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Development of Electric Vehicle

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Abstract: India is the second largest producer of two wheels in the world. It is ranked third behind Japan and China in terms of production of two wheels and domestic sales. India's two-wheeler industry has grown rapidly over the years. The two-wheeler business is about to enter a new era as the automotive industry has undergone a radical change with the introduction of fuel-efficient technologies. In India's two- wheeler industry, electricity, not petrol, diesel, or any other petrol, has caused a revolution.
Electric bicycles and scooters are popular ways of personal travel in developed countries like the United States, Japan, and China, and the Indian two-wheeler industry has embraced a new concept. As a result, electric bicycles and motor- cycles in the eld of personal travel have a promising future. This project looks at design and development, as well as comparing and comparing different components. Two-wheeled electrical components such as BLDC motor, battery, charger, controller, and dc-dc converter are also included in this article.
At the moment, fossil fuels can only be used for a limited time before becoming more expensive and causing environmental problems. As a result of these limits, alternative fuels and other sources of energy, such as solar and wind, are helping to propel the vehicle industry forward. In addition, electric cars are fast evolving. The electricity stored in a rechargeable battery is used to power an electric motor, which aids in the motorcycle's propulsion. This vehicle's top speed is limited to 50 km/h.
Keywords: Electric Vehicles (EV's), Battery, Brushless DC Motor (BLDC), DC-DC converters, Permanent Magnet (PM), Hub Motor, Miniature Circuit Breaker (MCB), Field Oriented Control (FOC)

I. INTRODUCTION

Electrification is the most credible means to accomplish clean and efficient transportation, which is critical to the world's long-term growth. Electrical vehicles have a long history dating back to the 19th century, but their popularity has grown in tandem with the rising concern about environmental harm caused by internal combustion vehicles in the twenty-first century. The automobile industry is currently confronting some of the most dicult technological challenges in its history. Because of automobile emissions, most governments throughout the world have amended their norms and regulations. Most nations are working on increasing fuel economy since regulations and legislation have been passed in most regions of the world to impose greater fuel economy and lower car emissions. These challenges, combined with rapidly changing customer preferences and in- creased market demand for better vehicle performance as well as increased market demand for vehicle reliability, have prompted automakers to rethink their requirements and look for new ways to design better vehicles for less money and in less time.

In the 1960s and 1970s, alternative fuel vehicles were needed to address issues such as internal combustion engine exhaust pollution, rising pricing, and reliance on crude oil and its decreasing resources. Since then, ongoing attempts have been made to develop feasible electric cars to replace present IC engine vehicles. Despite constantly growing technology and advancements, electric two-wheelers have several flaws that must be addressed in order to improve the vehicle's overall performance. The weight and size of the systems and components are the primary concerns that need to be addressed in order to increase the vehicle's range, speed, payload, and grade ability. Advances in materials, improved design and analytical methodologies, production processes, and optimization approaches, among other things, have all contributed to weight reduction. Based on the elimination of competing restrictions, design boundaries, and design uncertainties, such as design clearance and material flaws, design optimization should be done to produce a minimal weight with maximum or practical performance. The main structure of a motorbike is its frame. The frame supports the rider and any pillion or baggage, as well as the vehicle's primary components and systems (engine, transmission sys- tem, etc.). It also has front and rear suspension hinge points, as well as support for the rider and any pillion or baggage. The frame serves as a backbone for the vehicle, with numerous components put on it mistreatment rapid applications to provide strength and stiffness so that they may perform their intended function in the vehicle. The pinnacle tube, which carries the pivoting front fork, is located at the front of the frame, whereas pivot points for the shock absorber and swingarm are located in the back. The power-generating components (IC engine for a conventional petrol car, motor and batteries for an electric vehicle) are installed on the frame in such a way that they are protected in the event of an accident or collision while ensuring that their smooth operation is not hampered.

The frame also supports numerous additional vehicle peripheral components, such as rider seats, vehicle bodywork, and accessories. Aside from component mounting, the frame offers the necessary rigidity and resistance to shocks and impacts on the vehicle, safeguarding the rider and the vehicle's important components.

In the design and manufacture of an e-scooter, the electric system has a lot of potential. The electric system is made up of the battery, motor, motor controller, and other electrical components. The electric system's primary job is to supply power to the scooter's motor, which assists in its functioning. This energy is stored in a battery as chemical or electrical energy, which is then used by a hub motor to turn the electrical or chemical energy into mechanical energy. A working electric system is crucial in the case of a collision to ensure driver and vehicle safety. The brushless DC (BLDC) motor is mounted on the e-rear wheel's hub. scooter's BLDC motors are popular because of their compact size and quiet operation.

A. Problem Statement

The issue of global fossil fuel depletion, as well as the problem of air pollution caused by traditional internal combustion engines, motivates the search for alter- native energy sources to power vehicles. An electric car, which replaces a traditional combustion engine with an electric motor, is one potential option. It's critical to design and produce a cost-effective and high-performance electric car.

B. Objective

1) Basic Objectives

a) To maximize the speed and efficiency.
b) Smart battery charging discharge under controlled condition.

2) Main Objectives

The major goal of this study is to produce electric vehicles using smart technology developed by many researchers. In order to achieve this goal, we will do the following:

a) To reduce the emissions caused by today's vehicles and create eco-friendly environment.
b) Zero emission concepts in this term can be applied not only in a built-in EV but also in converting a fossil fuelled vehicle into its electric version.
c) Testing of complete developed system.
d) To overcome the drawback of existing EV's.

C. Scope

1) Battery swapping techniques can lead to increase in new businesses and hence will boost employee opportunities.
2) The use of electric vehicles will result in less consumption of fossil fuels with less charging cycles of batteries.
3) As India is a big market and also consists of huge number of middle class families ,the affordable electric vehicles will be revolutionary.
4) Electric vehicles will increase the business scope in the field of renewable energy like solar plants, wind mills , etc.

D. Methodology

The Essential Elements of an Electric Scooter The following are the essential elements of an electric scooter:-

1) Battery
2) Battery Charger
3) Motor
4) Motor Controller
5) DC-DC Controller
6) Vehicle computer and Electronics

The construction of an electric car is very straightforward. The propulsion parts are the most important components. The configuration is shown in [Fig.1].

