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Development of Smart Self-Energizing Electric Vehicle for Sustainable Mobility

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Abstract: The project aims to create a model on self-charging electric vehicle which produces electricity through its motion. The system uses regenerative motors which mount on the car wheels. The vehicle movement begins when the main motor powers the rear axle which drives the wheels for forward motion. The rear axle movement causes wheel rotation which generates motion through rolling friction that enables the regenerative motors on the wheels to start rotating. The regenerative motors generate rotational motion which enables them to function as generators that create electrical power for battery storage. The laws of thermodynamics together with energy conservation principles make it impossible to achieve total energy conversion from one source to another. The project aims to enhance electric vehicle performance through energy recovery from vehicle motion instead of achieving complete self-charging. The increasing environmental pollution from traditional vehicles makes this method an effective way to improve energy efficiency while developing sustainable transportation solutions for upcoming years.
Keywords: Self charge, Electric Vehicles, DC generator, Power measurement etc.

I. INTRODUCTION

Worldwide energy requirements have increased to such an extent that societies now depend heavily on fossil fuels which include coal and petroleum and natural gas.Industrial growth and transportation operations have relied on these energy sources for several decades but they do not provide any environmentally safe solutions. The burning of fossil fuels releases large amounts of carbon dioxide and other greenhouse gases into the atmosphere which contributes to global warming and climate change. Environmental problems require urgent solutions which need to develop and use energy systems based on renewable sources that produce less environmental damage and operate in a sustainable way. The transportation sector uses more than half of all fossil fuels which exist worldwide. Road vehicles such as cars, buses, and trucks account for a large share of petroleum usage. According to international energy reports, the transportation sector is expected to increase its share of the world's total oil consumption to nearly 55% by the year 2030. The world needs alternative technologies which will decrease fossil fuel usage because people consume fuel at an increasingly faster rate. The transportation sector has entered a new stage of development which focuses on two main technologies. The first technology aims to create electric vehicles. The second technology develops energy-saving transportation solutions.

Electric vehicles represent a highly effective method for decreasing environmental pollution and decreasing fossil fuel dependency. An electric vehicle uses multiple electric motors to move the vehicle forward instead of using an internal combustion engine. The system operates because the motors use electricity from rechargeable batteries which function as energy storage devices. The Battery Electric Vehicle (BEV) represents the most popular electric vehicle type which requires battery technology to determine its operational performance through energy storage capacity and charging time and efficiency. The electric vehicle market achieved greater global success because of battery technology advancements and increasing gasoline prices and environmental protection concerns which developed over time.

Electric vehicles present multiple benefits which exceed the advantages of traditional gasoline vehicles. The vehicles create no emissions from their exhaust system which decreases air pollution and they need less upkeep because their design includes fewer operational components. Electric vehicles operate without noise while they provide optimal performance and they generate lower expenses during their usage. The main drawback of electric vehicles exists because their battery systems restrict their maximum driving distance. The vehicle needs to undergo the recharging process after its battery power has been completely consumed and this process requires significant time which depends on both the battery type and charging method.

Researchers and engineers search for new techniques to enhance electric vehicle charging efficiency because they want to solve this problem. The first method combines solar energy as a renewable resource with electric vehicle systems. The vehicle can utilize solar photovoltaic (PV) panels which will transform sunlight into electric power when installed on its exterior. The generated electricity allows the vehicle to recharge its battery which results in longer distance travel without needing external charging stations.

The second approach uses an alternator or generator which connects to the vehicle wheel system. The system uses a generator to transform the wheels' rotational motion into electrical power during vehicle operation. The system uses generated electricity to recharge the battery system. Self-charging electric vehicles achieve battery recharging through solar power generation and mechanical energy recovery systems which enable movement-based charging.

People today need to protect energy resources and environmental systems because these two factors serve as essential components of sustainable development. People depend on automobiles for their daily activities but these vehicles create major environmental pollution problems through their high energy use. The development of vehicles which consume less energy and produce zero emissions has become an urgent need because of the existing requirement. A self-charging electric vehicle system which operates on renewable energy and energy recovery technologies presents an effective solution to this problem. These systems enable reductions in fossil fuel usage while they decrease environmental harm and support the creation of environmentally friendly transportation systems.

