iJRASET
International Journal For Research in Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 9 **Issue:** VIII **Month of publication:** August 2021

**DOI:** https://doi.org/10.22214/ijraset.2021.37330

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VIII Aug 2021- Available at www.ijraset.com

# Design Development and Analysis of Future Reliable Electric Vehicle

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***Abstract: Universal climate change has already had noticeable effects on the environment. Net damage costs of climate change are likely to be considerable and to swell over time and emissions from transportation sector and use of fossil fuels in this scenario is just like adding fuel to fire. This work is a small effort made not only to portray the development of future reliable technologies in eVehicle that provides a cleaner solution with less carbon footprint but also to explain and establish the importance of the eVehicle as the most efficient and clean means of transportation with the help of plan and performance analysis. This paper presents the detailed analysis of different components of Battery operated eVehicle. The proposed EV Design addresses issues like range, drive train efficiency, fast exploration of higher system voltages ,charging times and reduced vehicle weight and tries to develop it as an option that is significantly safe, energy efficient, environmentally-friendly and easily controllable and to do so design, analysis and MATLAB simulation is carried out on battery operated eVehicle. As a BEV has a complex structure for analysis a realistic model is considered the accuracy simulation results are verified with theoretical outcome.***

***Keywords: Electric Vehicle, Simulation, Brushless DC Drive, Renewable Energy, Climate change.***

## I.INTRODUCTION

The life of the oil resources on the earth is function of collective demand and supply. Chronological fact reveals that the increase in supply i.e. new discovery of oil reserves occurs slowly where as the counterpart consumption shows a very high growth rate. If the current consumption trend continues the world oil resource will exhausted soon in near future. This calls for the need that one should move to an alternative source and renewable energy. Moreover, climate change becoming the major threats besides that all harmful waste of fossil which are toxic, unsafe to human health and lead to ozone depletion. More and stricter waste discharge and fuel consumption regulations are motivating to have the development of safe, clean, and high-efficiency transportation. It has been well accepted that electric, hybrid electric, and fuel cell-powered drive train technologies are the most latent solutions to the problem of road transportation in the future. Hence, the use of electric vehicles over engine powered vehicles has been taken into account, to overcome the combustion of non-renewable fuel that leads to global warming and climate change. A renewable vehicle is lightweight, more efficient, pollution free, and is not harmful to nature and also many other advantages of EV are attracting automobile industries to use renewable sources to power their vehicles as the only next alternative.

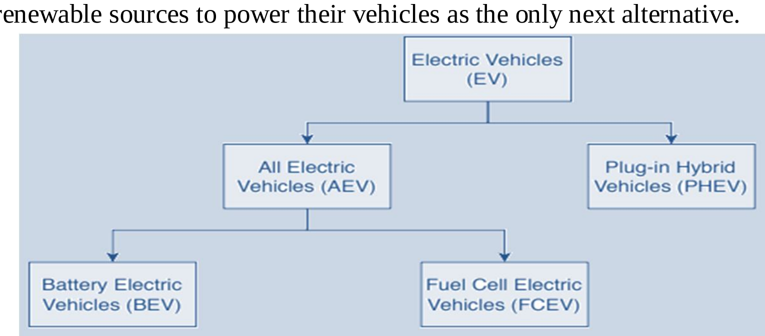


Figure I: Types of Electric Vehicles

The Battery Electric Vehicle or BEV is pure electric and runs solely on the power of an internal battery for energy. The distinguished feature of BEV is that there is no use of internal combustion engines but electric motors and motor controllers are used for propulsion. The electric energy stored in the rechargeable battery is provided to the electric motor and runs.