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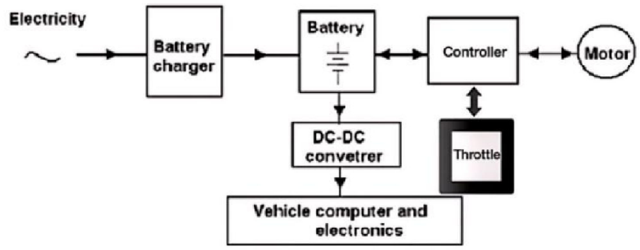

Fig -1: Key Components of Electric Vehicle

Batteries are the most common type of energy storage. Battery chargers work by transferring power from the grid to charge the battery. The battery voltage is DC, and the power electronics controller converts the current (I) into a switching signal to drive the motor. You can power other electrical components of the car with a DCDC converter that converts the voltage from the battery pack to a lower voltage, such as 5V to 20V.

a) Battery

The component that stores electrical energy and powers the vehicle's engine is called a battery. As you can see in [Table 1], different battery types have already been compared.

According to this data, high energy density, relatively lightweight and small lithium-ion batteries are the most efficient batteries for electric bicycles. Lithium- ion batteries can be dangerous, so it is important to check the cell quality and precautions

Parameter	NiCd	NiZn	NiMH	Li-ion/LiPo
Specific Energy (Wh/kg)	0-60	100	60-120	100-265
Energy Density(Wh/L)	5-150	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 Rate(%)	10	13	30	8-5
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

Table -1: Comparison Between Batteries

b) Battery Charger

The battery charger is essential for getting the most out of the battery. Efficiency and dependability, charging time, weight, cost, and power density are all notable characteristics of a battery charger.

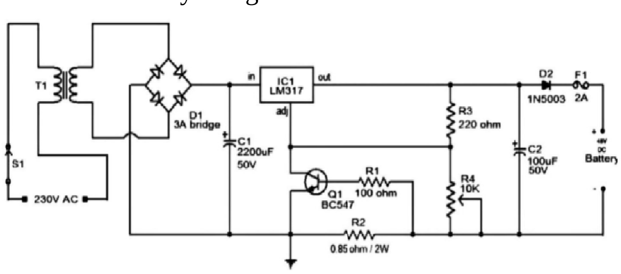

Fig -2: Electric Circuit Diagram of Battery Charger

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[Fig. 2] shows a circuit charger of a lithium ion battery (48V 5A) for a 48v 25 Ah battery. The circuit shown here is a limited-capacity lithium ion battery charger based on the popular LM 317 variable voltage controller. The value of resistor R2 determines the charging current. The charging voltage is determined by resistor R3 and POT R4. Large electrical power is reduced by transformer T1, and adjustments are made to bridge D1. The filter capacitor is C1. When the charger is off or when power outages are not available, diode D1 blocks the flow of electricity from the battery.

c) Motor

The use of permanent magnet (PM) in electronic devices instead of electromagnetic stimuli has many advantages, including no loss of pleasure, simplified construction, increased efficiency, faster flexible performance, and higher torque or power per unit volume. Although three-phase motors are very efficient and have a large outer box, two- phase brushless dc motors are also widely used in the construction and operation of circuits. The cross-sections of a two-phase engine with a useful pole are shown in [Fig. 3].

Fig -3: Two phase brushless dc motor

d) Motor Controller

A car controller is a tool or set of devices that control the operation of an electric motor in a specific way. Starting and stopping the engine, choosing to rotate forward or reverse, selecting and controlling speed, limiting, or controlling torque, and monitoring of heavy loads and errors are all possible with the car control. We are using a "sine wave vector control" for this project. Engine control block connected to battery. The motor controller is a key component of the system, which controls the entire operating system. An important requirement for control, especially for DC motors, is to control the amount of power supplied to the engine. The use of a motor controller was used to drive and control the BLDC engine. The car controller is a necessary part of all motor-driven devices. The motor controller works in the same way as the human mind, processing data and returning it to the user.

e) DC-DC Converter

A DC / DC converter is an electrical circuit or device that converts a voltage from a direct current (DC) source. It's a kind of power converter. Various EV power supply designs show that at least one DC / DC converter is required to connect an FC (frequency regulator), battery, or supercapacitor module to a DC port.. On the other hand, almost all topology DC / DC converters can be bidirectional. Bidirectional converters are useful for regenerative braking systems because they can carry current in either direction.
Switching converters have several drawbacks, including complexity, electrical noise, and the high cost of certain topologies.

E. Organisation of Dissertation

After considering the future prospects and opportunity of research of different energy recovery systems, regenerative suspension system is selected for project work. The next step involved extensive research, the topic is then discussed with members and group mentor and is finalized as "Development of Electric Vehicle"..
Modification in the system is done due to the unavailability of some materials and then experimentation of our model is done. From experimentation results are obtained in the form of voltage and current, which can be used to calculate the power output.
The results obtained after experimentation are compared with the results of literature reviews and the conclusions are made.

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II. SIMULATION WORK

A. *CAD Model*

Fig.[4,5] shows the CAD model of the vehicle chassis designed.

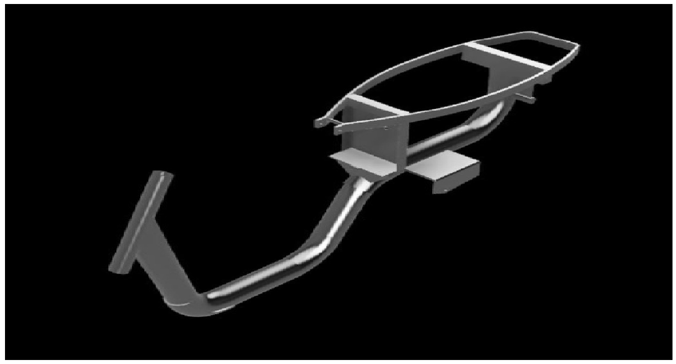

Fig -4: 3-D Model of Vehicle Chassis

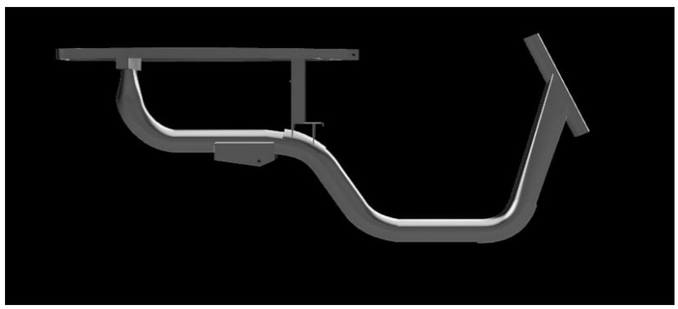

Fig -5: Side View of Chassis

B. *Finite Element Method (FEM)*

Fig. [6,7,8] shows the different analysis done considering various factors on the chassis/ frame.

