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EVs Lithium-ion Battery Heating Analysis and Monitoring

Swapnil Irkate[1], Varun Jaybhaye[2], Amogh Dongre[3]
Department of Instrumentation and Control Engineering, Vishwakarma Institute of Technology, Pune, India

Abstract: We are rapidly moving towards the future and EV's are going to be an important part of it. In this paper we are going to find out the reason why those electric vehicles are catching fire, how short-circuit in internal circuits due to variation in current, voltage can cause increase in temperature. Basically, there are two parameters are cause the heating issues in the battery i.e., internal and external parameters of the battery. So, in the proposed work, we have done with the sub parameters of the above two mentioned parameters observation that how they cause a temperature increase in battery.
Keywords: Lithium-ion battery, Charging, Discharging, Current, Voltage

I. INTRODUCTION

Electric vehicle is going to take a large leap in the few years globally. But with solution we also have problems, issues but this time they are serious and have direct relation with one's life.

The question and the issue are none other than why and how are the Battery exploding. First, we need to understand it from its core. for this, some analysis is done in this paper and hence that is the purpose of this project. Maintaining an appropriate temperature is essential for achieving optimal performance from a lithium-ion battery in electric vehicles. During the process of charging and discharging, changes in current and voltage can cause the battery's internal circuits to generate heat, which can impact its temperature. Therefore, it is important to analyze the rate of heat generation in the battery, which is influenced by factors such as temperature, battery aging, state of charge, and operation current.

A recent study conducted an experiment on a power-type lithium manganese oxide/graphite battery under varying conditions to analyze the effect of temperature, aging, state of charge, joule heat, and reaction heat on the rate of heat generation. The study used a large battery heat transfer model to calculate and verify the temperature variations and to accurately estimate the rate of heat generation under different conditions of aging and current. The findings suggest that this method is suitable for real-time applications and can provide a better understanding of the temperature variation in lithium-ion batteries.

II. LITERATURE SURVEY

This paper updates the latest battery batteries (EV) and related safety issues and protection strategies against fire. Li-ion (LIB) battery and fire hazard are particularly acute on EV, due to rise in demands on performance driving and speed charging, unavoidable road accidents, and increasing level of power and high packs of battery. [1] This paper described the features of PHEV fires based on temperature data, records, and photographic images. Two types of vehicles were used in the experiment, and their fires ignited due to external short-circuit faults in the battery packs [2] This paper has introduced various risk reduction measures that address the prevention and recovery from accidents associated with electric vehicles. These include, road accidents and battery damaging situations because of external or internal fires [3] a simulation model that combines electrode responses and charging transitions was developed for the purpose of predicting battery performance and was used to test power outages in particular. It was shown that changing the electrode boundaries of lithium-ion batteries makes it possible to create energy source systems suitable for use in a variety of natural vehicles considered [4] This paper examines the who to control Lithium-ion batteries in a healthy charging manner. This is a very serious problem because batteries are damaged by a number of complex and interconnected systems with the same frequency [5] Li-ion batteries are a great source of energy. Their power output is high compared to many other batteries. Li-ion batteries require low maintenance. They have good battery life. They have a free rate of 1.5-2% per month. They contain toxic substances such as cadmium which can drain the battery. For all these reasons a Li-ion battery is preferred over a Ni-Cd battery. There are some safety issues with li-ion batteries. These batteries are very expensive. They have extreme heat problems and can be damaged at high voltage. To overcome these problems, we can set a limit on its voltage and use a certain safety mechanism in it but this can also reduce battery performance. Li-ion batteries have some limitations that can be overcome with future technological advances. [6]

This study examines different internal and external structures of lithium-ion batteries by analyzing their performance in high-resolution emissions and simulating nail penetration. Results show that thin electrodes can improve ion diffusion, leading to better electrochemical performance and high emission efficiency, which benefits Cell 1 in terms of long-term performance. However, this electrode design has a negative impact on the relaxation of the electrochemical process during nail penetration, making Cell 1 the most dangerous among the three cells studied.
On the other hand, Cell 2 and 3, with thicker electrodes, exhibit lower volume and energy retention, but also have a stronger heat dissipation process during high-intensity extraction. These batteries maintain high temperatures below the critical threshold during nail penetration. This suggests that, while Cell 2 and 3 have some limitations, their thicker electrode design can provide better safety during certain types of usage scenarios. [7] The final part of the paper explores the chemistry of each Li-ion battery and its suitability for various applications. The study concludes that there is no one-size-fits-all solution, and the selection process for a Li-ion battery chemistry is critical. Improper selection can negatively impact the economic viability of an investment. Therefore, careful consideration is necessary when selecting a Li-ion battery chemistry for a specific system to ensure its optimal performance and economic viability. [8] [9] Lithium-ion batteries (LIBs) are crucial technologies for energy storage, transportation, and consumer electronics. However, some types of LIBs are prone to igniting or releasing gases, which can have significant consequences. Although rare, fires caused by LIBs differ significantly from other types of fires in terms of their ignition, spread rate, duration, toxicity, and pressure. As such, it is important to be aware of the unique risks posed by LIB fires and take measures to prevent and manage them effectively. [10].