*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429*
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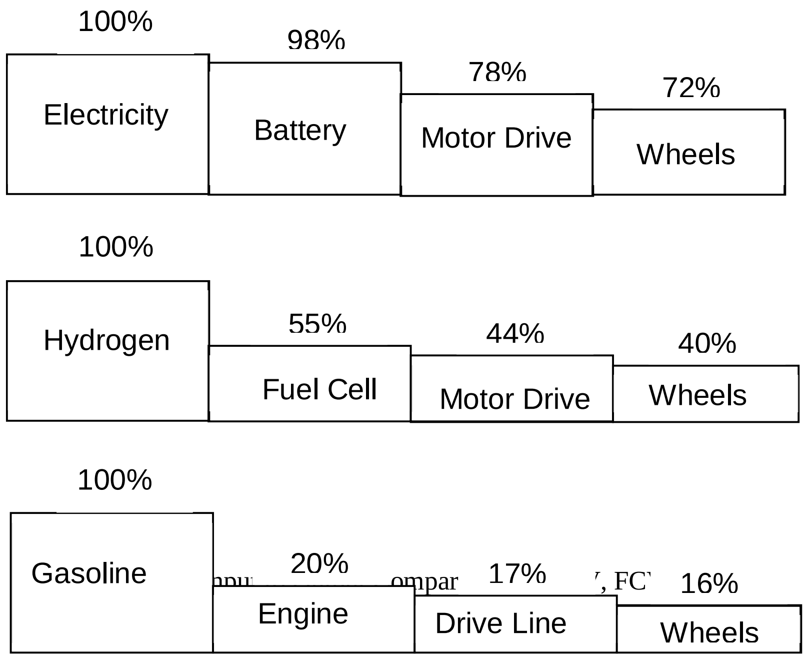
Hybrid Electric Vehicle (HEV) combines a conservative power train with an electric motor that uses battery stored energy. Vehicle is accelerated by the application of regenerative braking that stores the kinetic energy used to stop the car and thus charge its battery. So, the electric battery is charged while using the combustion engine.
Another category of an electric vehicle is Fuel cell vehicle (FCV) or fuel cell electric vehicle (FCEV) that works on fuel cell or in arrangement with an undersized battery or super capacitor, to control its onboard electric motor. Oxygen from the atmospheric air and compressed hydrogen are used by Fuel cells in vehicles to generate electricity.



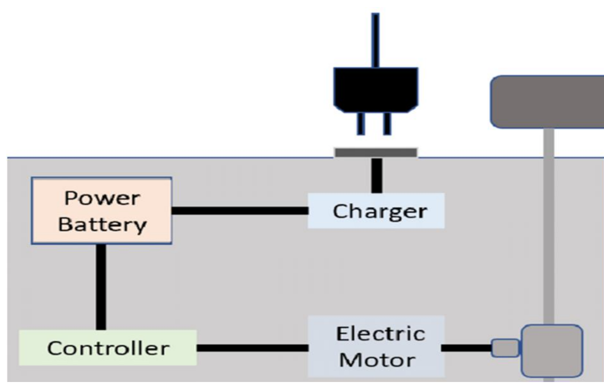



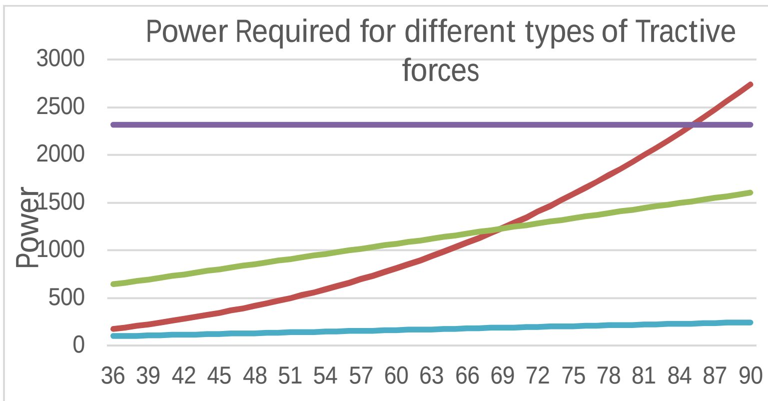
Figure III: Simple Design of BEV

The BEV required functioning in three different modes explicitly as Steady state mode, acceleration mode and regenerative mode. During the acceleration and Steady state mode the power flows from battery to motor whereas during regenerative mode the kinetic energy of the motor is converted into electrical energy and supplied back to the battery. Battery electric vehicles have some integrated components such as BLDC motor and a Controller unit.

1) *BLDC Motor:* Highly efficient and excellent in control features Brushless DC motors (BLDC) used to convert electrical energy into mechanical energy. The motor runs when a field of electric current passes through the coil in a fixed magnetic field thereby converting electrical signals into motion.
2) *Controller:* The controller transforms the battery's direct current into alternating current and regulates the energy flow from the battery and ensures balance and proper flow of energy within an eVehicle.

