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Smart Green Electric Vehicle Charging Station

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Abstract: The transition to electric vehicles (EVs) demands a robust infrastructure of charging stations powered by renewable energy sources to mitigate environmental impact and ensure sustainable mobility. This project proposes an innovative Electric Vehicle Charging Station (EVCS) that harnesses solar and wind energy, supplemented by grid connectivity for emergencies. The system incorporates diverse charging methods including AC, DC, and wireless technologies to cater to varying EV requirements. The core components of the proposed EVCS include a PWM-based solar charge controller, inverter, Arduino Uno microcontroller, and RFID- based wireless authentication system. The solar charge controller efficiently manages power from solar panels, optimizing charging performance while ensuring battery longevity. Inverter technology facilitates seamless conversion of DC renewable energy into AC power compatible with EV charging standards. The integration of an Arduino Uno microcontroller enables intelligent monitoring and control of charging processes, ensuring efficient utilization of available energy resources and enhancing user experience. Additionally, an RFID-based wireless authentication system enhances security and convenience by enabling contactless authentication for EV charging sessions.

Keywords: PV Arrays, Windmill, AC Charging, DC Fast Charging, Wireless Charging, Arduino Uno, proteus Simulink, EASY EDA

I. INTRODUCTION

The widespread adoption of evs necessitates the development of robust charging infrastructure to support their proliferation. This project aims to address this need by designing an Electric Vehicle Charging Station (EVCS) that harnesses renewable energy sources such as solar and wind power. By integrating these renewable energy sources into the charging infrastructure, the project not only promotessustainability but also reduces reliance on nonrenewable energy sources such as solar andwindmill. Solar energy stands out among various renewable resources [1]. The supplementary energy isderived from solar panels and stored in batteries for future use. Utilizing an inverter, this stored energy is then distributed to the load as additional power. The incoming solar energy and battery needs are totally different. This difference needs a charge controller which controls the incoming solar energy as per the need of the battery backup [2]. these electric vehicles come equipped with a variety of battery technologies, each with distinct charging requirements. For conventional lead-acid batteries commonly found in older EV models, AC charging is typically preferred dueto its compatibility and simplicity. However, with the advent of lithium-ion batteries, which are prevalent inmodern EVs for their higher energy density and faster charging capabilities, DC charging has emerged as the primary choice. There are different types of solar charge controllers available in the market. Depending on various concepts the charge controllers store the energy from the solar panel to the battery backup. Themost frequently used solar charge controllers arePWM based charge controller and MPPT based solar charge controller [3]. Moreover, wireless charging technology [4] offers a promising alternative, particularly for nextgeneration EVs equipped with solid-state batteries. Wireless charging eliminates the need for physical connectors, streamlining thecharging process and enhancing user experience. In our innovative wireless charging system, Arduino andRFID technology are seamlessly integrated to facilitateuser authentication and initiate the charging process. Upon scanning their RFID card, customers activate thewireless charging mechanism, allowing for convenientand hassle-free charging of their electric vehicles [5].

II. LITERATURE SURVEY

Acharya, S., & Aithal,P. S. [1]. This Study Shows Innovations in effective management of energy using green technology. The demand for electricity is increasing in such a way that it is not possible to meetthe requirements. This leads to the continuous hike in the price In this paper SHOWS innovativemethodology for the effective management to minimize the wastage, lower the usage cost and lower the maintenance cost of energy. The discussion in this paper is limited to Domestic electricity.

Wallies Thounaojam, V., & Balekundri, A. [2]. Design and development of microcontroller based solar charge controller. The paper demonstrates the Smart Solar Charge Controller which is part of solar power system is designed such that the solar battery gets recharged quickly and does not get over discharged thereby ensuring the prolonged lifespan of the solar battery. Once it reaches fully charged condition, a logicsystem in the charger will keep the battery on trickle charge. The charge controller will have smart battery management system in built. The charge controller will also take care of the deep discharge protection and cut off the load when the battery reaches a certain level when discharged.

P. Sridhar Acharya, and P. S. Aithal [3]. The comparative study of PWM Solar Charge Controllers and their Integrated System, this paper shows There are various methods of charge controllers which will convert the solar energy into the format that is required to the storage devices. Among them, the most popular charge controllers are PWM based as well as MPPT technology based. This paper highlights the benefits of PWM and MPPT technology. The paper also highlights the differences between the two types and gives a conceptual model of integration of both MPPT as well as the PWM solar charge controllers.