III. WHAT IS A LITHIUM-ION BATTERY AND HOW DOES IT WORK?

Lithium ion is used in lithium-ion (Li-ion) batteries as a major component in electrochemistry. During the discharge process, lithium atoms are ionized in the anode then electrons are separated. Lithium ions travel through the anode and then through the electrolyte to reach the cathode, where the electrons regroup and become electrically neutral. Because lithium ions are small, they should be0 able to pass through a micro-permeable separator between cathodes and anodes. Li-ion batteries have very high voltages and charge storage per unit mass and unit volume. They can use different materials as electrodes. Therefore, the most commonly used combinations in devices such as phones and laptops are lithium cobalt oxide (cathode) and graphite (anode). An anode that is mostly made from graphite and a cathode that is made from an oxide of lithium, mostly lithium cobalt oxide (LCO) in used in electric vehicles.

IV. WHY EV'S CATCH FIRE?

A short in a circuit board of EV due to a wiring fault or even a puncture in the cells can cause a rise in temperature and subsequently a fire. Faulty charging. A rise in temperature can be brought through a wiring fault or even a puncture cell which can led to subsequently a fire. Use of faulty as well damaged cables or wall outlets can also cause a fire. All this can lead to overflow of current or rapid change in the voltage causing internal short-circuit. A single contaminated cell can lead to a huge fire, igniting itself and then subsequent other cells which cause to the temperature rise. In appropriate flow of current/voltage across the circuit can led to dangerous accident.

V. ANALYSIS OF RELATION BETWEEN THE CHANGE IN CURRENT FLOW WITHIN THE INTERNAL-CIRCUIT AND TEMPERATURE OF EV'S LITHIUM-ION BATTERY

A tester to discharge the battery form fully charged Lithium-Ion cell to zero is used also it is checked through a resistor while measuring the current flowing through the resistor to calculate its capacity.
To check the capacity of a battery, battery capacity tester is used which discharges the fully charged lithium-ion battery with the help of resistor.
When the start button is pressed, tester which is connected to a 10ohm resistor in parallel discharges the battery. Voltage across the circuit is read with the help of microcontroller every second. Current flowing through the load can be found using Ohm's law.
Fully charged battery is need to be connected first. Current battery voltage is shown on the display. After pressing the start button, the battery testing begins. The following information is now displayed on the screen:

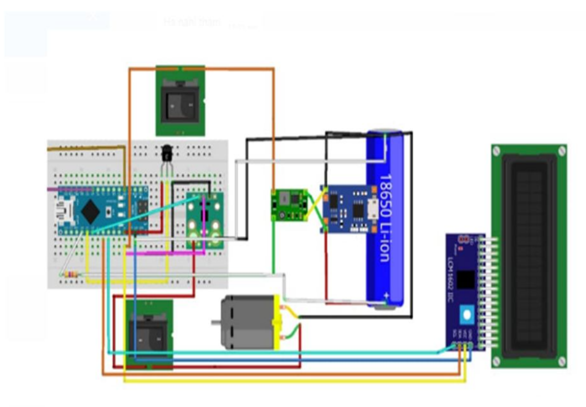
1) Number of times measurements performed
2) Voltage of a battery
3) And power over time in milliamps per Minute.

As mentioned there is drop in voltage. The test conducted throughout the process ends when the voltage reaches 3 volts and thus the battery is considered empty.
Depending upon the capacity of the battery this process will take time.
The actual battery capacity and the number of measurements taken are shown on display as the battery voltage drops below 3V.