## II. METHODOLOGY

To have a design and layout of an electric equivalent circuit in MATLAB-Simulink keeping all the topologies in account, the theoretical calculations for the proposed structure are made first and to decide the power rating of vehicle various vehicle dynamics like rolling resistance, gradient resistance, aerodynamic drag, etc. were taken into consideration. Further the forces acting on the Motorcycle such as tractive force, rolling resistance, gradient resistance and aerodynamics drag were calculated. For constant calculated and considered values of mass (250), inclination (5) Diameter (12), time for inclination (30) against the different velocities ranging from 36 m/s to 90 m/s taken as unit incremental velocity, Aerodynamic drag, rolling coefficient, rolling resistance (9.77), , gradient force (213.74), acceleration (138.88) are calculated. The output torque is noted having minimum and maximum values as 57.90 and 71.94 respectively, and the final rpm of the wheel is calculated having minimum and maximum values of 626.91 and 1549.86 respectively. Details are shown in the below Table I.




Velocity

Figure IV. Graph of Velocity V/s Power

Table I: Theoretical calculation of final RPM

| Drag | Total | Torque | Power for Drag | Power for Gradient | Power for Rolling | Rpm of wheel |
|---|---|---|---|---|---|---|
| 17.5 | 380.0 | 57.9 | 175.5 | 641.2 | 97.7 | |
| 18.5 | 380.9 | 58.1 | 190.5 | 659.1 | 100.4 | 626.9 |
| 19.6 | 382.0 | 58.2 | 206.4 | 676.9 | 103.2 | 644.3 |
| 20.6 | 383.0 | 58.4 | 223.1 | 694.7 | 105.9 | 661.7 |
| 21.7 | 384.1 | 58.5 | 240.7 | 712.5 | 108.6 | 679.2 |
| 22.8 | 385.2 | 58.7 | 259.2 | 730.3 | 111.3 | 696.6 |
| 23.9 | 386.3 | 58.9 | 278.6 | 748.1 | 114.0 | 714.0 |
| 25.0 | 387.4 | 59.0 | 299.0 | 765.9 | 116.7 | 731.4 |

## III. DESIGN CONSIDERATIONS

The electric system consists of a battery, motor, motor controller and other electronic equipment. This in turn gives power to the motor which helps in the running of the vehicle. Energy stored in the battery is in the form of chemical or electric energy is used by a hub motor and gets converted into mechanical energy. The brushless DC (BLDC) motor is preferred for its compactness and noiseless operation and fixed to the hub of the rear wheel of the vehicle body. The design is developed in such a way that it promise to have following objectives

*1)* Reduces the emissions
*2)* Achieves long range in single charge
*3)* Achieves high speed for BEV
*4)* Incorporates regenerative braking system to increase efficiency of vehicle

The circuit system consists of main blocks:

- Drive cycle, Controller, Battery, BLDC Motor, Vehicle Body

Table II: Comparison Chart between Batteries

| Parameter | NiCd | NiZn | NiMH | Li-ion/Li-Po |
|---|---|---|---|---|
| Specific Energy (Wh/kg) | 40-60 | 100 | 60-120 | 100-265 |
| Energy Density (Wh/L) | 50-150 | 280 | 140-300 | 250-730 |
| Specific Power (W/kg) | 150 | >900 | 250-1000 | 250-340 |
| Charge/Discharge Efficiency (%) | 70-90 | 80 | 66 | 80-90 |
| Self-Discharge | 10 | 13 | 30 | 8-5 |
| Rate (%) | | | | |
| Cycle Durability (cycles) | 2000 | 400-1000 | 500-1000 | 400-1200 |
| Nominal Cell Voltage (V) | 1.2 | 1.65 | 1.2 | NMC 3.6/3.7, LiFePo4 3.2 |

## IV. SIMULATION MODELS

To optimise complex structure and meet the future demands electric vehicle is designed with integrated system-level, multi-disciplinary and multiphysics considering the engineering data constraints as input a computational model is generated in MATLAB- Simulink with statistical dimensionality reduction. The equivalent electric circuit layout is modelled in MATLAB-Simulink. Properties of Constant voltage source, DC-DC voltage converter, Battery current sensor,3-phase Inverter, BLDC motor, gear ratio, wheel of vehicle and vehicle body are investigated, compared for electric motorcycle and modified to obtain voltage and torque waveform. The prototype tested by simulation requires less battery power for accelerating and maintaining speed, allowing a single charge to go long distance. Thereby reducing the battery pack size and weight, this is the biggest contributor to an overall weight.

