to monitor current data, receive real-time alerts, and remotely control the system for further investigation or action.
7) Customization and Scalability: The proposed system will be customizable to suit different power distribution scenarios, including different types of current sensors, transmission line configurations, and power theft detection algorithms. It will also be scalable to accommodate additional features or expand to cover more transmission lines or locations in the future.
8) Cost-effective Implementation: The proposed system will utilize low-cost components, such as NodeMCU ESP8266 and current sensors, to make it economically viable for utility companies to deploy and operate on a large scale, ensuring a cost-effective solution for power theft detection.

VI. RESULT & DISCUSSION

A. Result



B. Discussion

The proposed system for Transmission Line Power Theft Detection is designed to enhance the efficiency and effectiveness of detecting and addressing power theft in real-time, using advanced IoT technologies and data analysis methods. At its core, the system employs strategically placed current sensors along transmission lines to monitor the flow of electricity. These sensors are installed at critical points, including before and after energy meters and at potential theft points, to provide comprehensive coverage and accurate detection of any discrepancies in current flow.

The data collected by these current sensors is transmitted to a central monitoring system via the NodeMCU ESP8266 development board, a cost-effective and versatile IoT device equipped with Wi-Fi capabilities. This enables continuous data collection and real-time transmission to the cloud-based Blynk IoT platform. Blynk serves as the central hub for data visualization, storage, and analysis, providing a user-friendly interface accessible from both mobile devices and computers. This real-time data visualization allows utility company personnel to monitor the status of the transmission lines continuously.

The system's advanced data analysis capabilities are key to its effectiveness. By employing sophisticated algorithms, the system can detect abnormal current patterns that may indicate power theft. These algorithms compare real-time current data against expected patterns, historical data, and predefined thresholds to identify irregularities such as sudden spikes, drops, or inconsistent current flow. This analytical approach ensures that even subtle or sophisticated theft attempts can be detected promptly.

When the system detects abnormal patterns, it triggers an alarm and sends instant notifications to relevant authorities, such as utility company personnel. These alerts are delivered through the Blynk platform, ensuring that the appropriate actions can be taken swiftly to investigate and mitigate potential power theft incidents. This realtime alert system significantly reduces the response time compared to traditional methods, allowing for quicker resolution and minimizing the financial losses associated with power theft.

Additionally, the Blynk platform offers robust remote monitoring and control capabilities. Utility personnel can access the system remotely to monitor real-time current data, receive alerts, and even control the system for further investigation or intervention. This feature enhances the operational efficiency and flexibility of the utility company, enabling them to manage the system from any location.

The proposed system is designed with scalability and customization in mind. It can be tailored to fit different power distribution scenarios, accommodating various types of current sensors, transmission line configurations, and detection algorithms. This flexibility ensures that the system can be adapted to meet the specific needs of different utility companies and can be expanded to cover additional transmission lines or locations as required.

Moreover, the system's cost-effectiveness is a significant advantage. By utilizing affordable components such as the NodeMCU ESP8266 and standard current sensors, the system provides a financially viable solution for largescale deployment. This makes it accessible to utility companies of different sizes, enabling widespread adoption and implementation to effectively combat power theft.

In summary, the proposed system for Transmission Line Power Theft Detection leverages modern IoT technology, real-time data analysis, and a cloud-based platform to provide an efficient, effective, and economical solution for detecting and addressing power theft in transmission lines. Its advanced features, including real-time monitoring, instant alerts, remote access, and customization, make it a valuable tool for utility companies aiming to enhance their operational efficiency and reduce losses due to power theft.

VII. ADVANTAGES

There are several advantages of using IoT-based Transmission Line Power Theft Detection systems, including:

1) Real-time monitoring: IoT-based systems provide real-time monitoring of power consumption and current flow data, allowing for immediate detection of abnormal patterns or behaviors that may indicate power theft. This enables timely detection and prevention of power theft incidents, minimizing losses for utility companies.
2) Remote monitoring and control: IoT-based systems allow for remote monitoring and control of power consumption data, eliminating the need for manual inspection and reducing operational costs. Utility company personnel can remotely monitor power consumption data, receive real-time alerts, and take prompt action in case of power theft incidents, improving efficiency and reducing response time.
3) Improved accuracy and reliability: IoT-based systems leverage advanced data analysis techniques, such as machine learning algorithms, to analyze complex patterns and trends in power consumption data, leading to improved accuracy and reliability of power theft detection. This minimizes false positives or false negatives, ensuring that legitimate power theft incidents are accurately detected and false alarms are minimized.
4) Cost-effective and scalable: IoT-based systems can be cost-effective and scalable, with the potential for wide deployment in transmission line networks. Sensors and devices used in IoT-based systems can be affordable and easily installed, making the system accessible for implementation in various power distribution scenarios.
5) Enhanced security: IoT-based systems can provide enhanced security features, such as encrypted data transmission, authentication, and access control, ensuring the integrity and confidentiality of power consumption data. This protects against unauthorized access or tampering of data, ensuring the reliability and trustworthiness of the system.

6) Integration with existing systems: IoT-based systems can be easily integrated with existing utility company systems, such as SCADA (Supervisory Control and Data Acquisition) systems, smart grid systems, and AMI (Advanced Metering Infrastructure) systems, enabling seamless data exchange and coordination. This allows for efficient management and coordination of power theft detection and prevention efforts.