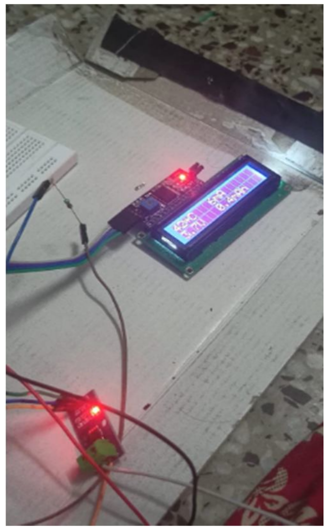
VI. ANALYSIS OF RELATION BETWEEN THE VARYING VOLTAGE WITHIN THE INTERNAL-CIRCUIT AND TEMPERATURE OF EV'S LITHIUM-ION BATTERY

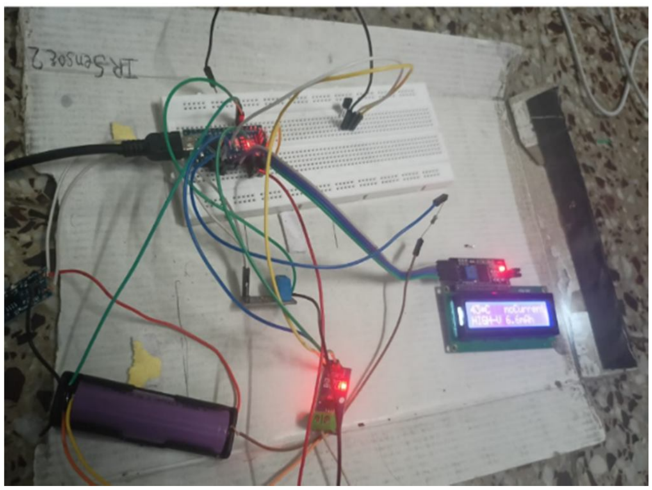
To measure the voltage of a Li-Ion cell using an Arduino Nano, it is necessary to use a voltage divider circuit. This circuit consists of two resistors connected in series, which together reduce the voltage of the cell to a level that is safe for the Arduino to measure. By measuring the output voltage at the junction between the two resistors, the Arduino can determine the voltage of the cell.
When designing a voltage divider circuit for this purpose, it is important to consider the maximum voltage of the Li-Ion cell and the maximum voltage that the Arduino can safely measure. For example, if the Li-Ion cell has a maximum voltage of 4.3V, the voltage divider circuit must reduce this voltage to a level below the maximum voltage that the Arduino can measure (which is typically 5V). To calculate the appropriate resistor values for the voltage divider, various formulas and equations can be used, depending on the specific requirements of the circuit.
When measuring the flow of current through a resistor, Ohm's Law can be used to calculate the current by measuring the voltage drop across a load resistor. However, when using a small shunt resistor, an amplifier circuit may be necessary to amplify the voltage signal to a readable level for the Arduino.
It is important to ensure that the negative terminal of the load resistor is connected to ground when measuring the voltage drop across it. This will allow for an accurate reading of the voltage drop across the resistor, which can then be used to calculate the current flowing through it using Ohm's Law.

VII. METHODOLOGY



A method for analyzing the parameters that cause to increase in the temperature of the electric vehicles' lithium-ion battery is presented in order to find out the major parameters that cause the thermal expansion in batteries and because of that the battery catches fire or it could explode. So, we do the research on the lithium-ion batteries' heating issues so we get that there are two main points that cause heat in batteries and they are the internal and external parameters of the batteries. So, in this study we basically work on three major parameters that come into the internal and external those are charging, discharging and the external temperature i.e., ambient temperature which directly affect change in current and voltage flow. This system treats the data of the lithium-ion batteries according to the factors like initial temperature of the battery, ambient temperature, charging, and discharging, because we used the dataset of the moving vehicle so we also have the factors speed, distance, battery temperature at stop/end, weather, time like that and these are the factors for the discharging parameter which is the internal thing that increase the temp of battery and like for charging we created the dataset by taking the actual live readings of the lithium-ion battery from zero charging to up to full charge to get each particular point of temperature during charging. So based on studies basic model consisting of Arduino, DC motors and sensors is made to understand the effect of current and voltage on the temperature out the patterns between them.





