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Smart Street Lights: Advancements in Street Lighting Technology

Sravani Dhulipalla[1], Sruthi Samhitha Kota[2], Manisha Meesala[3], Sahithi Kandhukuri[4]
Jawaharlal Nehru Technological University, Hyderabad

Abstract: ***This system is primarily designed to efficiently manage LED-based street lights using automatic intensity control. It accomplishes this by harnessing solar power through photovoltaic cells. The primary goal is to ensure that street lights shine brightly during peak hours, when traffic is at its busiest, while gradually reducing their intensity during late-night hours to conserve energy. This automation ensures that the street lights automatically turn on at dusk and turn off at dawn.***
White Light Emitting Diodes (LEDs) are employed as a replacement for High-Intensity Discharge (HID) lamps, offering the advantage of intensity control through pulse width modulation. This intensity control feature allows for energy conservation during late-night hours when street traffic is minimal.
The core of this system relies on a programmable microcontroller from the Atmega family. This microcontroller is responsible for adjusting the light intensity at different times, providing a flexible and efficient approach to street lighting. Additionally, a charge controller is incorporated into the system to manage battery charging, prevent overload, and protect against deep discharge.
The results of this developed switching control technique have been validated through a hardware setup, demonstrating its effectiveness in optimizing street lighting for energy savings and improved efficiency.
Keywords: Arduino UNO, LDR, LED, Infra-red, Resistors, USB, Street light, Solar panel, MOSFET, Battery, control regulator.

I. INTRODUCTION

We must prioritize energy conservation due to the finite nature of many of our primary energy sources such as coal and natural gas. These resources cannot be replenished, and we face the dual challenge of energy scarcity and significant wastage, with over 50% of energy lost through transmission, unnecessary lighting usage, low power factor, and other inefficiencies. Therefore, transitioning to renewable energy sources like solar power is both environmentally responsible and cost-effective.

Street lighting represents a substantial energy expenditure for cities. The current system relies on manual operation, with lights turning on in the evening and off in the morning based on a fixed schedule. However, this approach is far from optimal as it doesn't account for variations in natural light due to weather conditions, leading to energy wastage.

An intelligent street lighting system offers a solution to these problems, potentially reducing municipal lighting costs by 50% to 70%. The primary objective of this project is to create a sustainable future by using solar energy to power smart street lighting during the night. The term "smart" is aptly used because this system not only provides illumination but also detects the movement of pedestrians and lights their path between streetlights.

By integrating this technology into the entire street lighting network, it can be especially beneficial in remote rural areas with unreliable electric power supplies. However, it's equally applicable in metropolitan cities. A simple and effective energy-saving measure involves dimming the lights during off-peak hours, with brightness automatically increasing when motion is detected nearby. This approach not only conserves energy but also reduces operational costs.

Unlike traditional High-Intensity Discharge lamps (HID), which rely on gas discharge and lack controllability through voltage reduction, this system employs LED lights. Motion sensors, specifically infrared (IR) sensors, are utilized in conjunction with Arduino controllers to activate the LEDs. Furthermore, the system harnesses solar energy, a key renewable source, to power these smart streetlights, making it an environmentally conscious and efficient solution for urban and rural areas alike.