1) *Static Nodal Stress Analysis*

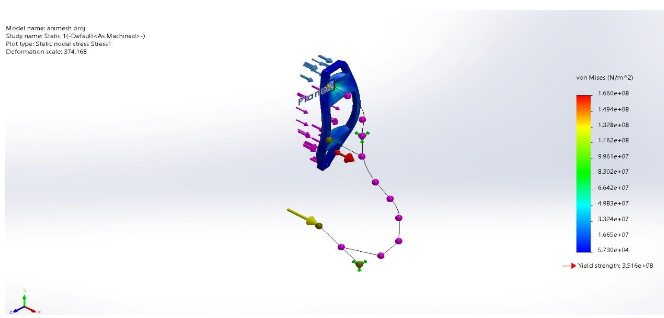

Fig -6: Static Nodal Stress Analysis

2) *Static Strain Analysis*

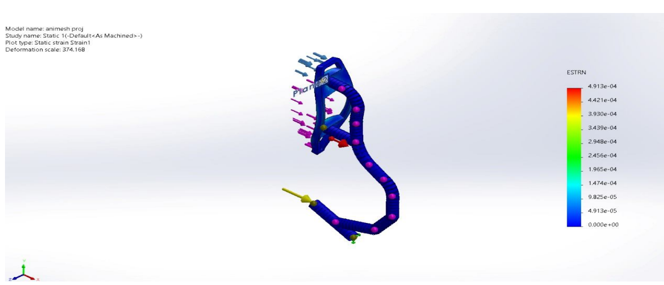

Fig -7: Static Strain Analysis

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3) *Static Displacement Analysis*

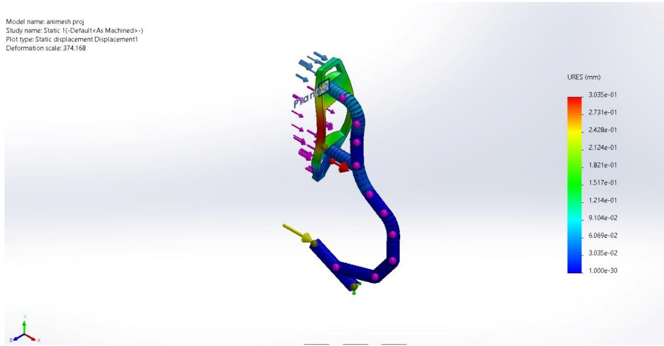

Fig -8: Static Displacement Analysis

C. *Structural Analysis of Shock Absorber*

1) *Analysis using Spring Steel as a spring material*

Material Properties:

Young's Modulus = 2.1×10^5 N/mm^2

Poisson's Ratio = 0.29

Density = 7.85×10^{-6} kg/mm^3

Load = 2943 N

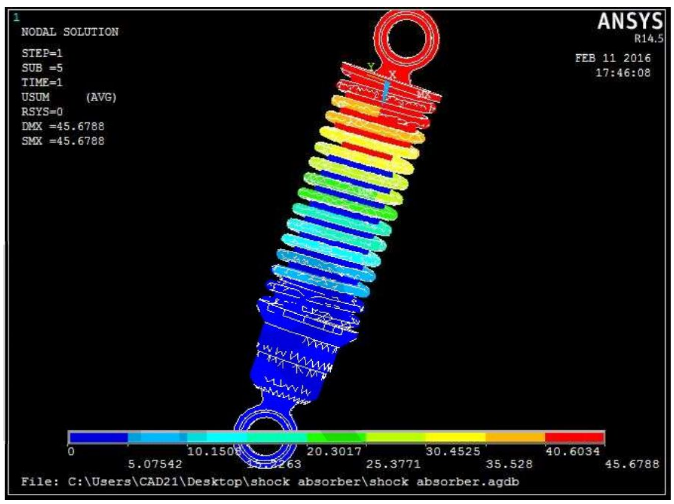

Fig -9: Displacement Analysis for Steel spring

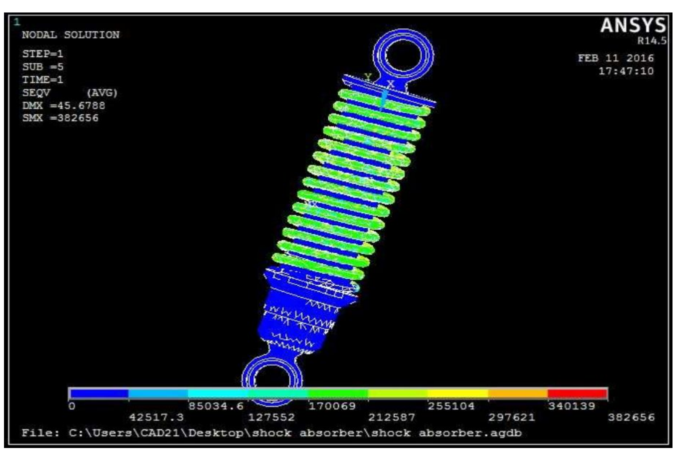

Fig -10: Von Mises Stress for Steel spring

2) *Analysis using Beryllium Copper as a spring material Material Properties*
   Young's Modulus = 2.8 ×105N/mm2
   Poisson's Ratio = 0.285
   Density = 1.85 ×10−6kg/mm3
   Load = 2943 N

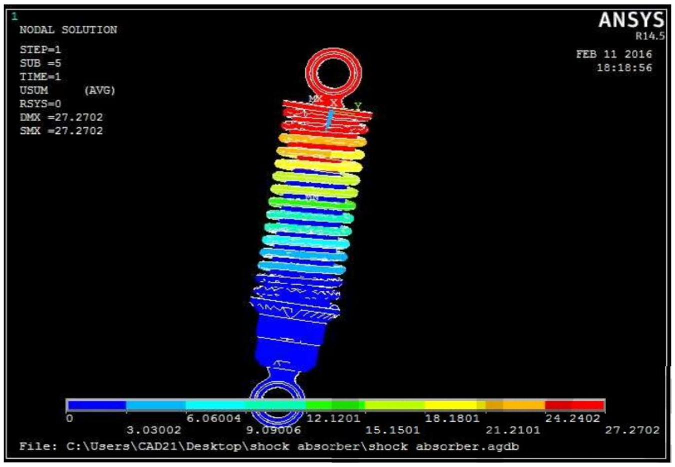

Fig -11: Displacement Analysis for Beryllium Copper

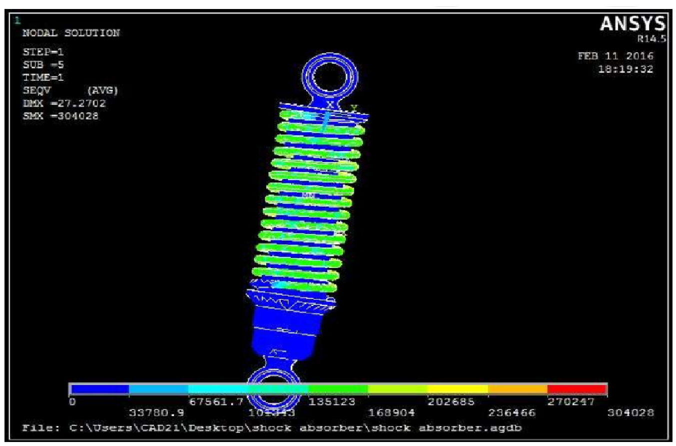

Fig -12: Von Mises Stress for Beryllium Copper

D. Results

Stress and deflection with different materials as shock absorber spring:

Material	Deflection (mm)	Von Mises Stress (N/mm^2)
Spring Steel	45.67	382656
Beryllium Copper	27.27	304028

Table -2: Stress and deflection for different material

III. NUMERICAL/ANALYTICAL ANALYSIS

A. Hub Motor Calculation

Given,
Wheel Diameter/Rim Size (d) = 17”/43.18cm
Speed in kmph (K) = 50 kmph
Gross weight of the vehicle (M) = 190 kg

- Motor Specification
  Volt (V) = 60 Volts
  Power (P) = 2000 Watt
- Power Equation
  Power(P) = Current (I) * Voltage (V)
  Hence,
  I = P/V = 2000/60 = 33.334Amp.
- Speed of Motor In RPM
  $N = K/(d \times 0.001885)$
  $= 50/ (43.18 \times 0.001885)$
  = 614.29rpm
- Torque of the motor(T)
  $T = (P \times 60)/ (2 \times \pi \times N)$
  $= (2000\times60)/ (2 \times \pi \times 614.29)$
  =31.106Nm
  Torque on wheel hub motor (T) = 31.106 Nm
- Selection of Motor
  Gradient resistance, Rolling resistance, and aerodynamic gravity are all factors to consider when determining a car's power rating. Driving a car needs a force of
  $F_{total} = F_{rolling} + F_{gradient} + F_{aerodynamic\ drag}$
  $F_{rolling}$ = Force due to rolling Resistance
  $F_{gradient}$ = Force due to Gradient Resistance
  $F_{aerodynamic\ drag}$ = Force due to Aerodynamic Drag
  F_{total} = total tractive force that the output of the motor must overcome, in order to move vehicle.

1) *Rolling Resistance*

The resistance of a vehicle provided by a tyre in contact with a wheel and road is known as rolling resistance. The following equation can be used to calculate force due to rolling resistance:

$F_{rolling} = C_{rr} \times M \times g$

Crr = Coefficient of Rolling Resistance

M = mass in kg

g = acceleration due to gravity = 9.81 m/s2

For application let's consider,

Crr = 0.01 as per the [Table 3].

Crr value	Types of Surface
0.001-0.002	Railroad steel wheels on steel rail
0.001	Bicycle tyre on wooden track
0.002	Bicycle tyre on concrete
0.004	Bicycle tyre on asphalt road
0.008	Bicycle tyre on rough paved road
0.006-0.01	Truck tyre on asphalt
0.01-0.015	Car tyre on concrete, new asphalt, cobbles small new asphalt
0.02	Car tyre on tar or asphalt
0.02	Car tyre on gravel-rolled new
0.03	Car tyre on cobbles-large worn
0.04-0.08	Car tyres on solid sand, gravel loose worn, soil medium hard
0.2-0.04	Car tyres on loose sand

Table -3: Coefficient of rolling Resistance

$F_{rolling} = C_{rr} \times M \times g = 0.01 \times 190 \times 9.81 = 18.639N$

2) Gradient Resistance

The vehicle's gradient resistor is the resistance it faces when ascending a hill or flying over a bridge, or when travelling down a slope. The angle between the ground and the path's slope is denoted by θ, as shown below [Fig. 13].

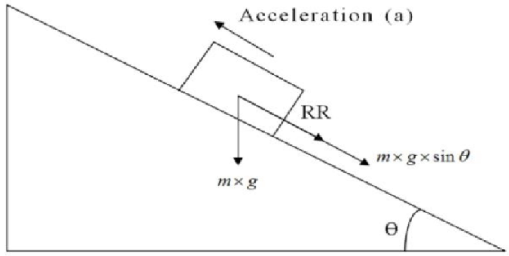

Fig -13: Free body diagram of a vehicle moving up an inclined surface

$F_{gradient} = \pm(M \times g \times \sin\theta)$

$F_{gradient} = 190 \times 9.81 \times \sin 2.5^{\circ} = 81.302N$

(The upward motion is represented by the positive sign, whereas the downward motion is represented by the negative sign. Let's use θ = 2.5 for this example)

3) Aerodynamic Drag

The resistive force supplied by a viscous force acting on a vehicle is known as aerodynamic drag. The form of the vehicle determines it linearly. The following equation gives the formula for determining aerodynamic drag.

$\mathbf{F_{aerodynamic\ drag} = 0.5 \times C_D \times A_f \times \rho \times v^2}$

where,

C_D = Drag Coefficient

A_f = Frontal area m^2

ρ = Air density in kg/m^3

v = velocity in m/s

For application let's consider

ρ = 1.1644kg/m^3 at 30° temperature,

C_D =0.5 and A_f =0.7as per[Table 4]

Vehicle	Cp	Af
Motor Cycle with a rider	0.5-0.7	0.7-0.9
Open Convertible	0.5-0.7	1.7-0.9
Limousine	0.22-0.4	1.7-2.0
Coach	0.4-0.8	6-10
Trucks without a trailer	0.45-0.8	6-10
Truck with a trailer	0.55-1.0	6-10
Articulated Vehicle	0.5-0.9	6-10

Table -3: Drag Coefficient and Frontal area of a Vehicle

$F_{aerodynamic\ drag} = 0.5 \times C_D \times A_f \times \rho \times v^2$

$F_{aerodynamic\ drag} = 0.5 \times 0.5 \times 0.7 \times 1.1644 \times 13.889^2$

$F_{aerodynamic\ drag}$ = 39.308N

$F_{total} = F_{rolling} + F_{gradient} + F_{aerodynamic\ drag}$

F_{total} = 18.639 + 81.284 + 39.308

F_{total} = 138.619N

The power required to drive the vehicle

Power = F_{total} × velocity × (1000/3600)

Power = 138.619 × 50 × (1000/3600)

Power = 1925.263W

As a result, the needed power to move the vehicle is 1925.263W, which is somewhat less than our motor standard of 2000 W, indicating that the design is safe.

B. Battery Calculation

From motor calculation we get,

Power = 2000W

Voltage = 60V

So, to find watt.hr = 2000W ×1hr = 2000W hr

It's not a good idea to discharge a battery completely throughout each charging cycle. Out of a fully charged battery, 80% should be used, leaving 20% in reserve.

