iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** IV **Month of publication:** April 2024

DOI: https://doi.org/10.22214/ijraset.2024.59348

Retrofitting of IC Engine to EV in Two-Wheeler

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Abstract: The global focus on sustainable transportation has led to the emergence of retrofitting existing conventional bikes as a practical strategy to transition from traditional combustion engine vehicles to environmentally friendly alternatives. This research delves into the conceptualization, design, and implementation of retrofitting technologies aimed at enhancing the performance, efficiency, and environmental impact of conventional bikes. In the age of Technological Advancement, Innovations, and Development, the Electric Mobility trend has captured the attention of all industries. Electric vehicles are poised to revolutionize the automotive sector. Renowned industries are prioritizing electrification over conventional propulsion methods. In the near future, IC vehicles are expected to be eclipsed by their electric counterparts. This project aims to address the issue of public transportation by providing a cost-effective and eco-friendly alternative to existing vehicles. The proposed design involves replacing the entire drivetrain with a pure electric power source, necessitating modifications to the OEM Bike. This project boasts cost-effectiveness, lightweight construction, interchangeability, and complete Eco friendliness, significantly reducing the use of hazardous substances that could lead to accidents or fatalities. Furthermore, the study examines the environmental benefits of retrofitting, considering the life cycle analysis of modified bikes and their potential contribution to greenhouse gas emission reduction.
Keywords: Retrofitting, IC Engine, Electric vehicle, Battery.

I. INTRODUCTION

The escalating demand for environmentally friendly and sustainable transportation solutions has propelled the need to convert internal combustion engine (ICE). operated bikes into electric-powered ones. Retrofitting IC-operated vehicles with electric power sources provides an opportunity to reuse vehicles that were on the verge of being scrapped, particularly those whose manufacturing dates have passed their prime. The growing demand for electric vehicles stems from the depletion of fossil fuels and the detrimental impact of carbon dioxide emissions from conventional ICE vehicles. Electric vehicles utilize electric drive motors that are powered by energy stored in batteries as the sole means to propel the vehicle. The rising global fuel prices have further incentivized the development of fuel-saving systems Nevertheless, the current electric vehicles on the market are notably pricier compared to their internal combustion engine counterparts.. Hence, retrofitting emerges as a cost-effective alternative to transform discarded scooters or bikes into functional and useful products. In the contemporary urban transportation landscape, the pursuit of sustainable and environmentally conscious mobility solutions has become increasingly crucial. While the development of electric vehicles has gained traction, the extensive use of IC engine Two-wheeler remains a prevalent mode of transportation in many regions. To bridge the gap between conventional fuel-driven systems and the urgent need for cleaner alternatives, the concept of retrofitting IC engine two-wheelers with electric drivetrain modifications has emerged as a promising approach. Integrating electrical drivetrain components into traditional IC engine two-wheelers represents a strategic and innovative strategy to enhance their efficiency and minimize their environmental impact. This modification involves incorporating electric motors, energy storage systems, and intelligent control units to create a hybrid powertrain. The motivation behind these modifications stems from the dual objective of mitigating the environmental footprint of two-wheelers and providing users with a transitional pathway towards more sustainable mobility. As cities grapple with air quality concerns and global efforts to curb greenhouse gas emissions intensify, retrofitting existing IC engine two-wheelers presents a compelling strategy to contribute to a cleaner and greener urban transport ecosystem. With the increasing global emphasis on sustainable transportation, retrofitting conventional two-wheelers presents an innovative approach to align existing vehicles with contemporary environmental standards. The retrofitting process involves integrating electric propulsion systems, energy storage solutions, and advanced control mechanisms into traditional internal combustion engine bikes. However, this transition is not without its challenges, posing several issues that need to be addressed for successful implementations.