VIII. RESULT

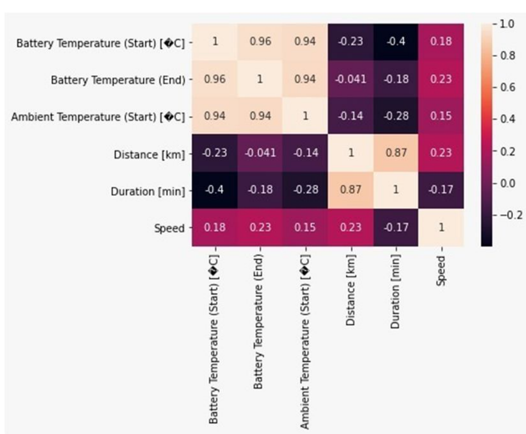


Fig.01 Relationship graph of variables

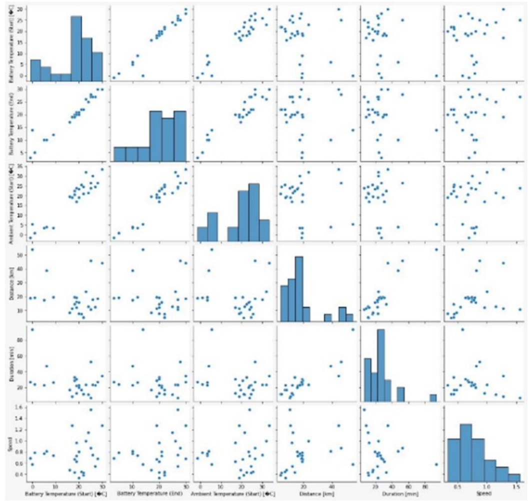


Fig.02 Matrix relationship between each variable

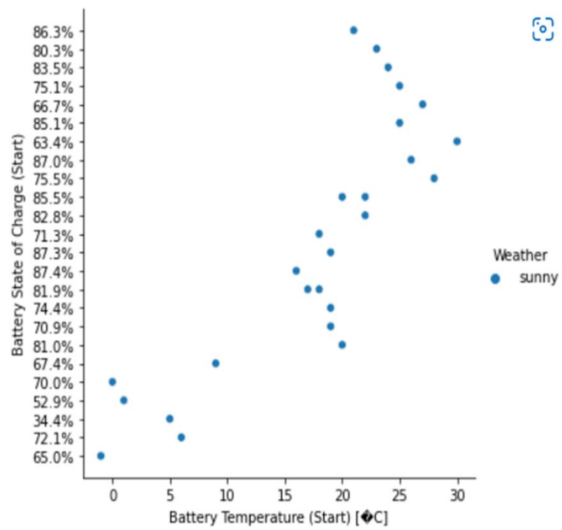


Fig.03 Battery SOC w.r.t Battery Temp. Start

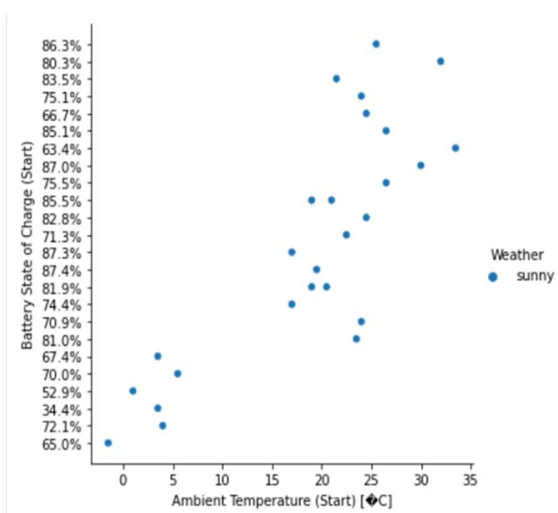


Fig.04 Battery SOC w.r.t Ambient Temperature

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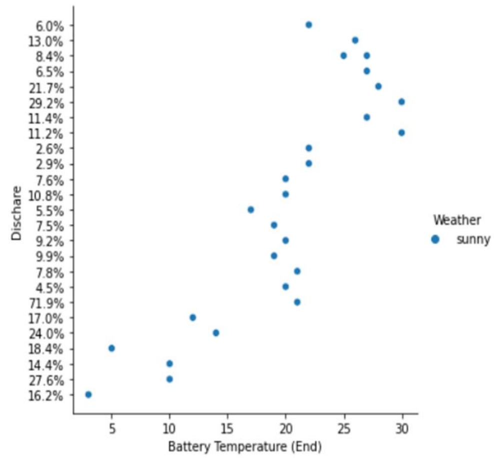