II. PROBLEM IDENTIFICATION

The existing world faces a situation where fossil fuels become depleted because people continue to use traditional vehicles. The main fuel for conventional vehicles consists of petrol and diesel. The process emits harmful gases into the atmosphere which includes HC (hydrocarbon) and CO (carbon monoxide) and Nox emissions that cause ozone depletion and global warming. The use of alternative fuels to replace fossil fuels has increased through the use of alcohol (methyl alcohol and ethyl alcohol) and biogas and bio-diesel and natural gas and vegetable oils like peanut oil and linseed oil and rapeseed oil and sunflower oil. But a proper cause and effects has not yet identified. The electric vehicle provides essential support which enables the automotive industry to enter its next development phase. Electric vehicles primarily depend on battery systems to function as their main power source. The battery requires extended charging periods while remaining in a stationary position which represents our main identified issue. The system generates higher electricity expenses because it needs to draw more power from regular sources. The current number of recharging stations proves inadequate because users spend too much time to complete the recharging process. The vehicle operation requires ongoing battery power which results in frequent deep battery discharges. The process results in a reduced battery life cycle. The process results in high expenses for battery replacement.

III. LITERATURE REVIEWS

1. Yin et al. (2023), investigated regenerative braking systems for electric vehicles using a fuzzy control strategy. The study aimed to improve energy recovery efficiency during braking while maintaining vehicle stability and braking performance. The proposed fuzzy logic controller dynamically distributed braking force between mechanical and regenerative systems. Simulation results demonstrated improved energy recovery and smoother braking compared with conventional control methods. The system also reduced energy losses and enhanced battery charging during deceleration. The findings indicate that intelligent control techniques can significantly improve regenerative braking efficiency and contribute to extending the driving range and overall energy efficiency of electric vehicles.
2. Urbina et al. (2023), developed a bicycle-embedded electromagnetic energy harvester designed to generate power for low-power electronic devices. The system captured mechanical energy from bicycle motion and converted it into electrical energy through electromagnetic induction. Experimental testing showed that the device could effectively generate stable electrical output sufficient for powering sensors, lighting systems, and small electronic gadgets. The design was compact and easily integrated into bicycle structures without affecting performance. The study concluded that bicycle-based energy harvesting systems provide a sustainable and cost-effective method for generating renewable energy for portable electronics and smart mobility applications.
3. Ramesh and Elangovan (2024), studied energy harvesting from fuel cell–powered bicycles for supplying electricity to home DC grids. The research focused on integrating a soft-switched DC–DC converter to improve power conversion efficiency and reduce switching losses. The system collected energy generated during bicycle operation and transferred it to a household DC distribution network. Experimental results showed improved energy conversion efficiency and stable voltage output. The proposed configuration enhanced power utilization and minimized energy wastage. The findings suggest that bicycle-based energy systems can contribute to decentralized renewable energy generation and support small-scale DC grid applications in sustainable energy systems.
4. Kore et al. (2025), presented the design and evaluation of an energy-efficient regenerative braking system for electric vehicles. The study focused on optimizing braking energy recovery while ensuring vehicle safety and performance. The researchers developed a prototype system and evaluated its performance under various braking conditions.

Experimental results showed that the system effectively captured kinetic energy during deceleration and converted it into electrical energy for battery storage. The proposed design improved energy efficiency and reduced overall power consumption. The findings highlight that regenerative braking systems can significantly enhance the sustainability and operational efficiency of electric mobility systems.

5. S. M. P. et al. (2025), designed and fabricated an electric bicycle integrated with a regenerative energy recovery system. The objective was to improve battery charging efficiency by recovering energy during braking and motion. The developed prototype included a motor, battery system, and regenerative controller that converted mechanical energy into electrical energy. Experimental testing demonstrated that the system successfully recovered energy during braking, thereby extending battery life and increasing travel distance. The study concluded that integrating regenerative technology in electric bicycles can enhance energy efficiency, reduce dependency on external charging sources, and promote sustainable transportation solutions.

6. Kim et al. (2021), proposed a parameterized energy-optimal regenerative braking strategy for connected and autonomous electrified vehicles. The study developed an optimization framework that determines the most efficient braking distribution between regenerative and mechanical braking systems. The strategy considered vehicle dynamics, battery limitations, and road conditions to maximize energy recovery. Simulation results demonstrated that the optimized strategy significantly improved regenerative energy capture while maintaining vehicle stability and safety. The approach also reduced unnecessary mechanical braking, thereby minimizing energy loss. The research highlighted the importance of advanced control algorithms in enhancing the energy efficiency of next-generation electric and autonomous vehicles.