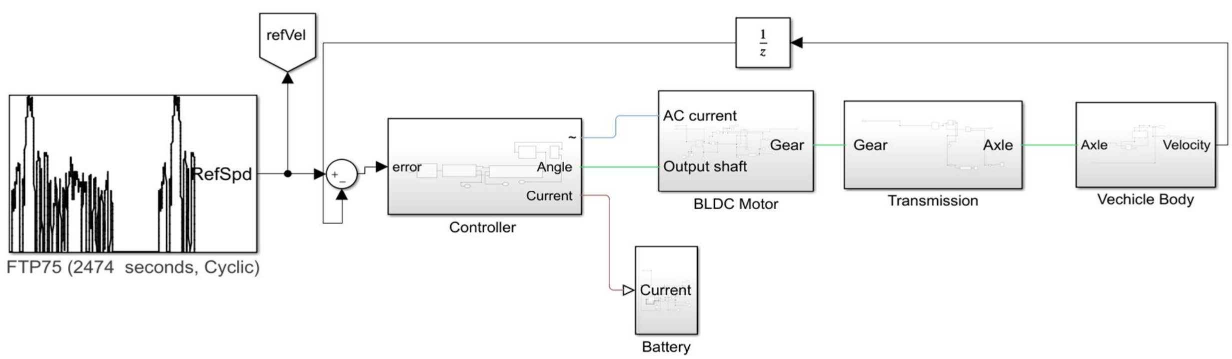



Figure V. Circuit Consisting of Main Block

The use of the permanent magnets in electrical machines in place of electromagnetic excitation results in many advantages such as no excitation losses, simplified construction, improved efficiency, fast dynamic performance and high torque or power per unit volume. A brushless dc (BLDC) motor is a synchronous electric motor which is powered by direct current electricity (DC) sandwich has an electronically controlled commutation system, instead of a mechanical commutation system based on brushes. In such motors, current and torque, voltage and rpm are linearly related. The construction of the modern brushless dc motor is very similar to the ac motor, known as permanent magnet synchronous motor.

Layout of batteries is done as it store electrical energy, allowing the motor of the vehicle to run. Lithium ion battery was the most efficient choice for an electric bike because it offers high energy density while remaining relatively light-weight and compact in size.

Below Figures illustrates modelled battery block and the structure of a typical three phase brushless dc motor. The stator windings are similar to those in a poly phase ac motor, and the rotor is composed of permanent magnets. Brushless dc motors detect the rotor position to produce signals to control the electronic switches. The most common position/pole sensor is the hall element.