Fig.05 Discharge w.r.t Battery temperature

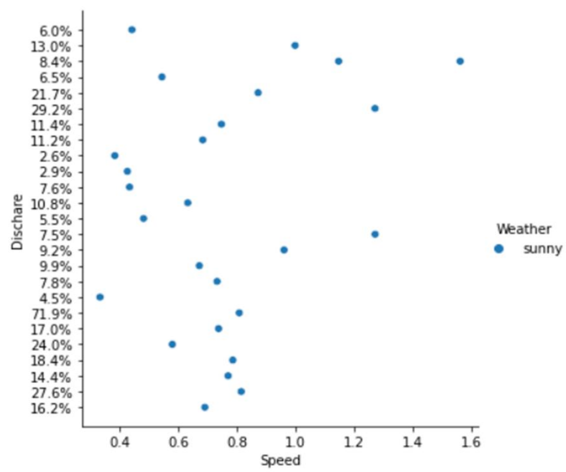

Fig.06 Discharging w.r.t speed:

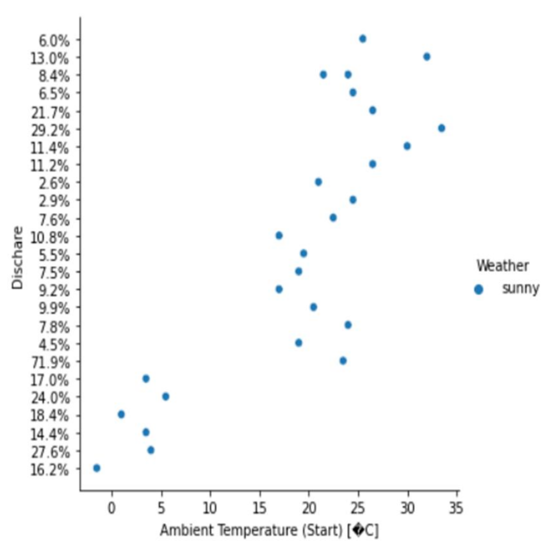

Fig.07 Discharge w.r.t Ambient Temperature

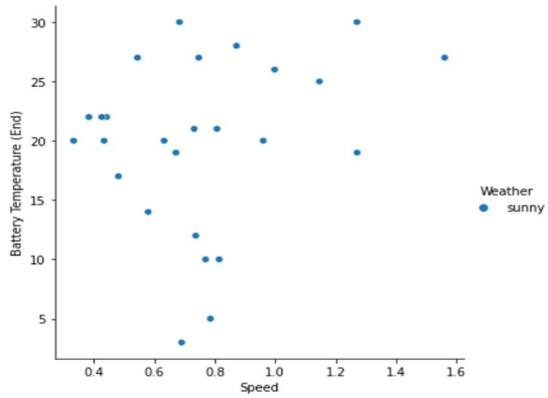

Fig.08 Battery Temperature w.r.t Speed

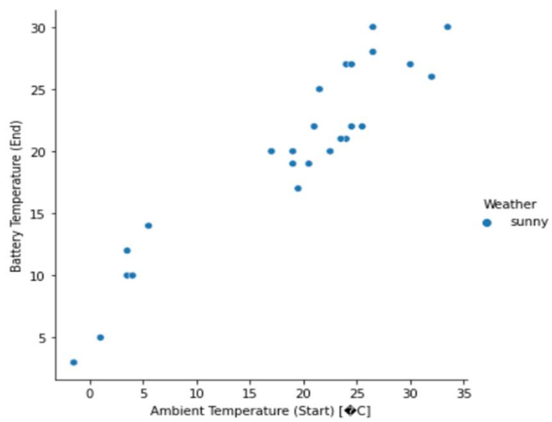

Fig.09 Battery Temp. End w.r.t Ambient Temperature

The goal of this project is to develop a circuit that can accurately measure the voltage, discharge current, temperature, and capacity of Li-ion batteries. These measurements will then be displayed on an LCD screen using a software that enables serial connections with another microcontroller. The objective is to provide comprehensive and real-time information about the battery's performance and status for monitoring and management purposes.In order for the working of the circuit independently, it was necessary to provide power to the Arduino Nano microcontroller A typical fully charged Li-Ion cell has a maximum voltage of 4.1V to 4.3V which is smaller than the 5V voltage limit of the Arduino Nano’s analog input pins. This pins can only bear 10kΩ internal resistance so we can simply connect the Cell to any one of the analog input pins without thinking about the current flowing through the pins. Now there is a need to measure the voltage of the cell to determine whether the cell is in the right operating voltage range and the cells are fully discharged or not.