7. Chen et al. (2020), investigated a model predictive control (MPC) based system for simultaneous vibration control and energy harvesting using an electromagnetic vibration absorber. The system converted mechanical vibrations into electrical energy while reducing structural vibrations. The MPC algorithm optimized system performance by controlling the electromagnetic actuator in real time. Experimental results indicated improved vibration suppression and effective energy harvesting from ambient mechanical motion. The harvested energy could power low-power electronic devices or sensors. The study demonstrated that integrating vibration control with energy harvesting can enhance system efficiency and provide a sustainable power source for self-powered monitoring systems.

8. Gautam et al. (2020), proposed a genetic algorithm-based eco-driving strategy for electric vehicles considering regenerative braking capabilities. The research aimed to optimize vehicle speed profiles to maximize energy efficiency and regenerative energy recovery. The developed algorithm analyzed traffic conditions, vehicle dynamics, and battery characteristics to determine optimal driving patterns. Simulation results showed significant improvements in energy efficiency and regenerative braking performance compared to conventional driving methods. The optimized strategy reduced energy consumption and increased the effective driving range of electric vehicles. The findings emphasize that intelligent driving strategies can significantly improve EV energy management systems.

9. Li et al. (2019), designed an energy harvesting device using a rotating motion rectifier for bicycle applications. The system captured rotational motion from bicycle wheels and converted it into electrical energy through a mechanical rectification mechanism and generator. Experimental results demonstrated efficient power generation even at low rotational speeds. The harvested energy could be used for powering lighting systems, sensors, and portable electronic devices. The design was compact, lightweight, and suitable for integration into bicycles without affecting riding performance. The study highlighted the potential of rotational motion energy harvesting as a sustainable and reliable power source in mobility systems.

10. Liu et al. (2021), developed a hybrid energy harvesting system for shared bicycles to support self-powered applications. The system combined multiple energy harvesting techniques, including mechanical motion and vibration energy conversion. The design aimed to generate sufficient power to operate smart bicycle components such as GPS trackers, sensors, and communication devices. Experimental evaluation demonstrated stable power output and improved energy harvesting efficiency under different riding conditions. The hybrid configuration enhanced reliability and ensured continuous power supply for electronic components. The study concluded that integrated energy harvesting technologies can support smart transportation systems and reduce dependency on external power sources.

IV. METHODOLOGY

A. Proposed System

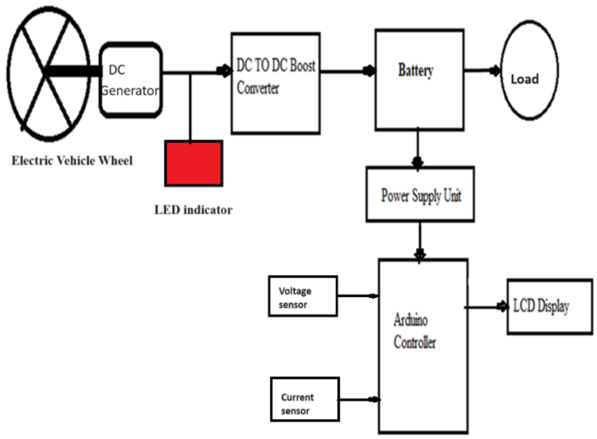

Figure 1. Proposed System

B. Working Principle

The Proposed work aims to establish an automated system which requires no human input for its execution. The requirement is to generate energy or power ,not from any external source but internally.

Power can be generated internally from wheel rotation which contributes mechanical power. The Principle of a DC power Generator is to convert mechanical energy to electrical energy. The output of a DC generator produces electrical energy which is stored as DC power in a 12 volt DC battery. The stored electricity has the output above the ground so that whenever there is need of the electricity the stored power can be directly transferred to any place in very short period of time.

Dynamo generates electricity it sends to dc boost converter. The boost converter functions as a device which maintains the DC power output at a stable level. The system stores electricity in a Battery. The system uses DC power to operate LED lights. The system uses voltage sensor and current sensor to measure the voltage an current value in battery. The collected data will be displayed on the LCD screen. The Arduino system controls all operational tasks. The LCD display connected to Arduino shows the voltage status of power generation.