Asst Prof. Swapna Manurkar, Harshada Satre, Bhagyashree Kolekar, Pradnya Patil, Samidha Bailmare [4] Wireless Charging of Electric Vehicle this paper demonstrates. As electric vehicles are a better alternative to curb the ongoing pollution it is vital to make amendments in the battery charging process to attain greater reliability. Electric vehicle battery charging can be done by plug in charging at charging stations or by wireless power transfer.

A.Ajithkumar, M., Ajithkumar, S., Gopi, V.G.,Balajisabarin athan, Mr. C. Gowrishankar [5]. Smart E-Vehicle Charging System Using Rfid, this paper proposed system RFID system for user identification and charging authorization as part of a smart charging infrastructure providing charge monitoring and control. The RFID provides a cost-efficient solution to identify and authorize vehicles for charging and would allow EV charging to be conducted effectively while observing grid constraints and meeting the needs of EV drivers

Shaikh Arbaz,Nayna Dahatonde,Nagori Meeran3, Shirgaonkar Zimad, Shaikh Maseera [6]. Electric Vehicle Charging System using Wireless Power Transmission, IoT and Sensors, the objective of this paper is to implement an electric vehicle wireless charging station and charging platform to transmit electrical power wirelessly through space and charge the battery of an electric vehicle.

Marwa Alghawi, Dr. Abdulla Ismail [7] Electric Vehicles in Smart Grid, this research develops a test system to study the functionality of the EV communication protocol with the network components in real-time. For the realization of technical communication, a model-based approach in terms of universal applicability is pursued.

III. PROPOSED METHODOLOGY

Based on operating Techniques of smart electric vehicle charging station consists of various technologies such as PWM based control technique for battery management, this charge controller has connection with inverter, and relay module for wireless charging system.

A. Pulse Width Modulation Technique

Smart solar charge controller using a microcontroller is designed to charge batteries in an efficient way so that their lifetime can be increased. The pulse width modulation technique is used to charge the battery effectively. A PIC microcontroller is used to generate PWM. The PIC microcontroller is used to read all these analog values of voltage and current. The CCP (Capture/Compare/PWM) modules in PIC16F877A are used for PWM generation also There are two CCP modules: CCP1 (at pin RC2) and CCP2 (at pin RC1). the charge controller may incorporate safety features such as overcharge protection, over-discharge protection, and temperature monitoring to prevent damage to the battery and ensure safe operation. The PIC microcontroller constantly monitors these parameters and takes appropriate action to protect the battery and charging system. A liquid crystal digital display is used to show the values of the battery's charging current, solar panel voltage, battery voltage, and load current. Protection is also introduced through programming techniques so that in case of excess current, the solar charge controller will stop working. It can handle up to 10 amperes, making it a 10 Ampere solar charge controller.

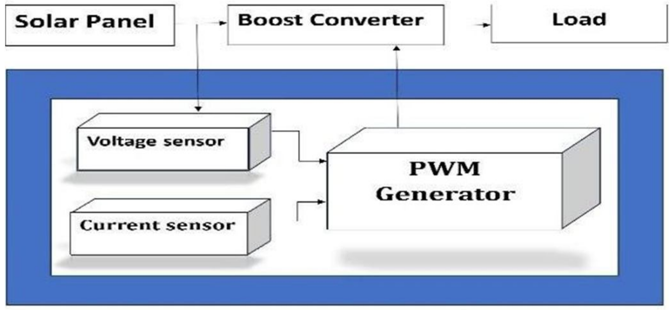

Fig -1: PWM Based charge controller

B. Inverter

An inverter is a crucial component in an electric vehicle charging station that converts direct current (DC) electricity into alternating current (AC) electricity. Since most electric vehicles utilize AC power for charging their batteries, inverters play a vital role in enabling the transfer of energy from various sources to the vehicle. in the context of a charging station powered by renewable energy sources such as solar panels and wind turbines, the electricity generated is typically in the form of DC. Therefore, an inverter is necessary to convert this DC electricity into AC electricity compatible with the electric vehicle charging infrastructure. The circuit consists of Astable multivibrator which uses two transistors and tuned to generate 50 Hz to 60 Hz at 50% duty cycle. The frequency can be from 50 to 60 Hz; this is due to the tolerance of the capacitors and resistors which creates inaccuracies Astable multivibrator acts as oscillator for this inverter. The driving stage has 2 MOSFETs IRF540N and the 230V / 9V-0-9V / 10A transformer boosts the output voltage.