II. OBJECTIVES

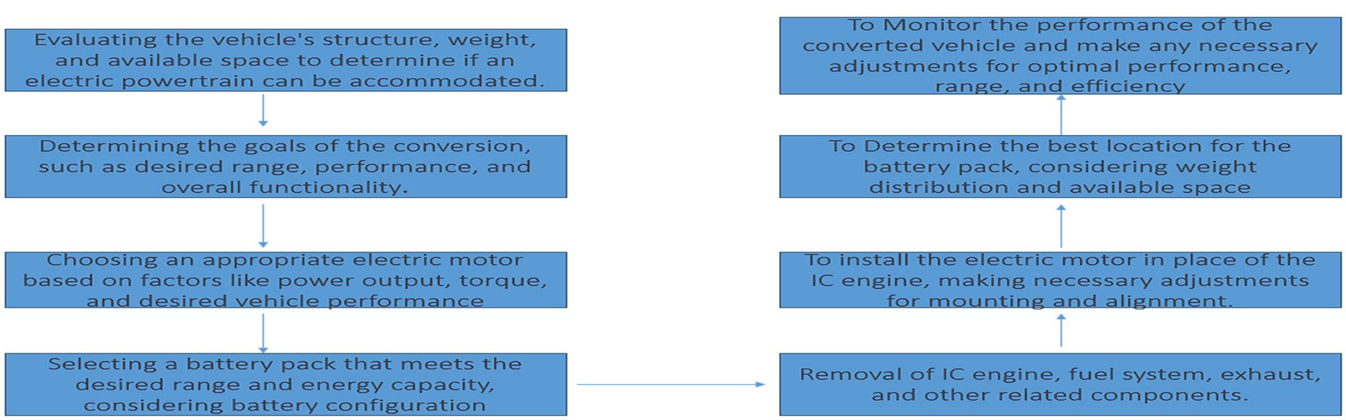
1) Utilizing all available spare parts on a vehicle for desired design upgrades without altering the original design.

2) Transforming a gasoline-powered vehicle into an electric vehicle by substituting the internal combustion engine with a BLDC motor through the retrofitting approach.
3) The vehicle should be electrically powered and driven with the help of powerful dc motor.
4) To design cost efficient, light weight and ecofriendly vehicle.