II. DESIGN OF THE MODEL

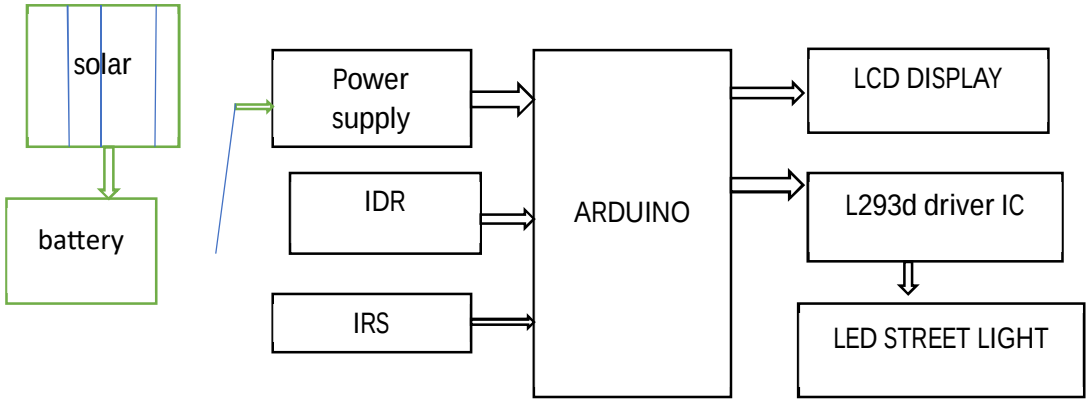
Solar panel is one of the most important parts.

1) During day time solar panel produces electricity and is stored in the battery.
2) In dusk to dawn time light sensor gives command to Arduino controller.
3) As per program it executes command and turns LED ON to 30% of max intensity when there is no motion below streetlight.

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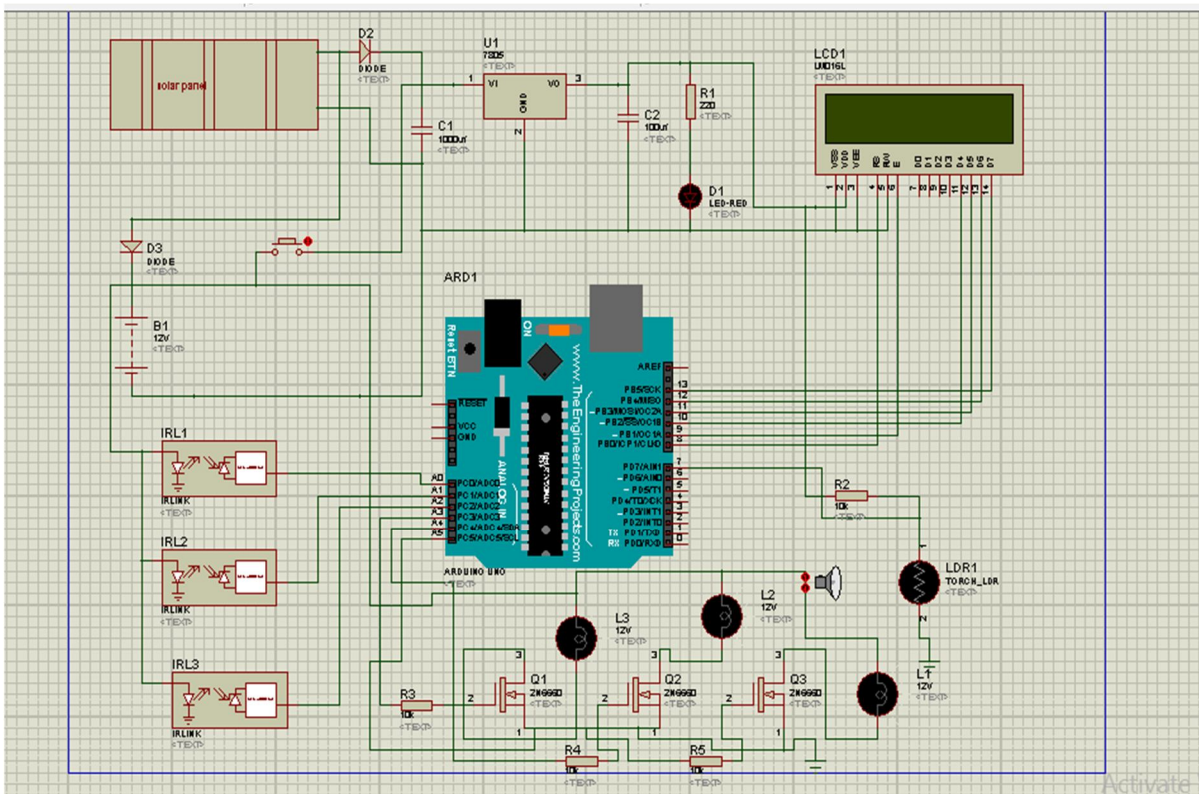
4) If any person or vehicle passes nearby streetlight, motion sensor gets activated and gives command to Arduino to increase brightness to 100%.
5) After preset time, if there is no movement detected, intensity reduces gradually to 30%.
6) In the morning, LDR sends command to Arduino and hence street light will turn OFF.
7) Normally streetlight will operate from electricity stored in the battery which is charged by solar energy.
8) If battery is not charged sufficiently due to cloudy weather condition, then streetlight will automatically switch to utility supply.

