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Automated Light System Using IOT

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Abstract: ***The proposed project focuses on developing an Automated Light System Using IOT designed to enhance energy efficiency by controlling lighting based on human motion. The system utilizes a PIR (Passive Infrared) sensor to detect human presence. When motion is detected, the light will automatically turn on. The system operates with both AC (Alternating Current) and DC (Direct Current) power sources and is controlled via an Arduino microcontroller, ensuring seamless automation. The integration of jumper wires allows easy connection of components such as the relay, bulb, PIR sensor, and AC power circuit. This automated lighting solution eliminates the need for manual control, offering an efficient method for energy conservation. The project demonstrates how basic sensors and an Arduino microcontroller can be combined to create an Automated light system using IOT that supports energy efficiency without the need for environmental light conditions to influence the system's operation.***

Keywords: Arduino, PIR Sensor, Relay, Bulb, AC Current, DC Current, IoT, Automation, Energy Efficiency.

I. INTRODUCTION

In Today's world, energy conservation has become one of the most important global concerns. A significant amount of electricity is wasted daily due to human negligence, such as forgetting to turn off lights when they are not needed.

To address this issue, automation technologies offer effective solutions for controlling energy usage. This research focuses on the development of a hardware-based Automated Lighting System using Internet of Things (IoT) that aims to improve energy efficiency by automatically controlling lights based on human motion detection. The system is built using a Passive Infrared (PIR) sensor, which detects the movement of people within a specific range. When motion is detected, the sensor sends a signal to an Arduino microcontroller, which then activates the light. If no motion is detected after a certain period, the system turns off the light automatically. This eliminates the need for manual switching, reducing energy waste and enhancing user convenience.Unlike software-based application systems, this project involves physical electronic components such as jumper wires, relays, bulbs, and AC/DC power sources, all interconnected through the Arduino board. The relay module is used to safely control high-voltage AC-powered devices, allowing the Arduino to switch the bulb on and off. The use of DC power also supports system control and sensor operation, making the setup flexible and adaptable to different environments. This device demonstrates how simple and affordable components can be used to build a practical IoT-enabled automation system. It does not rely on environmental light conditions (like daylight sensors) but purely on human motion, making it suitable for indoor locations such as homes, offices, and public spaces where lights are often left on unnecessarily. Overall, this project presents a cost-effective, energy-efficient, and user-friendly hardware solution for automated lighting control. It showcases how embedded systems and IoT concepts can be practically applied to solve real- world problems related to energy management.

II. LITERATURE SURVEY

P. Singh and L. Jadhav (2023) introduced an IoT-based energy-efficient Automated Light system utilizing PIR sensors**,** ESP32 microcontroller, and relays. This system integrates motion detection, light level sensing to provide a user-friendly and intelligent solution for automated lighting. The combination of smart sensing enhances user accessibility and energy management.

These studies collectively underline the potential of combining sensor technologies, microcontrollers, and IoT for developing Automated lighting systems. The integration of PIR sensors for motion detection, the use of microcontrollers like Arduino or ESP32, of smart controls through IoT platforms have proven effective in reducing energy consumption, lowering operational costs, and advancing towards more sustainable and automated solutions.

M. Patil and N. Verma (2022) developed a Smart Lighting System using IoT, employing Node MCU, relay, and bulb components. Their system is designed to turn on lights only when motion is detected in low-light conditions, combining both motion and light

sensing to optimize performance and conserve energy. This approach demonstrates an efficient way to automate lighting systems using IoT simple, low-cost components. As reviewed by Chaflekar, et al. [10] and Chaflekar, et al. [11] there exist job scheduling and load balancing challenges in cloud computing. There is a need of proposing a priority-based approach for efficient and equitable resource utilization. These studies collectively underline the effectiveness of integrating sensor technologies, microcontrollers (such as Arduino, ESP32, and NodeMCU), and IoT platforms in creating intelligent lighting systems. The use of PIR for motion detection and the implementation of smart control strategies have proven to significantly reduce energy consumption, operational costs, and contribute to sustainable automation in various lighting applications.