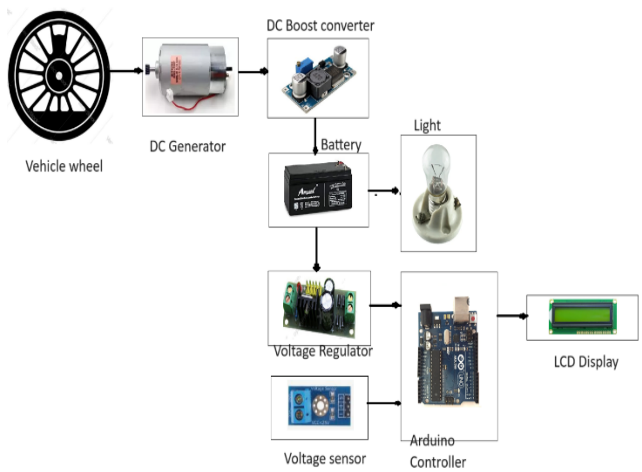

Fig. 2. Schematic Diagram

Electric power generation depends primarily on the fundamental operation of rotational energy. A Dynamo converts the initial system of rotational energy into mechanical power and subsequently transforms this power into electrical output. Rotational energy stands as the most basic energy form which people can transform into electrical power. Most of the electrical energy is mainly generated from rotational energy. All the energy resources can be converted into electrical energy from rotational energy since the alternator used for electrical generation is the rotational machine except solar energy. The two rollers in this system demonstrate different conditions because one roller operates at motion while the other roller remains stationary.

The static roller receives rotational energy through contact with the rotating roller. Afterward the static roller begins to spin. We can assume that the rotating roller as the train wheel. The system uses rotational energy as its main operational method to produce electric power. The conversion of rotational energy leads to mechanical power creation while electrical energy gets transformed into another electrical power output.

C. Hardware Used

1) Electric Vehicle Wheel:
The wheel provides rotational motion during vehicle movement. This rotational energy acts as the primary mechanical input for the power generation system.

2) DC Generator (Dynamo):
The DC generator converts mechanical energy from the rotating wheel into electrical energy. The generated DC voltage is used for charging the battery.

3) DC Boost Converter:
The boost converter increases and stabilizes the generated voltage from the dynamo to a suitable level required for battery charging.

4) 12V Lithium Battery:
The battery stores the electrical energy generated by the system and supplies power to connected loads.

5) Arduino Controller:
Arduino acts as the main control unit that processes sensor data and controls the monitoring system.

6) Voltage Sensor:
Measures the battery voltage and sends the data to the Arduino for monitoring.

7) Current Sensor:
Detects the current flowing to the battery and helps monitor charging conditions.

8) LCD Display:
Displays real-time voltage and current values generated by the system.

9) LED Indicator:
Shows the operational status of the power generation system.

D. Software Used

- Arduino IDE: For programming microcontroller functions and interfacing sensors.
- Embedded C: Used as the primary coding language for hardware control.

V. RESULTS AND DISCUSSION

The proposed self-energizing electric vehicle system was tested to evaluate its capability to generate electrical energy from wheel rotation. The experimental setup consisted of an electric vehicle wheel connected to a DC generator (dynamo), a DC boost converter, a 12V battery for storage, and an Arduino-based monitoring system with voltage and current sensors. The generated electrical energy was used to power a load such as an LED, while the Arduino processed and displayed real-time voltage and current values on the LCD display.

During the testing phase, the wheel was rotated at different speeds to observe the corresponding electrical output from the dynamo. As the rotational speed of the wheel increased, the mechanical energy supplied to the generator also increased. This resulted in a higher electrical output voltage and current. The boost converter played a crucial role in stabilizing and regulating the generated voltage before storing it in the battery. This ensured that the energy produced from irregular wheel speeds could still be stored efficiently.

The results indicated that the system was capable of generating usable electrical energy from rotational motion. At low speeds, the generated voltage and current were relatively small, but as the speed increased, the power output improved significantly. This confirms that the system effectively converts rotational energy into electrical energy. The stored energy can then be used for low-power applications such as lighting systems, sensors, or auxiliary vehicle electronics.

Another important observation was the stability of the monitoring system. The voltage sensor and current sensor successfully transmitted real-time data to the Arduino controller.

The LCD display continuously showed the voltage and current values, allowing users to monitor the charging condition of the battery. This real-time monitoring improves system reliability and helps prevent overcharging or excessive discharge of the battery.

The experiment also showed that the energy generation process is fully automatic. Once the wheel rotates, the dynamo immediately starts producing electrical energy without requiring any manual operation. This feature makes the system suitable for electric vehicles where additional energy can be recovered during motion. Although the generated power is relatively small compared to the main battery capacity, it can still contribute to auxiliary loads and improve overall energy efficiency.