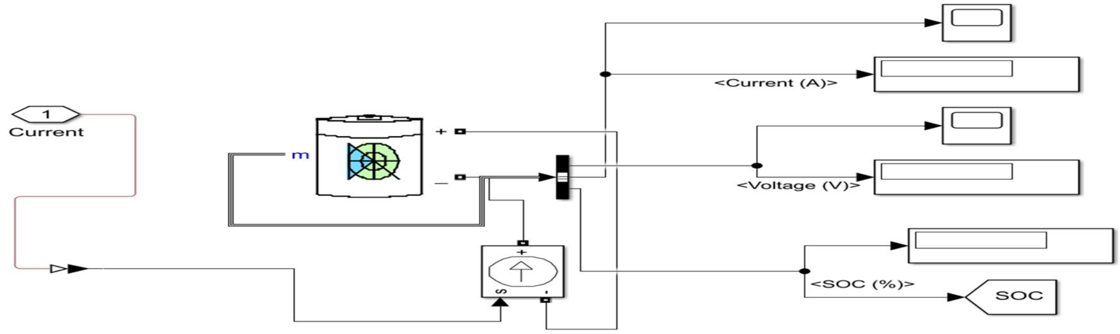



Figure VI. Li-ion Battery Block Modelled in Matlab-Simulink

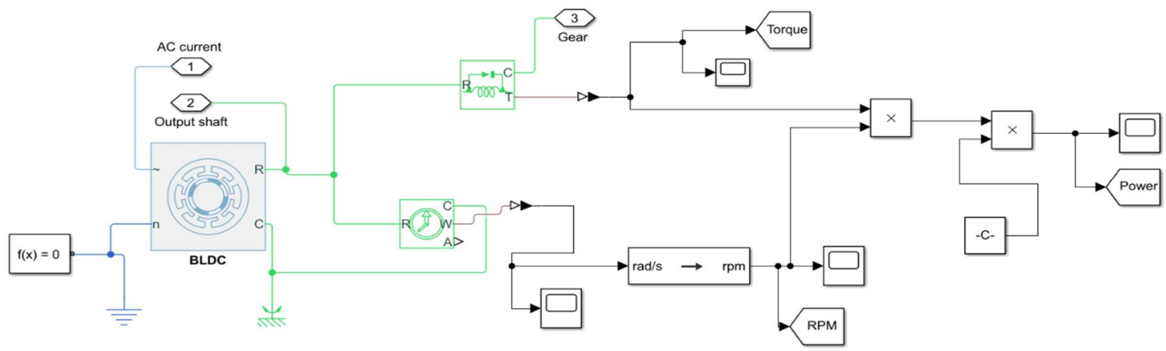



Figure VII. BLDC Motor Block Modelled in Matlab-Simulink

A BEV was visualized based on dimension and performance data from the various electric vehicles available on the market for modelling in this article. The parameters are, the power train comprises three main parts: a lithium-ion battery, control system, and a permanent magnet synchronous motor (PMSM) connected to the wheels via a gearbox transmission, to match the high speed of the electric motor shaft to the lower speed of the wheels. The simulation structure is designed and integrated into MATLAB/SIMULINK.

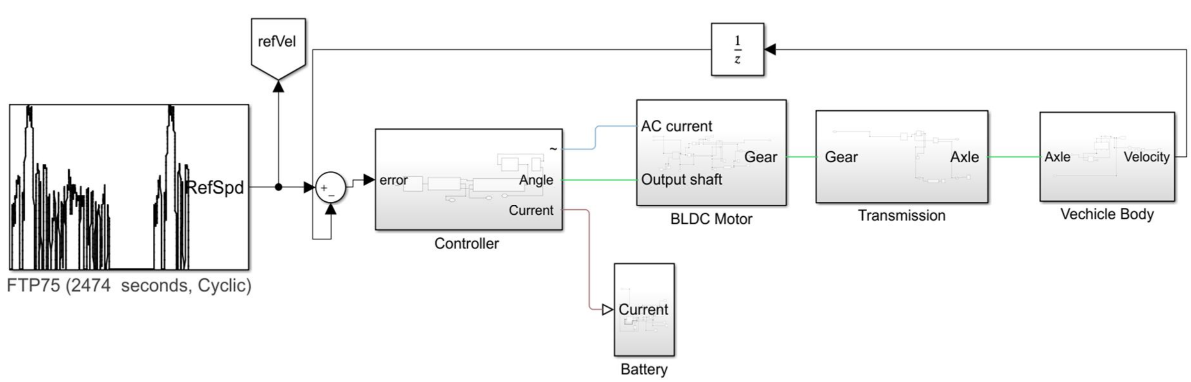



Figure VIII. Circuit System with Main Blocks

## V. RESULTS AND CONCLUSION

The results from the design and analysis of MATLAB- Simulink modelled battery electric vehicle authenticates that it can stand up to all extreme conditions including high power requirements, long range, variable speed. It results in sound outcomes in terms of driving range battery capacity and maximum speed of 180 kms, 45 Ah and 90 kmph respectively and also generates maximum power of 4 KW under the condition of use of BLDC motor with battery charging of around 2-3 hours.

The above simulation results coincide with theoretical calculations with point to note is the discharge rate of battery depends on the drive cycle. Above average life capacity of battery is assured by selection of material as Li-ion type of battery is providing the features such as light weight, less dense and relatable operational temperature limit of 25-45 $^{0}$C. Technologies like regeneration system, swapping batteries, Inductive power transfer are incorporated to overcome losses and failures. As a result a safe and efficient way of battery management system is incorporated in eVehicles thus climate damage mitigation is ensured to provide a safe and clean energy environment.