Block diagram for this model is shown below:



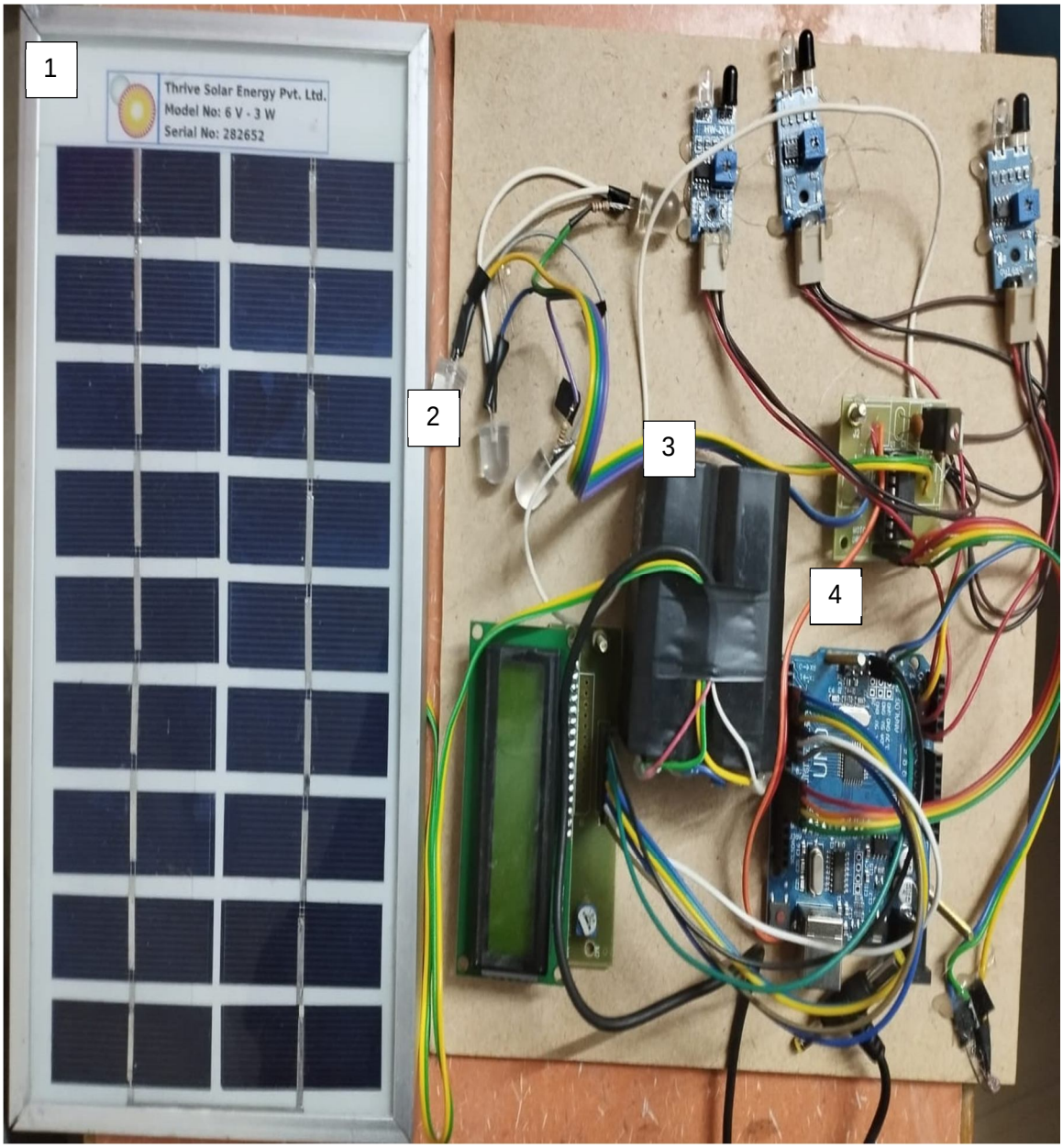
When power is supplied, the LDR senses the brightness in surrounding environment and sends the value to Arduino. Arduino sends the appropriate pulse signals to MOSFET and the MOSFET then decides the voltages to be sent to the LEDs. The intensity of lights depends on the voltages provided to the LEDs.