III. METHODOLOGY

The methodology for the proposed Automated Lighting System Using IoT involves both hardware integration to create an energy-efficient lighting system that activates based on human motion. This system aims to reduce electricity waste by eliminating manual switching and operates independently light. The project follows a systematic process that includes component selection, circuit design, programming, testing, and deployment. The hardware setup begins with selecting key electronic components: a PIR (Passive Infrared) sensor to detect human motion, an Arduino microcontroller to process inputs and control outputs, a relay module to handle the switching of the AC-powered bulb**,** jumper wires for electrical connections, and power sources including AC current for the bulb and DC current for the Arduino and sensor modules. The PIR sensor is connected to one of the Arduino's digital input pins, while the relay is connected to a digital output pin. The bulb is wired through the relay to safely allow switching with the low-voltage control from the Arduino. All connections are made using jumper wires to ensure a clean and modular design. The software part of the project is developed using C++ programming language within the Arduino IDE **(**Integrated Development Environment**)**. The Arduino is programmed to read data from the PIR sensor. When motion is detected (sensor output is HIGH), the microcontroller sends a signal to the relay module to turn ON the bulb. If no motion is detected for a predefined duration, the Arduino sends a LOW signal to turn the bulb OFF. The time delay can be adjusted in the code according to user needs. This simple logic is embedded into the Arduino's firmware, making the system responsive and autonomous. Once the programming is complete, the system undergoes testing and calibration. During this phase, the motion detection range of the PIR sensor is fine-tuned, and the relay's switching performance is verified. Safety precautions are strictly observed when handling AC current during the setup. Calibration also includes optimizing the delay period to strike a balance between user convenience and energy conservation. After successful testing, the system is ready for deployment**.** It can be installed in indoor spaces such ascorridors, rooms, or passageways where lights are frequently left on unnecessarily. Since the system does not rely on light sensors (e.g., LDR), it functions effectively in any lighting condition, particularly in enclosed or dark environments.In conclusion, this methodology presents a cost-effective, efficient, and reliable solution for automated lighting using IoT. With the combination of basic electronics and C++ programming through Arduino IDE, the project showcases how easily accessible technology can be leveraged to promote energy efficiency in day-to-day applications.

A. Arduino

Arduino is an open-source electronics platform centered around easy-to-use hardware and software. At the heart of the Arduino is a microcontroller—a compact integrated circuit designed to process and execute instructions. The platform can be programmed using the Arduino IDE (Integrated Development Environment), making it accessible even to beginners. Android Studio is an incorporated improvement condition (IDE) for creating for the Android stage[14]. In an automated lighting system, the Arduino acts as the control center. It receives signals from sensors like PIR (Passive Infrared) modules and processes these inputs to control output devices such as relays and lights. When the sensor detects motion, the Arduino interprets this signal and activates the connected light source. Its affordability, simplicity, and vast online community support make it highly suitable for DIY and IoT-based automation projects.

Fig.3.1 Arduino / Microcontroller

B. PIR Sensor

A PIR (Passive Infrared) sensor detects infrared radiation emitted by warm bodies such as humans and animals. It doesn't emit energy itself but instead senses changes in infrared radiation in its field of view. When motion is detected, the sensor outputs a HIGH signal to the Arduino. This makes PIR sensors ideal for motion- activated systems like automated lighting, where lights are turned on only when movement is detected within a specific range. A PIR sensor is used to detect motion by sensing infrared radiation emitted by objects that are warm, such as humans or animals. It does not emit any energy of its own but passively detects variations in infrared energy within its range.

When a moving object enters the sensor's detection zone, the sensor sends a digital HIGH signal to the Arduino, indicating the presence of motion. This signal can then be used to activate lighting. PIR sensors are energy-efficient and cost-effective, which makes them perfect for applications like security systems and automated lighting.

Fig. 3.2 PIR Sensor (Passive Infrared)

C. Relay

A relay is an electrically controlled switch that allows low-power control systems like Arduino to operate high-power devices safely. It acts as a bridge between the microcontroller and devices powered by high- voltage AC current. In lighting systems, relays control the power supply to bulbs, enabling the Arduino to turn them on or off without directly handling high voltages, thus maintaining electrical safety. A relay is an electromechanical switch that allows a low-power device, such as an Arduino, to control high-voltage appliances like bulbs. Since the Arduino operates on low voltage DC (typically 5V), it cannot directly control AC-powered devices due to safety concerns. The relay acts as an interface between the low-power circuit and high-voltage components.

In an automated lighting setup, the Arduino sends a signal to the relay, which then either opens or closes the circuit to the bulb. This allows the light to be turned on or off without manual interaction. Relay modules come with built-in driver circuits, LED indicators, and protection diodes, making them safe and convenient for integration.

Fig. 3.3 Relay Module

D. Bulb

The bulb is the primary output device in a lighting automation system. It provides illumination and is typically powered by AC current. The bulb is connected to the circuit via a relay, allowing it to be turned on or off automatically based on input from the PIR sensor. Various types of bulbs (incandescent, LED, CFL) can be used depending on energy requirements and system design.The bulb is the main output device in a lighting automation system. It is the component that provides illumination and is typically powered by 110V or 220V AC, depending on the region. In automated systems, the bulb is connected to the AC power source through a relay, which allows it to be switched on or off by the Arduino based on sensor input.