VIII. CONCLUSIONS & FUTURE SCOPE

In conclusion, the proposed system for Transmission Line Power Theft Detection using current sensors at strategic locations, NodeMCU ESP8266 with extension, and Blynk IoT platform offers a promising solution for detecting power theft incidents in the transmission line network. By deploying current sensors before and after the energy meter, as well as a theft lead and two home loads, the system can accurately monitor and analyze the current flow in real-time, allowing for the detection of abnormal patterns that may indicate power theft. The integration of IoT devices, such as NodeMCU ESP8266, and the use of Blynk IoT platform enable remote monitoring, data collection, and analysis, providing utility companies with a convenient and efficient way to detect power theft incidents. The system can also be integrated with existing utility company systems, such as SCADA or billing systems, for seamless operation and management. The proposed system has the potential to significantly reduce power theft losses, improve revenue collection for utility companies, and enhance the overall efficiency and reliability of the transmission line network. However, thorough testing, validation, and optimization of the system are crucial to ensure its accuracy, reliability, and scalability. It is also important to comply with relevant regulations and standards during the implementation of the system.

Overall, the proposed system for Transmission Line Power Theft Detection using current sensors, NodeMCU ESP8266, and Blynk IoT platform holds promise as an effective solution for detecting power theft incidents and mitigating losses in the transmission line network. Further research, development, and testing are needed to optimize and validate the system's performance in real-world settings.

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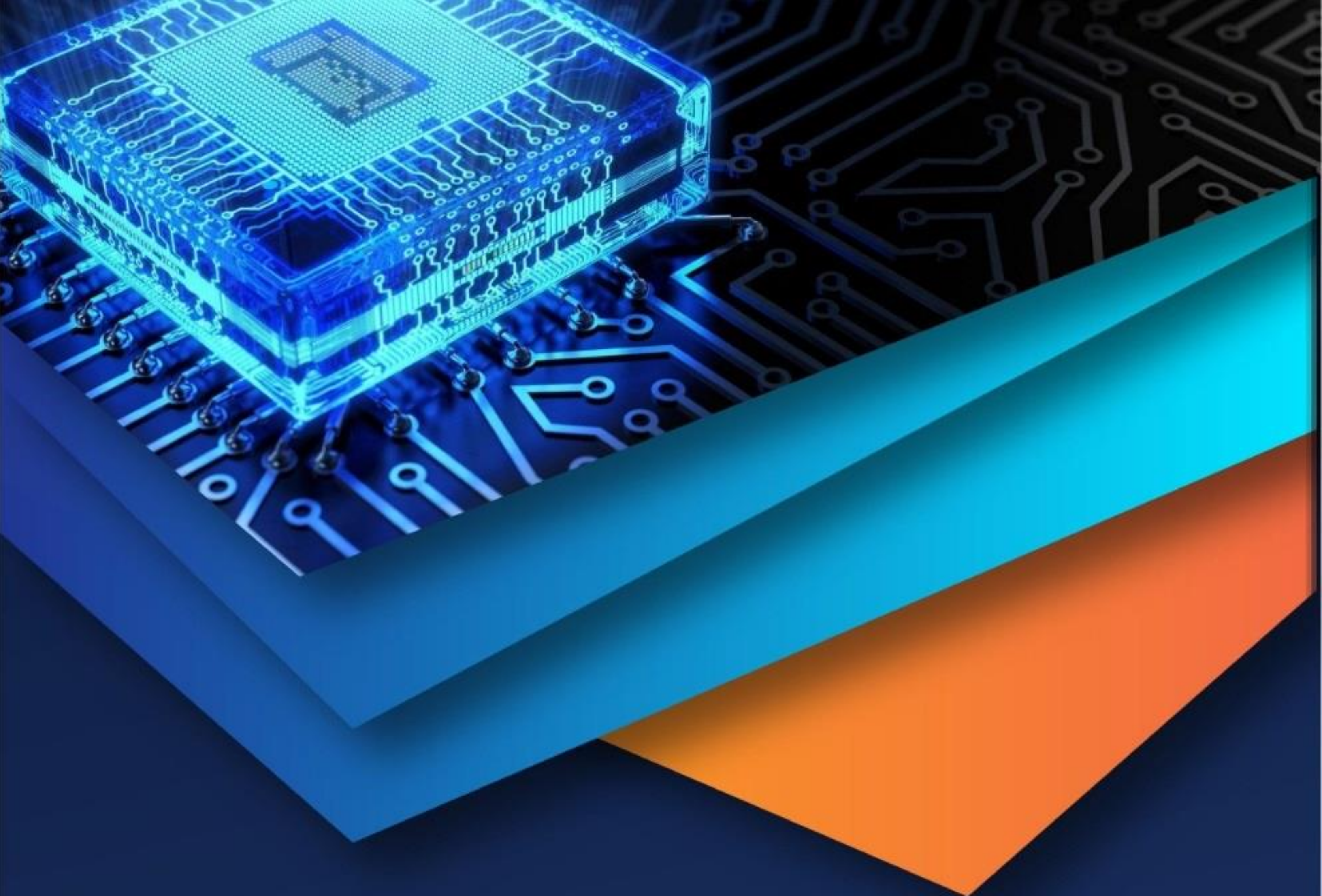

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