The simulated model is shown below:



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III. PROTOTYPE MODEL

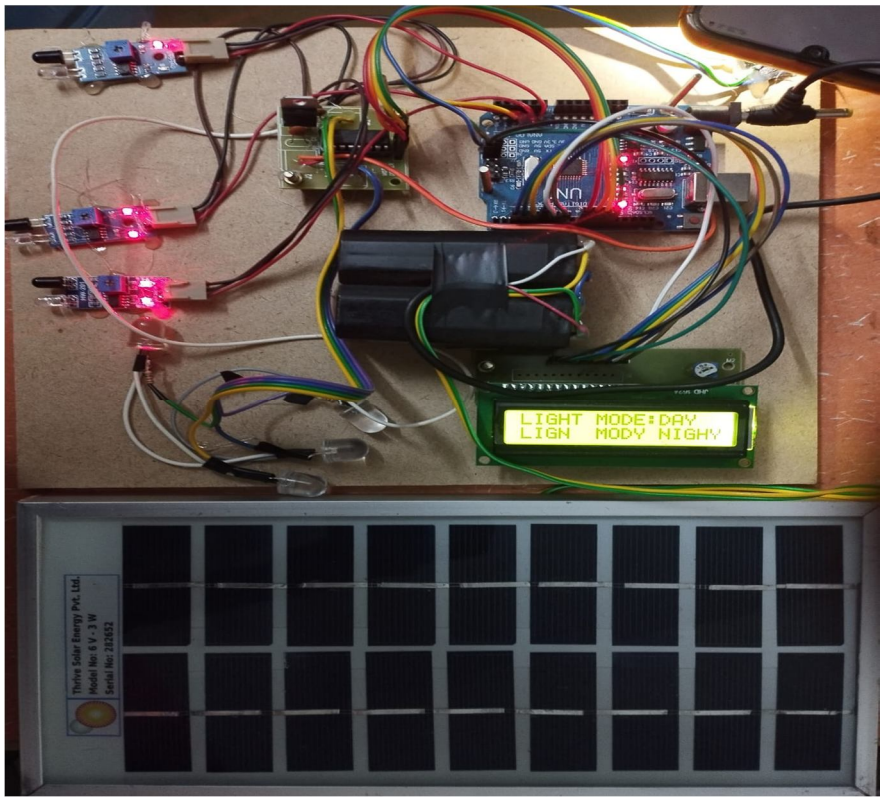


In the prototype above the main components used are:

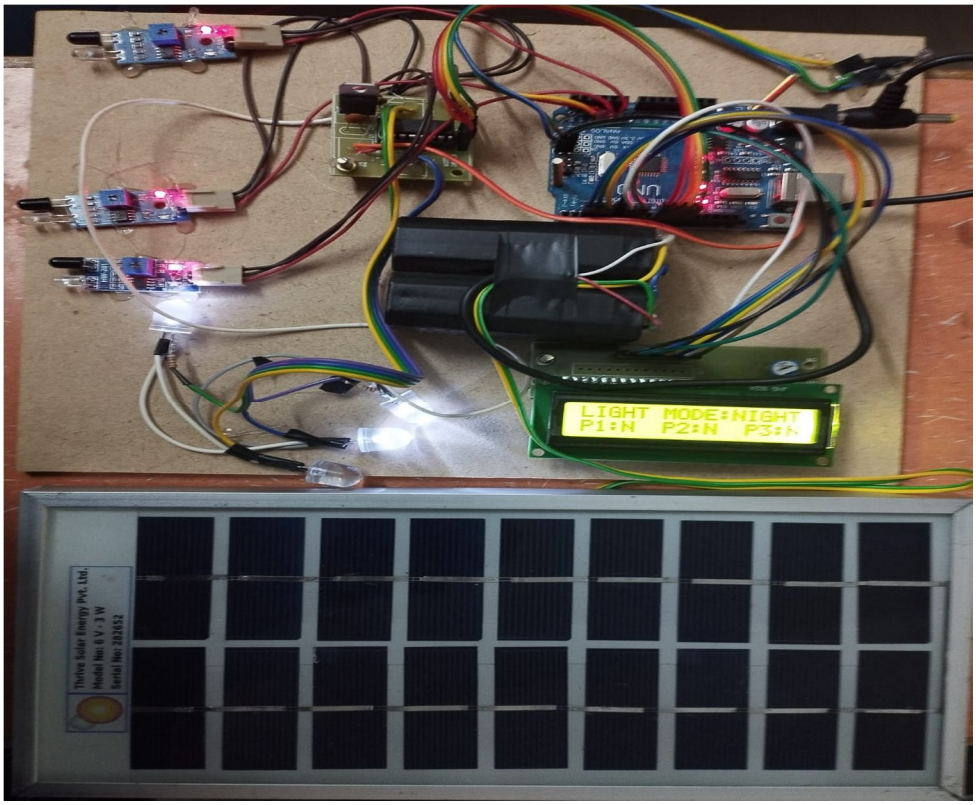
1) Solar panel
2) LEDs
3) Batteries
4) Arduino UNO

Apart from this IR sensors, LDR display, resistors are also used.
During day time solar panel produces electricity and it is stored in the battery.

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During dusk to dawn time light sensor gives command to Arduino controller. As per program it executes command and turns appropriate LEDs ON to produce 30% of max intensity when there is no motion below streetlight.



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IV. CONCLUSION

Solar power is a crucial and prominent renewable energy source, demonstrating its utility in various applications, including street lighting. An exemplary application in the realm of electronics is the solar-powered automatic street light controller, which enhances the quality of life by automating street lighting. The fundamental premise behind this technology is to upgrade conventional street lights by introducing automatic control mechanisms. To ensure safe and efficient operation, a charge controller is used. It plays a pivotal role in safeguarding the battery and increasing its capacity.

In urban settings, there exists a vast network of street lights, and the annual electricity maintenance expenses are considerable. In the above model it is true that the initial setup cost and ongoing maintenance can present challenges. However, the benefits far outweigh these drawbacks. This model boasts significant advantages, including a reduction of approximately 40% in electricity consumption per street light. Moreover, with continuous technological advancements and effective resource management, the initial installation expenses and maintenance costs can be minimized through periodic checks and maintenance routines.

In essence, this solar-powered automatic street light controller represents a cost-effective and environmentally friendly solution to the challenges posed by traditional street lighting systems. It not only contributes to energy conservation but also offers the potential for long-term cost savings and enhanced operational efficiency.