Table 1: Sensor Reading vs. System Response

Wheel Speed (RPM)	Voltage (V)	Current (A)	Power (W)
20	1.8	0.12	0.216
40	3.2	0.18	0.576
60	5.0	0.26	1.30
80	7.4	0.34	2.52
100	9.8	0.42	4.12
120	11.6	0.48	5.57

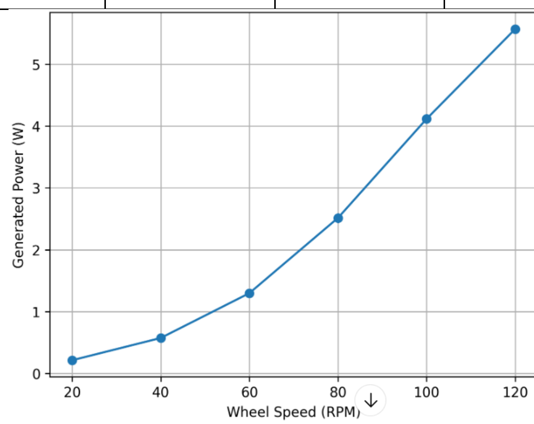

Figure 3. Power generated vs wheel speed

This graph clearly demonstrates that higher rotational speeds produce higher electrical power, validating the effectiveness of the proposed energy generation system.

However, some limitations were observed during the experiment. At very low speeds, the generated voltage was insufficient to charge the battery effectively. This means the system performs best when the vehicle is moving at moderate or high speeds. Additionally, mechanical losses due to friction between components slightly reduce the overall efficiency. Future improvements could include using high-efficiency generators, better gearing mechanisms, and optimized boost converters to increase the energy output.

Overall, the results demonstrate that the proposed system successfully converts wheel rotational energy into electrical energy and stores it in a battery while providing real-time monitoring. The concept proves to be a promising approach for improving energy utilization in electric vehicles and reducing dependency on external charging sources.

VI. ADVANTAGES

There are several advantages to a self-charging vehicle system utilizing a 12V generator attached to the wheels of vehicles and a 12V, 5Ah battery:

1) Sustainable Energy Generation: By harnessing the rotational energy of the vehicle's wheels, the generator can produce electricity without relying on external power sources. This sustainable energy generation reduces the vehicle's dependence on fossil fuels and contributes to a greener transportation solution.

2) Continuous Power Generation: The generator operates whenever the vehicle is in motion, providing a continuous source of power to charge the battery. This ensures that the battery remains charged or maintains a high level of charge, allowing for uninterrupted operation of the vehicle's electrical systems.
3) Extended Driving Range: With a self-charging system in place, the vehicle can potentially extend its driving range without the need for frequent recharging stops. This is especially advantageous for electric vehicles (EVs) or hybrid vehicles, which may otherwise be limited by battery range.
4) Increased Efficiency: By capturing and converting kinetic energy into electrical energy, the self-charging system improves the overall efficiency of the vehicle. It maximizes the use of available energy resources and minimizes energy wastage during vehicle operation.
5) Reduced Environmental Impact: Self-charging vehicles produce fewer emissions and pollutants compared to traditional combustion engine vehicles. By promoting cleaner energy generation and consumption, these vehicles contribute to lower air pollution levels and mitigate climate change impacts.
6) Lower Operating Costs: With the ability to generate electricity on-the-go, self-charging vehicles can reduce the need for external charging infrastructure and associated costs. This can lead to lower operating expenses for vehicle owners and operators over the vehicle's lifetime.
7) Enhanced Reliability: The self-charging system provides a redundant power source for the vehicle's electrical systems, enhancing overall reliability and resilience. In case of battery depletion or failure, the generator can continue to supply power, ensuring uninterrupted operation of critical vehicle functions.

VII. CONCLUSION

The system successfully demonstrates a reliable approach to convert wheel electric vehicle rotational movement into electrical power. The project aims to create an automated power generation system which generates and stores energy without using outside electrical resources. The experimental results confirm that rotational energy from the wheel can be successfully converted into electrical energy using a DC generator. The system uses a DC boost converter to control power output which it then keeps in a 12V battery for later utilization.