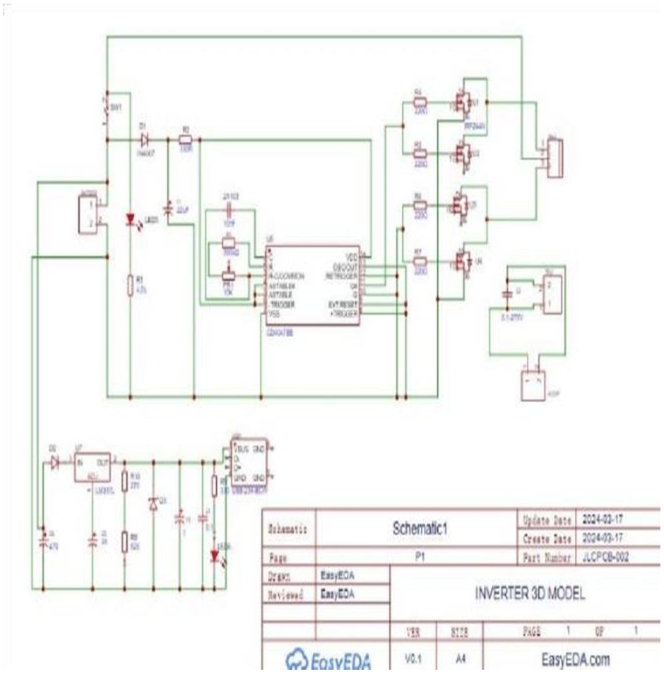

Fig -2: Inverter circuit diagram

C. Inductive Wireless Charging System

The basic principle of Inductive wireless charging is Faraday's law of induction. Wireless transmission of power is achieved by mutual induction of magnetic field or flux between transmission and reception coil. When the main AC supply applied to the transmitter coil, it creates an AC magnetic field that passes through receiver coil and this magnetic field moves electrons in receiver coil causes AC power output. This AC output is rectified and filtered to Charge the battery of an electric vehicle. The amount of power transferred relies on frequency, mutual inductance and distance between the transmission and reception coil. Operating frequency of Inductive wireless charging is between 19 to 50 kHz.

The harmonic current can cause heating in a conductor which lead increase in current value than expected. This effect increases the resistance of the wire in the coil, which may already have a relatively high resistance due to its length and small diameter. While the proximity effect is caused due to the conductor magnetic field, which disrupts the current distribution in adjacent carriers. Inductor value for multi-layer, multi-row coil is calculated by using below formula: -

$$L = \frac{\mathbf{0.8} + (\boldsymbol{Raduis}^{\mathbf{2}} * \boldsymbol{Turns}^{\mathbf{2}}))}{(\mathbf{6} * \boldsymbol{Radius} + \mathbf{9}\boldsymbol{Length} + \mathbf{10} * \boldsymbol{Depth})}$$

Where, L = inductance of coil (Henry) Turns = Number of turns in the wire coil

Radius = Mean radius of the coil (centimeters) Length = length of coil (centimeters) Depth =thickness of coil (centimeters)

Or we can useinductance meter to find the value of inductor.

Design Of Transmitter and Receiver Circuit for the EV:

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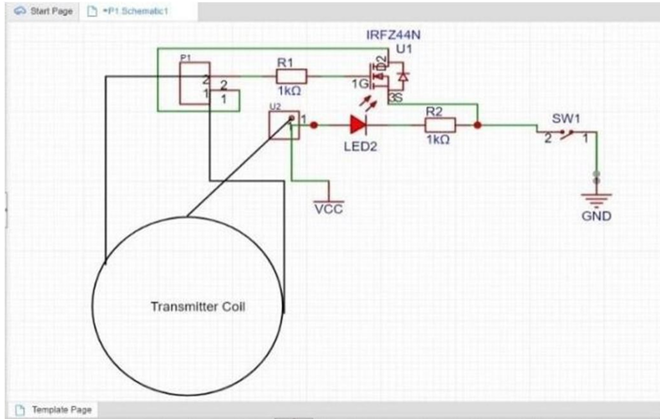

Fig 3-: TX-Wc Model Circuit

This circuit is responsible for generating an alternating current (AC) that creates an oscillating magnetic field. This field is what induces a current in the receiver coil, thus transferring power wirelessly, the transmitter coil, often referred to as the primary coil, consists of multiple turns of wire wound around a core. This coil is made 30 turns of 25-gauge wire. The coil is usually designed to resonate at a specific frequency to maximize efficiency.