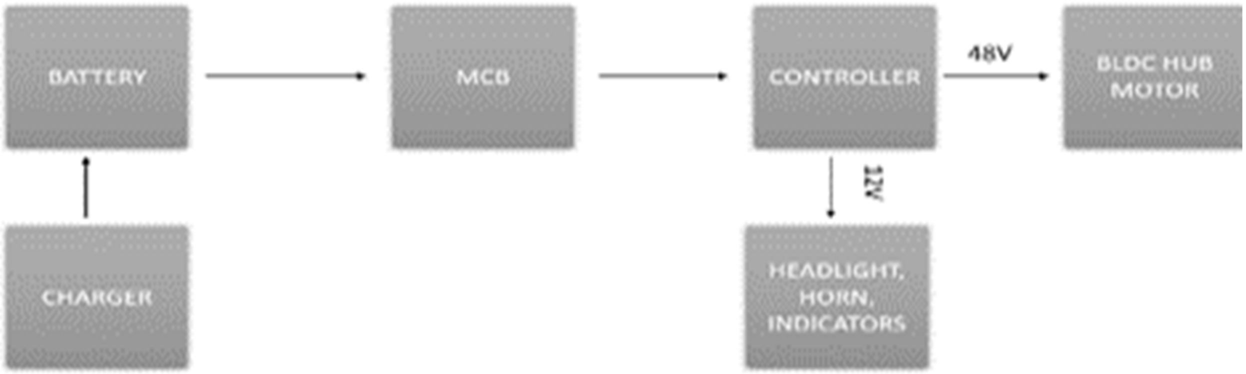
III. LITERATURE REVIEW

The attention in recent years as a pragmatic approach to transition toward sustainable urban mobility. Studies by [1] and [2] highlight the potential of retrofitting as a cost-effective and environmentally conscious alternative to traditional vehicle replacement. Environmental Impact and Emissions Reduction: Research by [3] and [4] highlights the environmental advantages of retrofitting two-wheelers with internal combustion engines. These studies demonstrate that incorporating electric drivetrains leads to a significant decrease in greenhouse gas emissions and enhances air quality in urban environments. Economic Feasibility and Affordability: [5] and [6] delve into the economic aspects of retrofitting, emphasizing the potential cost savings compared to purchasing new electric vehicles. These studies highlight the importance of developing affordable retrofitting kits and financial incentives to encourage widespread adoption. Technological Challenges and Innovations: The retrofitting process introduces various technological challenges, as discussed by [7] and [8]. These challenges include adapting existing vehicle structures, managing increased weight from new components, and developing sophisticated control algorithms. Innovative solutions, such as modular retrofitting kits and advanced thermal management systems, are proposed to address these challenges. User Acceptance and Behaviour Patterns: Understanding user perspectives and behaviour is crucial for the successful implementation of retrofitting initiatives. Studies by [9] and [10] explore user attitudes, motivations, and concerns related to retrofitting. Factors such as range anxiety, charging infrastructure, and the perceived benefits of electric drivetrains are examined to inform strategies for increasing user acceptance. Framework and Policy Implications The regulatory environment significantly influences the feasibility and uptake of retrofitting initiatives. [11] and [12] analyze existing policies and propose recommendations for creating an enabling environment. These studies highlight the need for standardized regulations, safety certifications, and incentives to support retrofitting initiatives. Case Studies and Real-World Implementations: Case studies of retrofitting projects provide valuable insights into the practical challenges and successes of implementation. [13] and [14] present detailed analyses of retrofitting initiatives in specific regions, showcasing the technical, economic, and environmental outcomes of such projects. Charging Infrastructure and Energy Considerations: The availability of charging infrastructure is a critical factor for the successful operation of retrofitted electric two-wheelers. Research by [15] and [16] discusses the development of charging networks and explores energy consumption patterns, addressing the concerns related to range, charging times, and energy efficiency. Life Cycle Assessment and Sustainability Impact: [17] and [18] focus on life cycle assessments to evaluate the overall environmental impact of retrofitting. These studies consider the environmental implications of manufacturing, operation, and disposal of retrofitted two-wheelers, providing a comprehensive view of their sustainability. Future Trends and Research Directions: Lastly, [19] and [20] discuss emerging trends and propose future research directions in the field of retrofitting. This includes advancements in battery technologies, smart grid integration, and the role of connected technologies in optimizing the performance of retrofitted two-wheelers, environmental concerns, economic feasibility, user acceptance, and regulatory challenges. However, it also emphasizes the need for continued research and innovation to overcome technical obstacles and further enhance the effectiveness of retrofitting initiatives.

IV. METHODOLOGY



V. BLOCK DIAGRAM



VI. VEHICLE SELECTION AND EVALUATION

1) Evaluate various models of IC engine two-wheelers to identify suitable candidates for electrical drivetrain modification.
2) Consider factors such as chassis design, available space, and compatibility with retrofitting components.
3) Prioritize models with versatile designs for ease of retrofitting.

A. System Requirement Definition

1) Define the performance goals and requirements for the modified electrical drivetrain.
2) Determine parameters such as power output, range, and acceleration characteristics.
3) Establish design specifications based on the intended use and user preferences. Component

B. Selection and Integration:

1) Identify and source key components, including electric motors, controllers, batteries, and associated wiring.
2) Ensure that the selected components are compatible with the chosen two-wheeler model.
3) Develop integration plans for seamless incorporation of electrical components with existing systems.

C. Charging System Integration:

1) If the modification includes electric-only operation, integrate a charging system compatible with the selected battery technology.
2) Determine the charging infrastructure requirements and develop a charging protocol for the retrofitted two-wheeler. Safety and Compliance Testing:
3) Conduct comprehensive safety tests to ensure the retrofitted two-wheeler complies with relevant safety standards.
4) Address concerns related to braking systems, stability, and emergency shut-off mechanisms.
5) Obtain necessary certifications to comply with regulatory requirements.

Ensure that the converted electric two-wheeler complies with applicable regulations and standards for electric vehicles in your region. This may involve obtaining certifications or approvals from regulatory authorities.