Various types of bulbs can be used depending on the system's goals:

- LEDs (Light Emitting Diodes): Highly energy-efficient and long-lasting.
- CFLs (Compact Fluorescent Lamps): Moderate energy efficiency.
- Incandescent bulbs: High energy consumption and shorter lifespan.

Fig. 3.4 Bulb

E. AC Current

Alternating Current (AC) is the standard form of electricity supplied to homes and commercial buildings. It alternates direction periodically and is used to power high-voltage devices such as light bulbs and appliances. In an automated lighting system, the bulb receives AC power through the relay, which acts as the control switch.

AC (Alternating Current) is the form of electricity commonly supplied by power grids to households and commercial establishments. It periodically changes direction and is used to power high-voltage appliances like bulbs, fans, and home appliances. In an automated lighting system, AC current is crucial for powering the bulb. The relay acts as a safety and control device, enabling the microcontroller to handle the bulb without any risk of electric shock or damage. The Arduino itself cannot directly interact with AC current, so the relay serves as the crucial intermediary.

F. DC Current

Direct Current (DC) flows in one direction and is used to power low-voltage components like Arduino boards and sensors. Typically provided via batteries or USB power supplies, DC current is essential for powering the microcontroller and ensuring safe operation of the control circuit. DC (Direct Current) flows in one direction and is used to power low-voltage devices like microcontrollers and sensors. Arduino boards, for example, typically operate on 5V or 3.3V DC. DC power is usually supplied via USB cables, battery packs, or DC adapters. All control components in the system—including the Arduino, PIR sensor, and the relay's control side—are powered using DC current. This separation between low-voltage control and high-voltage output ensures safety and reliability in automation setups.

Fig. 3.5 DC Battery

G. IoT (Internet of Things)

IoT refers to the interconnection of physical devices through the internet, enabling data exchange and remote control. In lighting automation, IoT can be integrated to allow users to monitor or control lighting remotely via smartphones or web applications. This adds flexibility and user control beyond physical presence. The Internet of Things (IoT) refers to a network of interconnected physical devices that communicate and share data over the internet. When IoT is integrated into lighting automation systems, it significantly enhances functionality.

With IoT-enabled lighting, users can:

- Monitor light status remotely.
- Control lights using a smartphone or web application.
- Automate lighting based on schedules or environmental data.
- Receive notifications about unusual activity (e.g., motion detected when the home is empty).

By connecting the Arduino to Wi-Fi modules like the ESP8266 or ESP32, developers can turn basic automation into a smart, cloud-connected solution.

H. Energy Efficiency

Energy efficiency involves using less energy to perform the same task, thereby reducing waste. Automated lighting systems enhance energy efficiency by ensuring that lights are only activated when motion is detected, minimizing unnecessary energy use and helping to lower electricity costs and environmental impact. Energy efficiency means achieving the desired output (like lighting) while using the least amount of energy possible. Automated lighting systems play a critical role in promoting energy efficiency. By using motion sensors and microcontrollers, lights are only activated when needed—such as when someone enters a room or hallway. This eliminates the issue of lights being left on unnecessarily, which can waste electricity and increase costs.

Moreover, pairing automation with energy-efficient bulbs like LEDs further reduces energy consumption. In the long run, these systems can significantly lower utility bills and reduce the carbon footprint.

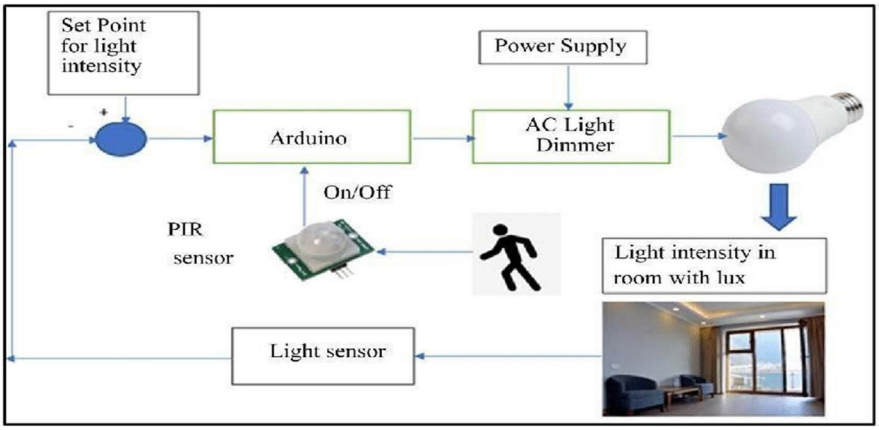

Fig.3.6 Block Diagram / Automated Light System.