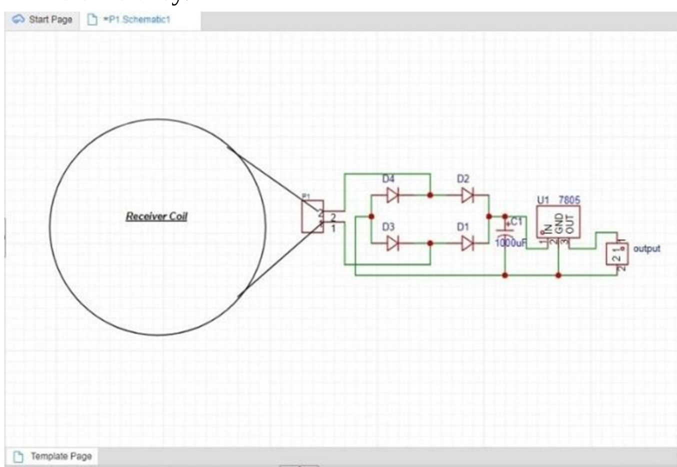

Fig -4: RX-Wc Model Circuit

The receiver coil, often referred to as the secondary coil, is similar to the transmitter coil but is typically smaller in size and designed to resonate at the same frequency as the transmitter coil. The receiver circuit includes components such as a rectifier to convert thealternating current induced in the receiver coil into direct current (DC). A voltage regulator may also be included to stabilize the output voltage to the device being charged. In cases where the device being charged has arechargeable battery, the receiver circuit may also include a battery charging circuit to control the charging process and ensure the battery is charged safely.

D. Power Sources for EV Charging System

The EV charging station provide various chargingoptions to the customer which include AC, DC Fast andwireless charging also the grid connection is available for the emergency situations.

The power source categorizes in two groups 1st one is wired and 2nd is wireless, wired charging methods, which may be further broken down into AC and DC charging technologies, require a direct cable connection between the EV and the charging equipment to achieve charging, by using AC charging technologies, EV batteries are not charged directly;rather, the battery is charged by the onboard charger (OBC) that supplies the battery. These technologies add weight to the entire system because the conversion unit, which converts AC into DC, is housed inside the vehicle. They are frequently charged using either single-phase (1ϕ) onboard slow charging or three- phase (3ϕ) onboard fast charging systems.

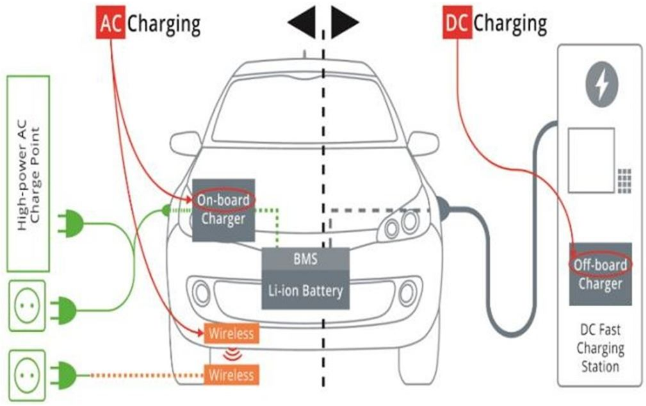

Fig -5: AC, DC Fast and wireless charging

The time difference between AC charging and DC fast charging is dramatic. The power output for AC Level 1charging at 12A and 120VAC could be up to 1.4 kW, while AC Level 2 charging at 80A and 240V offers up to 19.2 kW. Theoretically, it would take about five to six hours to fully charge a 100-kWh battery pack, evenusing the highest power level of AC charging at 19.2 kW.
This are the calculation for the prototype of ac and dc fast charge works in EVs,

E. AC Charging

AC charging typically involves converting AC power from a wall outlet to DC power to charge the battery. The charging rate is usually measured in watts (W) orkilowatts (kW).
AC charging rate of 3.3 kW, which is common for Level 2 chargers. to calculate the time, it takes to charge the battery, we can use the formula:

$$\boldsymbol{Time}(\boldsymbol{Hours}) = \frac{\boldsymbol{Battery\ Capacity}\ (\boldsymbol{Ah})}{\boldsymbol{charging\ rate}(\boldsymbol{mA})}$$

First, convert the battery capacity to Ampere-hours(Ah):