Sensor and microcontroller integration enables the system to achieve better efficiency together with enhanced monitoring capabilities. The voltage and current sensors continuously measure the electrical parameters of the battery, and the Arduino controller processes this information and displays it on the LCD screen. The system provides real-time information about energy production and storage activities.

The system automatically starts when the wheel begins to turn, which makes it useful for electric vehicles and any equipment that uses rotating parts. The produced power is sufficient for operation of low-power systems which include lighting and monitoring equipment. The proposed system enhances energy efficiency by demonstrating sustainable power generation technologies which lead to better energy efficiency results.

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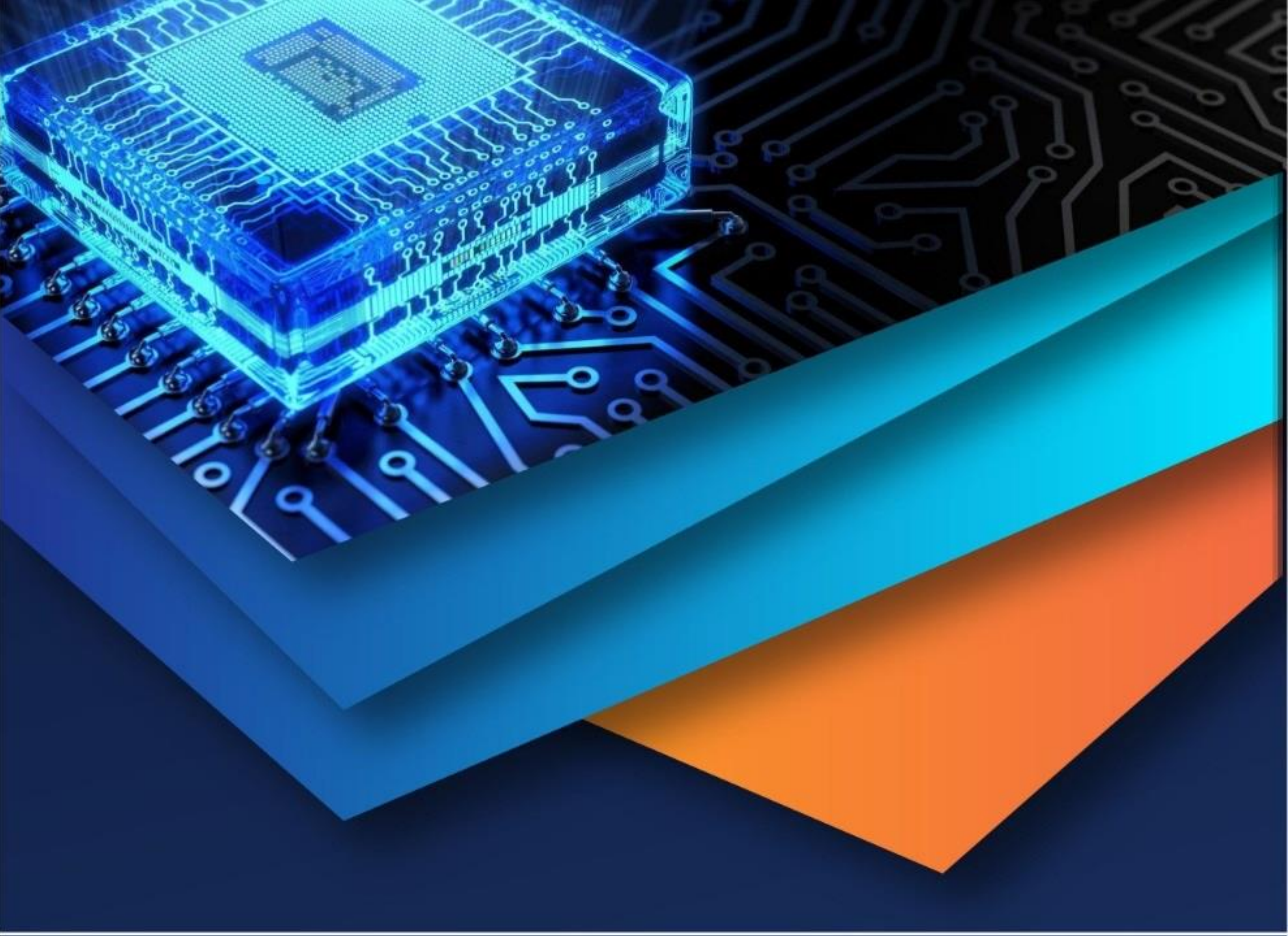

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