## VI. ACKNOWLEDGEMENT

This work is carried out at Sreenidhi Institute of Science And Technology, Hyderabad; Authors would like to thank management, Executive Director, Principal and Project Supervisor. Authors would like to thank all anonymous reviewers in advance for their so called insights

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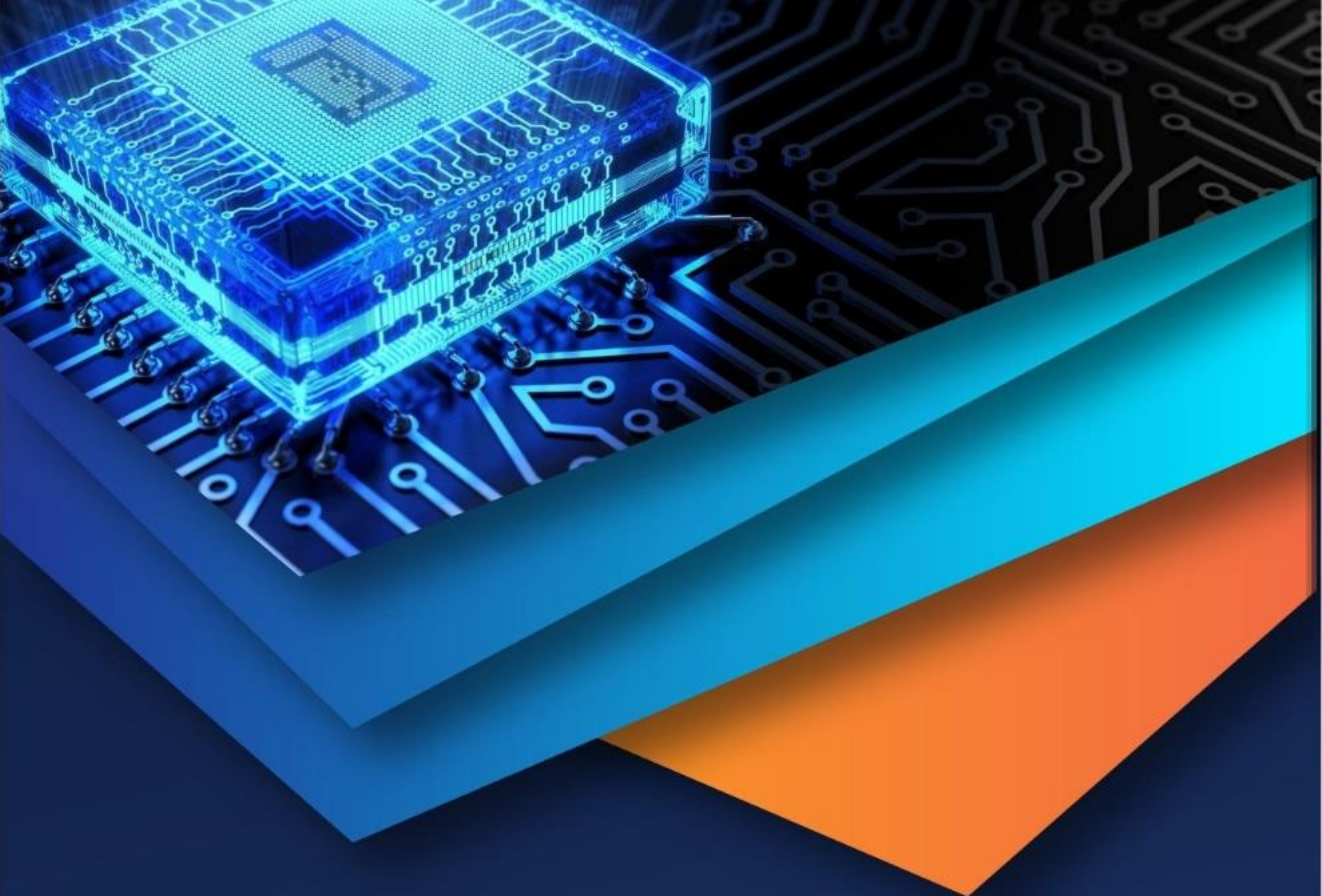


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