F. Electric Vehicle Charging Cost Estimation Platform

EV charging system provides a comprehensive solution for electric vehicle drivers, offering a user-friendly website designed to streamline the process of calculating charging costs. By inputting essential details such as vehicle type, battery specifications, and charging power, drivers can obtain accurate estimates of the amount they need to pay based on their specific usage. (**https://charginghub.netlify.app/**)

$$battery\ capacity \text{ Battery Capacity (Ah)} = \frac{(mAh)}{1000}$$

Then, plug the values into the formula:

$$Time\ Hours = \frac{5000\ mAh}{3300\ mA}$$

$$Time\ Hours = \frac{5000}{3300} h \quad ours$$

$$Time\ Hours = \frac{3300}{5000} h \quad ours$$

Time (hours)≈ 1.52 hours.

G. DC Fast Charging

DC fast chargers can deliver higher charging rates compared to AC chargers, typically ranging from 50 kW to 350 kW or even higher.

DC fast charging rate of 50 kW. Using the same formula as above:

$$Time(Hours) = \frac{5000\ mAh}{5000\ mA}$$

$$Time(Hours) = \frac{5000}{5000} h \quad ours$$

$$Time(Hours) = \frac{5000}{5000} h \quad ours$$

Time (hours)≈ 0.1 hours' Time (hours)≈0.1 hours. This translates to approximately 6 minutes to charge the battery using a 50 kW DC fast charger.

DC Fast Chargers can recharge an EV battery to 80%capacity in as little as 20-30 minutes.

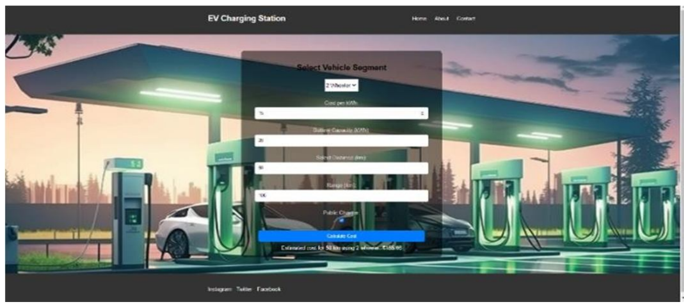

Fig -6: EV Charging Interface

IV. SIMULATION / IMPLEMENTATION

A. Design and Simulation

Utilize simulation software such as proteus Simulink to model the renewable energy system including solar panels, wind turbines, and battery storage, Simulate the PWM-based solar charge controller to optimize charging efficiency and battery lifespan. The Model the grid connection system to ensure seamless integration with renewable energy sources and provide backup power. Simulate communication protocols between Arduino Uno and RFID wirelesscharging modules to ensure reliable wireless charging functionality.

B. Hardware Implementation

Procure necessary components including solar panels, wind turbines, batteries, inverters, Arduino Uno, RFID modules, and EV chargers. Install solar panels and wind turbines in suitable locations to maximize energygeneration. Connect the renewable energy system to the PWM-based solar charge controller and battery storage, further Program Arduino Uno to control power distribution, monitor energy flow, and communicate with RFID wireless charging modules after that test the system under various conditions to ensure functionality, efficiency, and reliability.

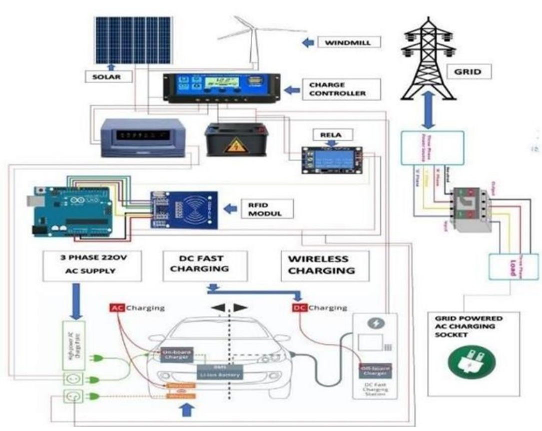

Fig -6: Smart EV charging station

V. CONCLUSIONS & FUTURESCOPE

The Electric Vehicle Charging Station (EVCS) project presents a comprehensive solution to the growing need for sustainable transportation infrastructure. By harnessing renewable energy sources such as solar and wind power, the EVCS not only facilitates the widespread adoption of electric vehicles but alsoreduces reliance on fossil fuels, thereby mitigating environmental degradation and climate change.