IX. CONCLUSION

In this paper the analysis of the heating issues in the lithium-ion battery and which parameters are affects the issues are studied successfully. We successfully analyzed the generation of heat in the lithium-ion battery during the period of charging and the discharging and change in current and voltage and observed the different variations in the temperature of battery. Also, we successfully created the change in current and voltage dataset by taking real-time reading and change of temperature of battery, ambient temperature, initial state of charge of battery, after each particular percentage we checked the amount of state of charge. The reading which we calculated in the raw dataset and the real-time dataset we get the correct output of heat generation analysis. So, we conclude on that if the temperature of battery increases then there is not only the external temperature of environment is responsible there are some internal factors are affected equally to increase heat in battery. As the analysis we observe if the discharging rate and the charging rate of battery get decrease and increase at particular threshold values according to the sub-parameters like speed, external temperature, time, distance then they cause change in current and voltage flow in internal circuit and thus the heat generation in battery.

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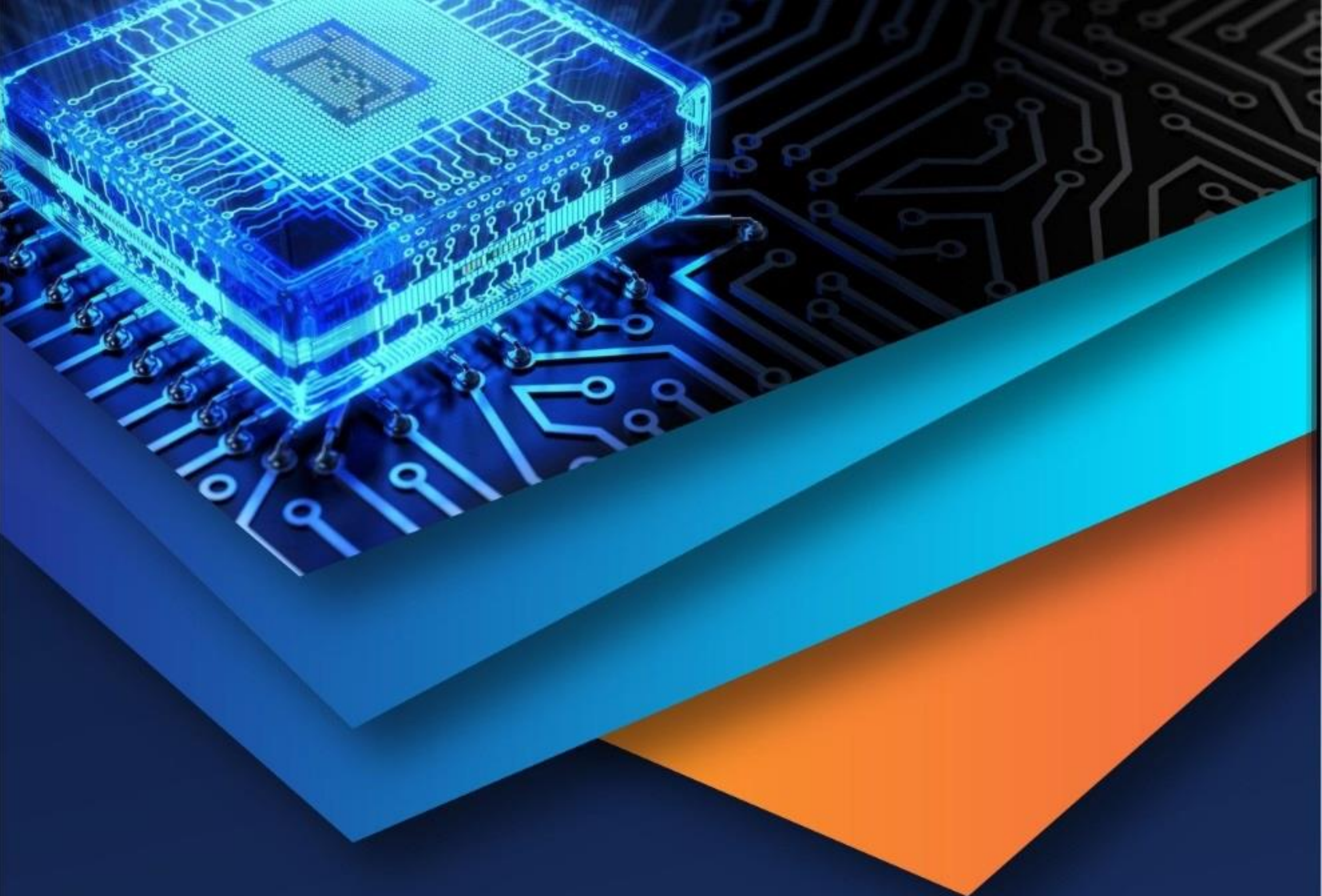

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