Battery Watt-hr = (2000/0.85) = 2352.94W hr

Current(Ah) in battery = (2352.94/60) = 39.21Ah

C. Battery Pack Capacity

Power = 2000W

Efficiency of Motor = 80%

Efficiency of Battery = 85%

Suppose the speed of the vehicle is 50kmph and Distance to be travelled is 50km then, the travel factor will be-

T_f = (Distance to be travelled)/Speed = 50/50 = 1

Battery Pack Capacity (BPC) is calculated as:

BPC =2000× (Tf)/(Battery efficiency × Motor efficiency)

BPC =2000×1/(0.85 × 0.8) = 2941.17W = 2.914kW

D. Battery Charger

Let's consider we want to charge our battery in 4 hrs and wattage is 2400W then,

Wattage of Charger = (Battery Wattage / Time (in hrs)) = 2400/4 = 600W

Current of Charger = Watt/Volt = 10A

So to charge 60V ,40Ah battery in 4hr we need 60V/10A charger.

E. Shock Absorber

A shock absorber is a mechanical device that dissipates energy by smoothing or dampening shock impulses. It is the job of the shock absorber to absorb or dissipate energy. It lowers the effect of travelling through rough terrain in a vehicle, resulting in enhanced quality and increased comfort due to significantly reduced amplitude of disturbances. The spring is com- pressed fast when a vehicle is travelling on a level road and the wheels hit a bump.

The compressed spring will seek to return to its regular loaded extended state, rebounding past its normal height and lifting the person. The spring will then be pushed down to its regular loaded height by the vehicle's weight. As a result, the spring returns to its original position. This bouncing is done over and over again, each time a bit less, until the up-and-down action ends. If bouncing is allowed to run unchecked, it will not only make the ride unpleasant, but it will also make vehicle handling problematic. In a suspension system, the spring design and material selection are critical.

1) Generalized Parameters for Helical Spring

Material: Spring Steel, Beryllium Copper

Coil Mean diameter D = 65 mm

Wire Diameter d = 8 mm

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Total number of coils n = 15
Pitch = 14 mm
Let's consider bike weight be 65 kg and weight of two persons be 135 kg.
Then Total weight = Bike weight + weight of two person = 200 kg
Consider Factor of Safety (FOS) = 1.5
Total Weight = 200 ×1.5 = 300kg
Therefore, total load on shock absorber
= 300 ×9.81 = 2943N

IV. EXPERIMENTAL VALIDATION

A. Finite Element Analysis Method

Finite element analysis stresses a computer model of a material or design and analyses it to produce specific results. It is used in both the manufacture of new products and the refining of existing products. The modified product or structure is used to adapt the existing product or structure to the new terms of service. Two types of analysis are commonly used: 2D and 3D modelling.
This is a complex system of nodes that create a grid. This mesh is pre-programmed with material and structure properties that define how the structure behaves in different load scenarios. Nodes are distributed throughout the material at a specific density based on the expected stress level at a specific location. Areas under high stress have higher node densities than areas with or without stress.
Previously tested materials, fillets, corners, complex details, and fractures in high stress areas are potential points of interest. The web acts like a spider web, with web elements extending from each node to each of the surrounding nodes. This network of vectors conveys the physical properties of the object, resulting in a large number of components.

1) Steps Involved in FEM

In general, each computer-aided engineering work comprises three phases:

- *Pre-processing:* Defining the finite element model and environmental parameters that will be used to evaluate it.
- *Analysis Solver:* A finite element model is solved.
- *Post-processing:* Visualization tools are used to post-process the data.

a) *Pre-processing:* The first stage in utilizing FEA is to create a finite element model of the structure to be analyzed, which is known as pre-processing. The input of a topological description of the structure's geometric properties is required by most FEA tools. This can be in 1D, 2D, or 3D format, with line, shape, or surface representations, but 3D models are presently more widely used. After the finite element geometric model has been produced, a meshing procedure is utilized to define and break up the model into tiny components. A finite element model is defined in general by a mesh network, which is made up of the geometric arrangement of elements and nodes. Nodes are locations where properties such as displacements are calculated. FEA software uses node numbers as an identifying assistance while studying solutions in structures like deflections.

b) *Analysis:* Generate a model solution, the FEM uses a succession of calculating algorithms based on applied forces and element properties. For example, structural analysis determines the deformations, strains, and stresses caused by applied structural loads like force, pressure, and gravity.

c) *Post-processing:* The ramifications of the analysis may then be viewed and fully identified utilizing visualization tools inside the FEA system. The precise position of data like as stresses and deflections may be discovered using numerical and graphical methods.

B. Crash Analysis

The two most important engineering approaches for creating high quality vehicles in automotive engineering are collisions and structural analysis. Computer simulation technology has significantly improved the safety, reliability, comfort, and environmental and production efficiencies of today's vehicles. This extraordinary feat is made possible by the improved software and powerful computers that have become accessible over the last two decades. Safety is a top priority for drivers and passenger seats. In response to this great concern and expectation, the government has enacted more and more laws. Details may vary slightly from country to country, but the basic needs are about the same. In the event of a minor impact, the vehicle must provide adequate protection to the driver and occupants. Several new physical security features are available to protect car occupants, including B. ABS brakes, airbags, traction control. Collision reaction behavior is a less noticeable aspect that drivers and passengers in the passenger seat cannot observe.

The body and various components are well-designed protective barriers for car occupants. They act as crushable zones and absorb impact energy. Multiple design iterations, prototypes, and crash tests are all part of the traditional process. Treatment is time consuming and costly. With the advent of high-performance computers and crash simulation software, the process has changed. Instead of relying on experimental verification, the security design process is complemented by computer simulation

Most modern car bodies are made of stamped sheet metal that is spot welded to form a single body. This closed form is known as Body in White (BIW). BIW structural components with- stand most of the specified loads for crushing loads for strength, stiffness, fatigue resistance, and impact resistance**.**

1) Crashworthiness Tests Criteria And Model Requirements

Crashworthiness is a term used in the automotive industry to characterize the structural ability of a vehicle to bend plastically while providing ample living space for the occupants in the event of a moderate deceleration accident. For example, occupant packing, and restraint systems can help reduce serious injuries and deaths. Collision safety is determined using a set of test and analysis methods. There are four main techniques to evaluate a vehicle's crashworthiness right now:

a) Frontal.
b) Side.
c) Rear

C. Modal Analysis

The frame acts as the backbone to which components such as batteries, controllers and motors are connected. Therefore, it is important that the frame does not buckle on bumpy roads. Also, it should not be transferred to the body as distortion. You can build a bicycle frame using steel, aluminium, or alloy. Most of the frames are hollow tubes. Resonance occurs when the natural frequency of the motorcycle frame matches the excitation frequency. As a result of resonance, the frame experiences dangerously large vibrations, which can lead to excessive deflection and failure. Experimental modal analysis is essential to overcome these challenges. Experimental modal analysis can be used to identify the natural frequency, damping, and unique structural properties of modal shapes. Experimental modal analysis is a technique for capturing the modal characteristics of structures in all modes of the frequency range (EMA) of interest.