The integration of multiple charging options, including AC, DC, and wireless charging, ensures compatibility with a wide range of electric vehicles, enhancing convenience and accessibility for users. Additionally, the inclusion of a PWM-based solar charge controller optimizes energy harvesting from solar panels, maximizing efficiency and reducing operational costs over time. Continued advancements in EV charging technology are expected to enhance charging efficiency, reduce charging times, and improve user experience. Innovations such as ultrafast charging, wireless charging, and smart charging solutions will revolutionize the EV charginginfrastructure, making it more convenient and accessible for consumers.

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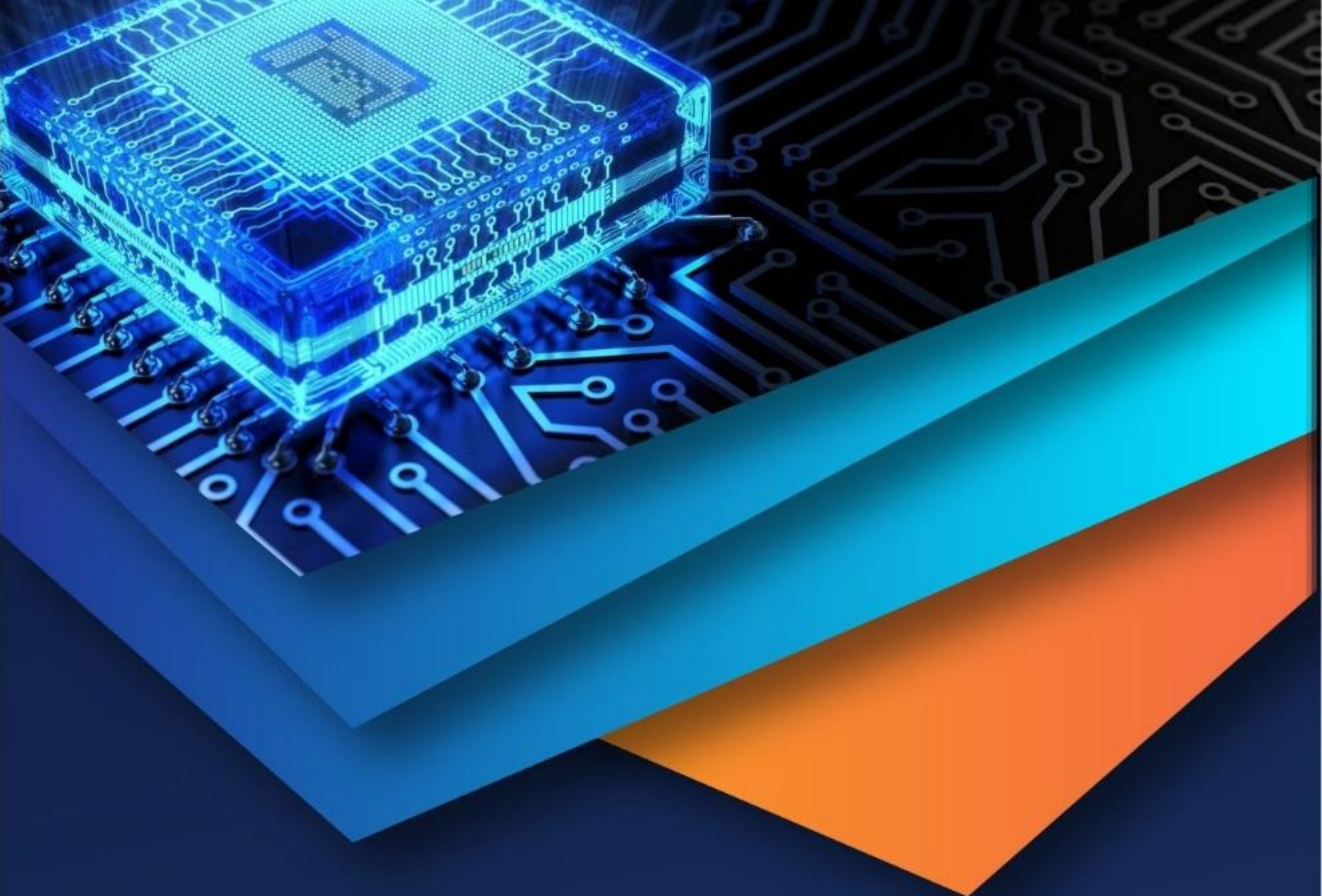

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