IV. RESULTS

The implementation of the Automated Lighting System Using IoT yielded successful results, validating the core objective of activating and deactivating a light bulb based solely on human motion detection. When the PIR sensor detected motion within its range, it effectively triggered the Arduino microcontroller**,** which then activated the relay module to switch ON the AC-powered bulb. In the absence of motion for a predefined time period, the system turned the bulb OFF automatically, confirming that the automation logic and delay function worked as intended.This behavior was consistently observed during testing in multiple indoor setups such as hallways and rooms, indicating the system's practical applicability and reliability. Building on earlier experience with secure cloud storage systems (2015) [12] it was hypothesized that newer ML models, when combined with systematic data preprocessing, The system functioned efficiently without the influence of environmental light conditions, demonstrating that the exclusion of components core performance. Additionally, the integration of C++ programming within the Arduino IDE ensured smooth operation and logical decision-making based on motion inputs. The hardware components including jumper wires, relay, bulb, and power supply were all successfully interfaced and performed reliably under different testing conditions. Overall, the project fulfilled its aim of offering a cost-effective, user-friendly, and energy-efficient lighting control solution. The behavior of data objects is expressed most naturally in terms of operations that are meaningful for those objects[15].

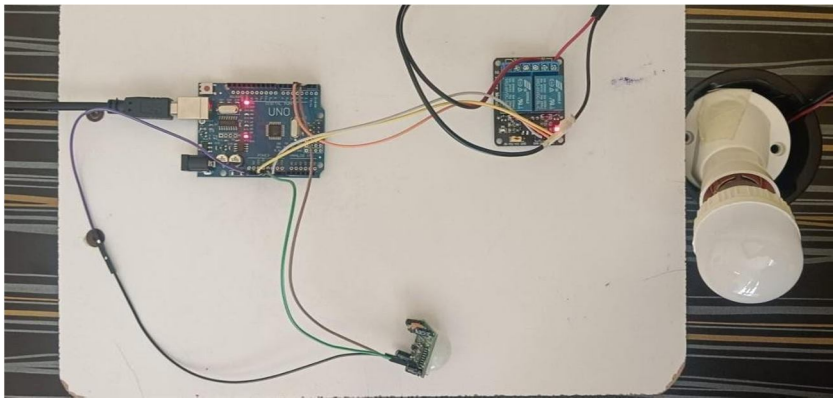

Fig.4.1 Before Detecting Human Motion.

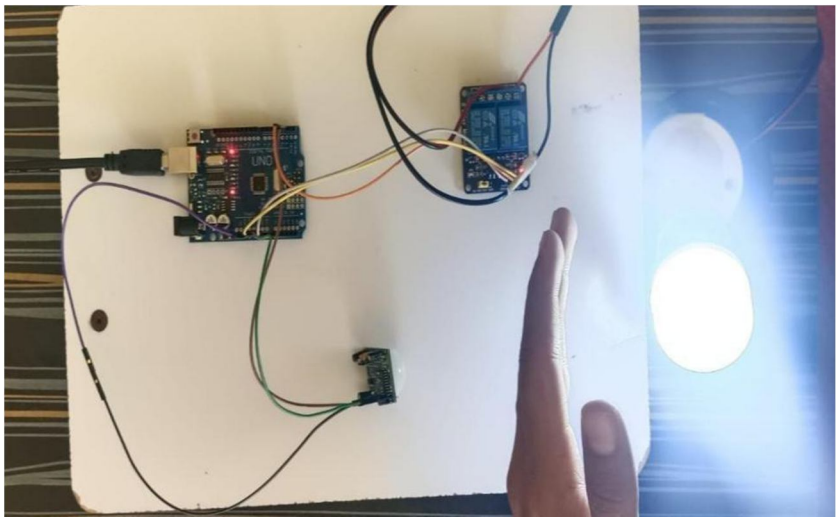

Fig.4.2 After Detecting Human Motion.