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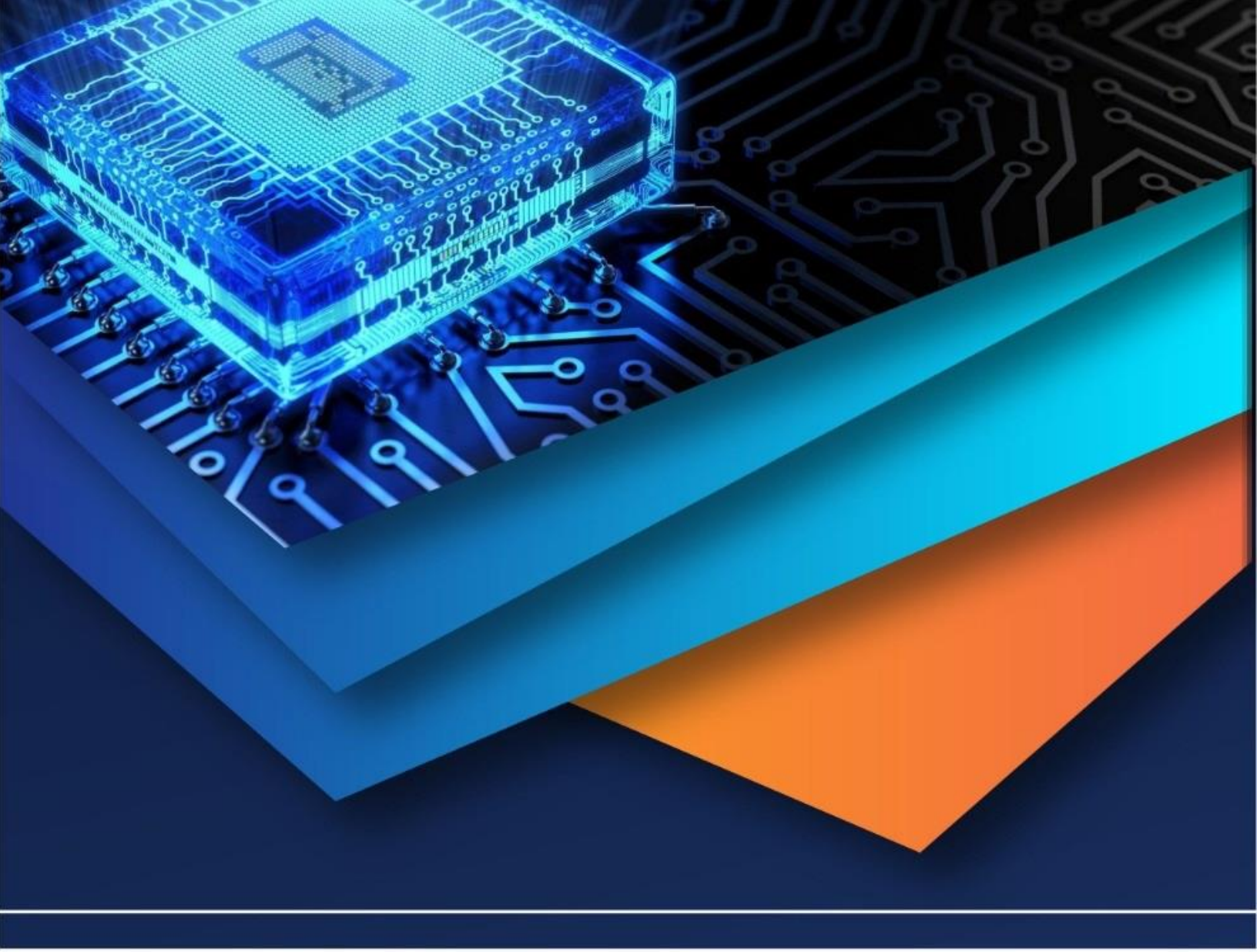
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