Modal analysis is a powerful technique for describing, modelling, and understanding structural dynamics. A set of discrete vibration modes can be used to characterize the dynamic behaviour of structures over a particular frequency range. The modal features that characterize each mode include natural or resonant frequencies, mode geometry, and (modal) attenuation. Within the frequency range of interest, the modal parameters of all modes provide a comprehensive dynamic description of the structure. You can then use the model to find possible solutions to a particular problem using the component's modal properties. Another way to evaluate the frequency response of a structure is modal frequency response analysis. With no modal or damping, modal frequency response analysis uses the modal shape of the structure to minimize size, separate equations of motion, and make numerical solutions more efficient. Modal frequency response analysis is a natural extension of normal mode analysis, as modal shapes are often calculated as part of the structural description.

D. Material Selection

The motorbike frame houses the seat, battery, suspension, and motor. The frame should be perfect in every manner, with reduced weight and accurate geometry. Above all, the motorbike frame's material should be exceptional, large, and give great handling. As a result, material selection should be prioritised by the vehicle engineer. Light weight, safety, cost effectiveness, and outstanding comfort should all be factors in the selecting process. Engineers have used a variety of materials over the years to create an effective frame based on these considerations. The frame's quality and character will differ depending on the type of material used. The materials that are most commonly utilised are discussed. The material should be robust and easy to deal with, such as welding. The material should be of good quality, such as light weight, sturdy, and inexpensive, in order to match the motorbike completely.

1) *Steel:* Steel is an easy-to-use and inexpensive material. Widely used as a frame from the 70's to the 80's. Processes thin and heavy materials. It is a cheap but easily eroded material. Steel is stronger, but more difficult to mould. In the case of a light motorcycle, it cannot be used as a frame. It easily oxidizes and cannot be used for a long time. It works well in pinch situations, but as the weight increases, the fuel consumption of the motorcycle decreases. Due to the longevity of steel, many improvements have been made to make it lighter and more corrosion resistant. It is currently used in low-priced motorcycles and is not primarily used in sports motorcycles.

2) *Carbonfibre:* Comparing to steel and aluminium, the carbon fibre gives good rigidity and more light weight but the standard of the motorcycles is reduced. Like titanium, the carbon fibre is also too costly. The motorcycle frames produced by carbon fibre are light in weight and also has good mechanical properties. So only few bike frames are produced with carbon fibre. The carbon is combined with epoxy to get good results but it is never been used in motorcycle frames.
3) *Aluminium:* Aluminium is used in modernized bicycles as the most common lightweight property. It's also strong and lightweight enough to be used on most sport bikes. The material can be harder than steel and is superior to other materials. Aluminium has excellent resistance to corrosion and heat transfer. In recent years, the use of aluminium materials for frames has increased significantly in the manufacture of automobiles and motorcycles. Many standard racing bikes use aluminium material.

E. Design Consideration

When designing a chassis or frame for an electric motorcycle, it is important to consider different types of chassis structures suitable for assembling the various components required for electric mobility, such as: Four battery packs, controllers, other important components, and important components such as brakes, and systems such as horns and turn signals found on traditional motorcycles. Because the motor used in this project is a hub motor, the space required for it is reduced.

The following are the many types of motorbike frames now in use:
1) *Spine Frame:* The backbone frame is another name for it. The bike's spine is made out of an enormous diameter tube from which the components are hanging, providing a core structure.
2) *Single Cradle Frame:* It consists of a top tube and a down tube that extend from the steering head to the swingarm pivot, forming a loop to which various components are attached.
3) *Perimeter Frame:* Two beams wrap around the engine to unite the steering head and swing arm in the smallest distance feasible for increased stiffness. It is also known as Beam or twin spar.
4) *Monocoque Frame:* It consists of a structure that sustains loads through an outer skin that also acts as a core for component mounting.
5) *Trellis Frame:* The frame is made up of a series of triangles made up of a number of short steel or aluminum tubes that are welded together to give it strength and stiffness.

The power producing system of the vehicle is the fundamental structural difference between a regular IC engine two-wheeler and an electrical two-wheeler. A battery pack system and an electronic controller replace the components of the IC engine two-wheeler, such as the engine, exhaust, and gasoline tank. For both forms of two-wheelers, the planning and implementation of various mechanical components such as front and rear suspension, gearbox, brakes, and seating systems are identical. As a result, the two-wheeler chassis must be constructed in such a manner that the battery pack system and an electrical controller take up the area previously occupied by the engine, exhaust, and gasoline tank, without impacting the performance of the other vehicle systems.

F. Geometrical Consideration

1) *Caster Angle:* The angle at which the steering pivot axis tilts back and forth from the vertical when viewed from the side is called a caster. The casters are positive when the pivot axis is tilted backwards and negative when tilted forwards. When the vehicle is moving forward, the positive casters help improve the stability of the straight line by straightening the wheels. The mechanism that causes this tilt can be seen on the front wheel (top) of the shopping cart. The steering axis of the shopping cartwheel is in front of the point where the wheel touches the ground. As the cart moves forward, the steering axle pulls the wheel, and as the wheel is dragged along the ground, it lags the steering axle. The distance between the steering axis and the wheel and the tread is proportional to the force with which the wheel follows the steering axis. The farther the distance, the greater the power. The term "trail" is used to describe distance.

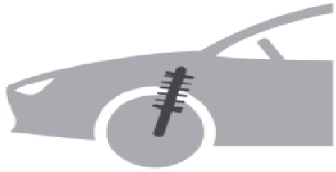

Fig -14: Caster angle

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2) *Trail:* Front axle spacing is calculated by drawing a straight vertical line between the center of the front axle and the axle line passing through the center of the headstock axle on the ground. The vehicle's stability increases when the trail is longer than the straight path. It makes turning more difficult. The length of a trail is measured in meters. A motorbike with too much trail is difficult to turn, while one with too little is unstable. When you compare the rake and trail values for different bikes, you may get an indication of how much simpler they are to manage and how close they are. With the fork angle in the typical range, a certain amount of trail is factored in to provide good stability and correct handling. There are exceptions to this rule, like as the fact that the more trail a motorbike has, the more stable it may be. However, if the trail is increased too far, the handling reverts to that of a chopper. When there isn't enough trail, the motor- cycle's stability suffers greatly.