V. CONCLUSION AND FUTURE SCOPE

The Automated Lighting System Using IoT has successfully shown how lighting can be controlled in a simple and efficient way using human motion. By using a PIR sensor**,** Arduino microcontroller**,** and relay module**,** the system automatically turns the light on when someone is present and off when no one is around. It does not need any manual switch or light sensor to work. This helps save electricity and reduces wastage. The system is easy to set up, affordable, and works well in places like rooms, hallways, and entrances where lights are often left on unnecessarily. In the future, this system can be improved by adding IoT features such as remote control through a mobile app or website. More smart features like data tracking**,** usage reports**,** or voice control using platforms like Alexa or Google Assistant can also be added. The system can be expanded with more sensors to cover larger areas or made smarter by using machine learning to understand people's habits and adjust the lighting automatically. With these improvements, the system can be used not just in homes, but also in bigger places like smart buildings and factories to save more energy and improve automation.With more time, the software can be improved to include security with using the cloud concept is our original after thought to programming the software[13].

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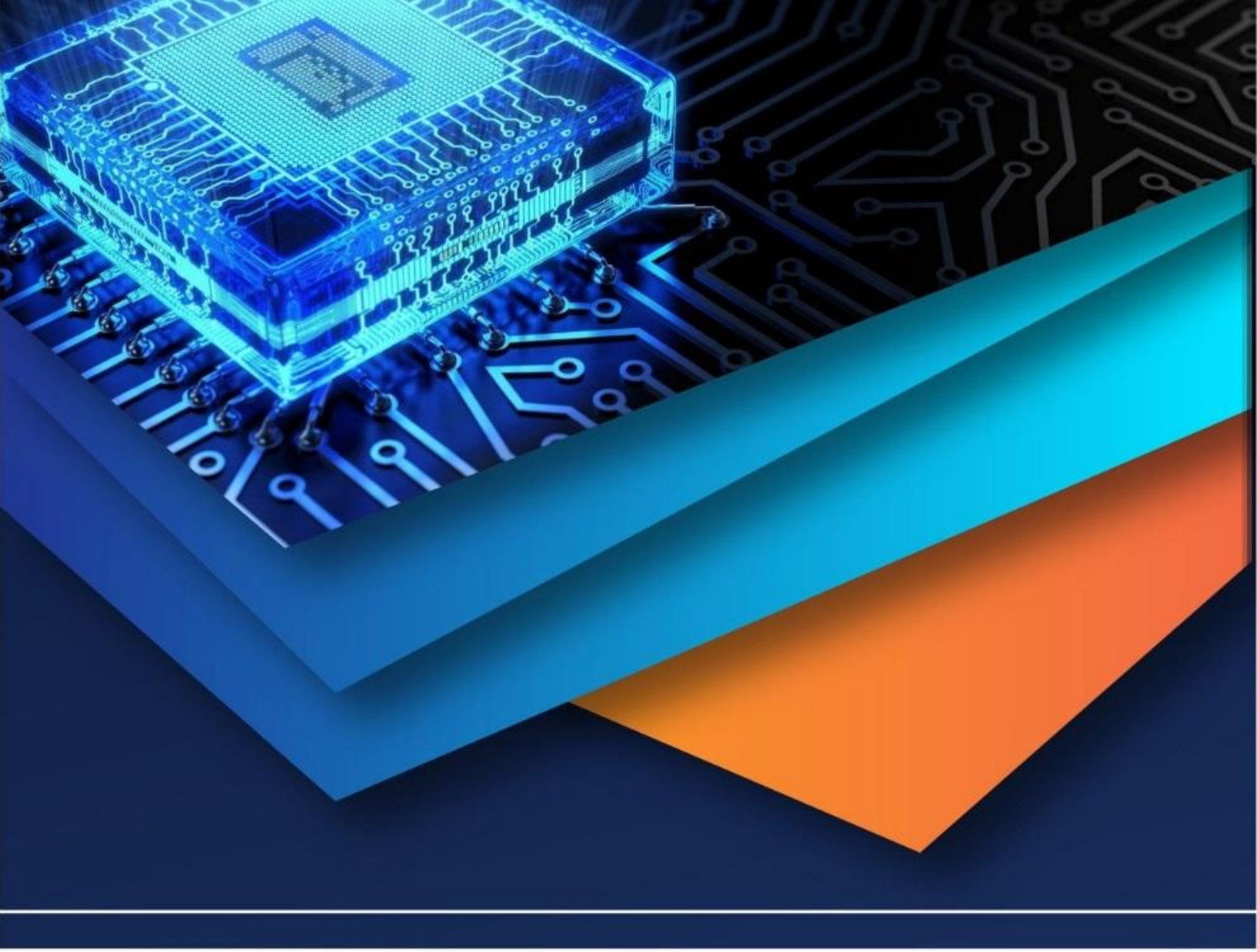

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