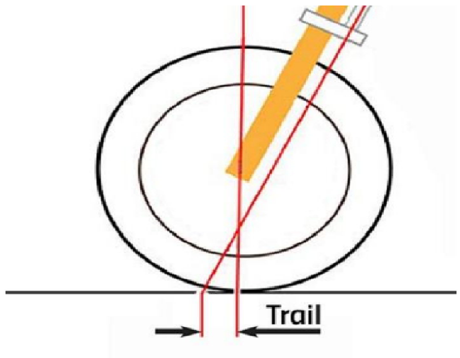

Fig -19: Trail

G. *Dimensions of Chassis*

1	Overall Length (mm)	1640
2	Overall Width (mm)	380
3	Overall Height (mm)	1110
4	Wheel Base (mm)	1220
5	Weight (kg)	65
6	Design Vehicle Weight (kg)	65

Table -5: Dimensions of Chassis

H. *Motor Controller Specification*

1	Rated Power	1000 Watt
2	Rated Voltage	48 Volts
3	Temperature Range	$-25^{\circ}$to 45°
4	Length	150 mm
5	Width	90 mm
6	Weight	0.75 kg

Table -5: Specification of Motor Controller

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I. Hub motor and Battery Specification

1	Power of motor	1000 Watt
2	Rim Size	10 Inches
3	Rated Voltage	48 Volts
4	Rated Top Speed	615 rpm
5	Motor Torque	36 N-m
6	Maximum Load Carrying Capacity	190 kg
7	Rated Efficiency	80%
8	Battery Current Rating	32 A-hr
9	Battery Pack Capacity	2.941 kW
10	Charger	10A
11	Charging Time	4-5 hrs

Table -7: Specifications of Motor and Battery

V. RESULT & DISCUSSION

A. Cost Analysis

Sr no	Component Name	Qty	Cost (Rs)
1	BDLC 3-phase DC Power 48V 1000W Motor	1	12500
2	Controller 1000 Watt	1	2500
3	Hand Throttle	1 Pair	1050
4	Speedometer	1	800
5	Lithium Ion 48 V 32 Ah Battery	1	25000
6	Rear Wheel tyre	1	1000
7	Brakes	2	500
8	Paint (250 ml Can)	4	1000
9	Wires, battery connections, heat shrink sleve	-	5500
	TOTAL		44850

Table -7: Specifications of Motor and Battery

B. EV Comparisons

Sr no	Company	Ather	Ola	TVS	Bajaj	eVolt
1	Range (km)	70	120	75	95	75
2	Peak Power (kW)	5.4	8.5	4.4	4.08	1
3	Torque (N-m)	22	58	33	16	36
4	Battery Capacity (kWh)	2.23	2.98	2.25	3	1.536
5	0-40 kmph in sec	3.9	3.6	4.2	4.5	5
6	Max Speed	80	90	78	70	50
7	Kerb weight (kg)	108	121	118	118	65
8	Price (Rs)	125000	144500	110000	110500	55000
9	Charging Time (hrs)	4	3.5	4.5	4	2.5
10	Rim Size (Inches)	12	12	10	12	10
11	Motor Power (watt)	1500	2000	1200	1200	1000

Table -7: Comparison of eVolt with available electric scooter in market

C. Target Markets for EV's

Electrical Vehicle are considered within reach of middle-class customers. The Electrical Vehicle are selling of in India would target the middle-class customers and rich customers. The manufacturer selling the electrical vehicle in India would have target in mostly city area. In this region the electrical vehicle would cover the average distance and available the charging station. The manufacturer selling the electrical vehicle in consideration of both genders. The electrical vehicle which can use male or female. According to requirement electrical vehicle can be used. For example, it can be used for college purpose, once purpose. In marketing strategy first mover advantages gained by initial significant occupant of market segment. The people which are thinking about buying an electrical vehicle is target for sold out electrical vehicle.

VI. CONCLUSIONS

1) Our design is a prototype of an electric vehicle driven by a hub motor that may be utilised as a personal mobility vehicle for short trips of 60-70 kilometres, such as visiting university campuses, grocery stores, and other local locations.
2) The design is finished with the goal of making a vehicle that is pollution-free, efficient, and affordable.
3) The car also aids in the conservation of fossil fuels and the reduction of air pollution. We also attempted to lower the vehicle's weight as much as feasible, achieving a weight of 65 kg.
4) We used mathematical modelling to back up our choice of motor and battery, and the results show that the motor can operate the bike and the battery can offer a range of roughly 60-70 kilometres on a single charge.
5) Because it has a competitive advantage over mechanically powered vehicles in the near future, this prototype may be further enhanced in terms of mass manufacturing and safety requirements.

VII.FUTURE SCOPE

The main solutions for improving the energy efficiency of electric vehicles are sought, including the energy savings stored in the vehicle itself and the expansion of the vehicle's power range with given output resources. Below are some of the current options that may lead to such advances.

1) When braking, energy is used
2) Using waste heat energy generated in brake drums as a source of energy
3) Solar cells provide additional energy
4) Mechanical energy Transfer Mechanism has been improved
5) New Generation supercapacitors, fuel cells and batteries are all used
6) Increasing of efficiency of power convertors
7) Improved car shell design

Today's energy problems are so serious that the entire industry is focusing on clean and renewable energy (solar, wind, etc.). Prototypes of hybrid vehicles are widespread, and mass production is expected to be announced in the near future. In addition, some cars are designed to run entirely on electricity, resulting in zero emissions. Glass-roofed photocells generate energy even in the dark and use it to drive vehicle fans. Even when the car is turned o, the inside of the car always receives fresh air and a comfortable temperature (up to 50% lower temperature), reducing fuel consumption. Solar roofs are still in their infancy as urban vehicle development is heading towards solar car prototypes. A solar car is an electric vehicle that runs entirely or partially on solar energy. Photovoltaic (PV) cells in solar panels often convert the energy of the sun directly into electricity. The term "solar car" generally refers to a vehicle that is entirely or partially powered by solar energy. Solar energy can also be used to power communication systems, control systems, and other auxiliary functions. The priority goal is to develop batteries with high energy density and low ESR. In addition, recent studies have shown that fuel cells meet the performance requirements for commercial use in electric vehicles. High-power density super-capacitors enhance vehicle acceleration while simultaneously collecting all of the energy during rapid braking, resulting in improved power supply characteristics.

A. Battery Cell

Battery cells are the most basic component of battery packs used in electric vehicles. The module consists of a large number of battery cells and a battery pack of several modules. Batteries are the most expensive component of an electric vehicle. It's about half the price of an electric car. As a result, the cost of batteries is reduced and the cost of electric vehicles is reduced. The cost of electrodes and electrolytes must be brought down to a reasonable level. Increased thermal protection, greater power density, longer lifespan, and lightweight materials are all part of the battery cell development. For electric vehicles, a variety of battery technologies are available. The following is a summary of what they have said.:

1) *Lead-acid Battery:* These batteries use lead oxide as a positive active material, lead sponge as a negative active material, and sulfuric acid as an electrolyte medium. Lead-acid batteries have the advantage of being widely available and inexpensive. This technology has been around for about 50 years and has finally matured. These draw- backs include short life and low power density. They are also heavy.
2) *NMC (Lithium Manganese Cobalt Oxide):* The anode in these batteries is graphite. Because of their low cost, NMC batteries are widely utilised. The battery's additional characteristics are that it has the highest specific energy and is lightweight. This provides you a huge advantage over other alternatives. The downside of these batteries is that they cannot be charged quickly (less than an hour), and they normally take 6 hours to charge for average EV use. They can't be exposed to temperatures of 40 degrees or higher. These batteries have a DoD of 80% and can withstand up to 2500 charge-discharge cycles. The battery's usual drain rate is 2 hours.
3) *Nickel-Metal Hydride Battery:* The positive electrode in these batteries is nickel hydroxide, while the negative electrode is titanium or nickel. Alkaline electrolyte solutions are used. These batteries can withstand a broad range of temperatures and have a lengthy life cycle. They're also biodegradable. They do, however, have fewer charge-discharge cycles.
4) *LFP (Lithium Phosphate):* Between the NMC and LTO batteries, the LFP batteries fall in the middle. They are more temperature resilient than NMC batteries, but not as much as LTO batteries. They are also capable of charging and discharging at a quicker rate. India's approach to battery cell development should be a collaborative effort with global companies rather than a stand-alone eort. Many nations, such as the United States, Japan, China, and Korea, have superior battery technology, therefore India would be prudent to partner with them. This can be accomplished in a variety of ways. One option is to allow international companies to invest in India's infrastructure. This will assist the country in acquiring the necessary expertise in the field of battery technology. Allowing OEMs (Original Equipment Manufacturers) and national labs to engage with global businesses is another option. In any case, India's battery production needs to be scaled up on a large scale.

B. Pollution

The main drawbacks of traditional internal combustion engine vehicles are noise pollution, air pollution at the ground level, and inefficient use of scarce natural fuel resources. During stable operation, the efficiency of the gasoline (Otto) engine peaks at about 25-30 degrees h but drops to 7-15% during stop-and-go city driving. Considering the conversion efficiency from raw energy sources (especially coal), the overall efficiency of the mixed driving cycle can be as low as 7%. An attractive way to eliminate air pollution on the ground and reduce urban noise is the introduction of electric vehicles. This also eliminates the need for petroleum-based fuels for transportation. Even if the conversion efficiency from the raw energy source of the power plant is taken into consideration, the overall conversion efficiency remains low. Usually less than 12% in a mixed drive cycle.

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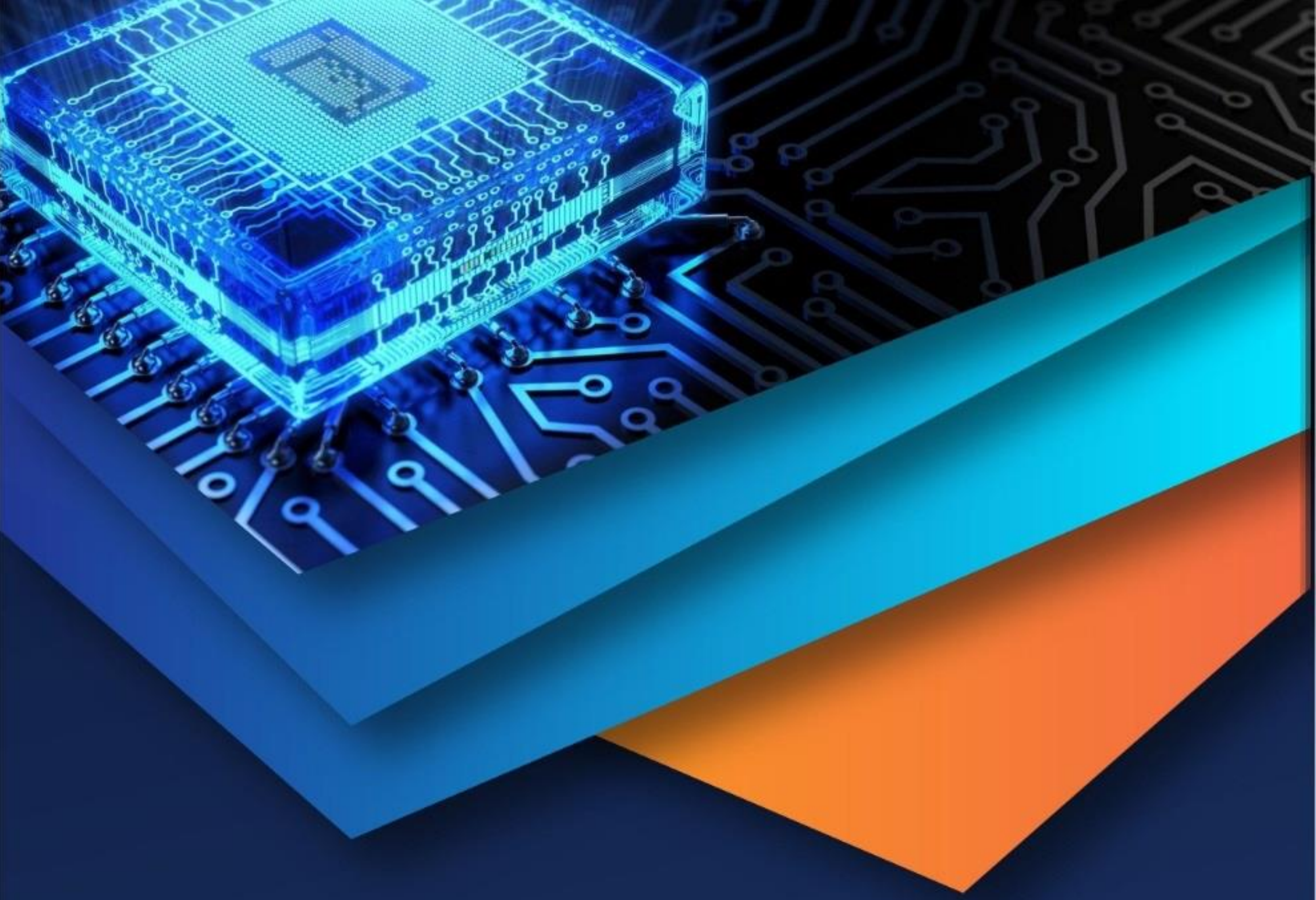

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