VII. COMPONENTS & SPECIFICATIONS

A. BLDC Hub Motor

1) We use a 48V BLDC hub motor instead of an IC engine.
2) The main purpose of the BLDC hub motor is to give acceleration to the mechanical transmission.
3) The shaft of the BLDC hub motor is inbuilt into the rear wheel of a vehicle.
4) As the motor starts the shaft of the motor starts to rotate and due to this the wheel of a vehicle also starts to rotate.
5) As we accelerate the speed of the motor the speed of the vehicle automatically increases.

Fig 1. BLDC Hub Motor

B. Controller

1) A controller is the heart of an electrical vehicle and it simply helps in driving a motor.
2) The controller converts the battery's DC power into AC and manages the energy transfer from the battery.
3) Switching devices like silicon-controlled rectifiers swiftly control the flow of electricity to the motor by interrupting it, turning it on and off rapidly.
4) Achieving high power (either in speed or acceleration) occurs when the intervals are brief.
5) Low power occurs when the durations between intervals are extended.
6) Controller Rating: - 48V, 28Amp

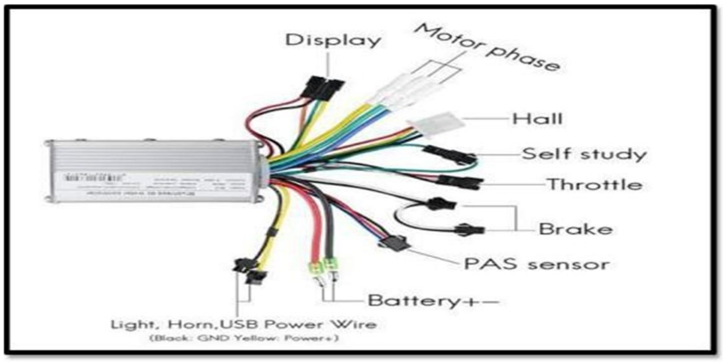


Fig 2. Controller

C. Lithium Phosphate Battery

For this project, lithium phosphate batteries are being utilized.

Table 1. Battery Specifications

SUPPLY VOLTAGE	12 Volt
CURRENT RATING	28Ah
WEIGHT	20 Kg

Fig 3. LITHIUM PHOSPHATE BATTERY

D. Speed Throttle

1) The throttle is positioned on the right handlebar of the e-bike and is linked to the controller.
2) A throttle allows driving an e-bike from zero to rated speed.
3) The throttle transforms the DC voltage provided by the battery into alternating voltage based on its position adjustment.
4) This alternating voltage and variable frequency drive the BLDC motor at a different speed. It uses the hall-effect type sensor

VIII. DESIGN CALCULATIONS

A. Center Of Gravity Calculations

(For IC Engine):

HORIZONTAL LOCATION OF CG

Wheelbase (WB) = 1270 mm

Weight (including driver) = 220 kg

Weight percentage = 55 – 45 (R-F)

Weight on Front (Wf)= 99 kg

Weight on Rear (Wr)= 121 kg

From above we came to know that 55% of weight is on the rear wheel. Thus, the Horizontal location of the CG will 55% of the Wheelbase i.e, 1270*0.55= 698.5 mm.

B. Vertical location of CG

Height of CG =H1+(WfxL1xLn) / (WtxH2)

L1 = Length of wheelbase = 1270 mm

H1 = Height of front hub off the ground = 330.2 mm

H2 = Height of rear wheel hub above the front wheel hub (how high the rear-end has been lifted) = 355.6 mm

W1 = Weight of front wheel at ground = 99 kg

W2 = Weight of rear wheel at ground = 121 kg

W3 = Weight of front wheel when bike is lifted = 140 kg.

Wt = Total bike weight = W1 + W2 = 220 kg

Wf = Weight increase on the front wheel due to lifting. = W3 - W1 = 41 kg

Ln = New wheelbase =√ (L1^2 - H2^2) = 1219.2 mm

•H = 13+(41x50x48) / (220x14) = 98413 / 3080 = 810.26 mm • The above calculation refers that for an IC engine operated vehicle, the CG is situated at a height of 810.26 mm and distance of 698.5 mm form the front wheel.

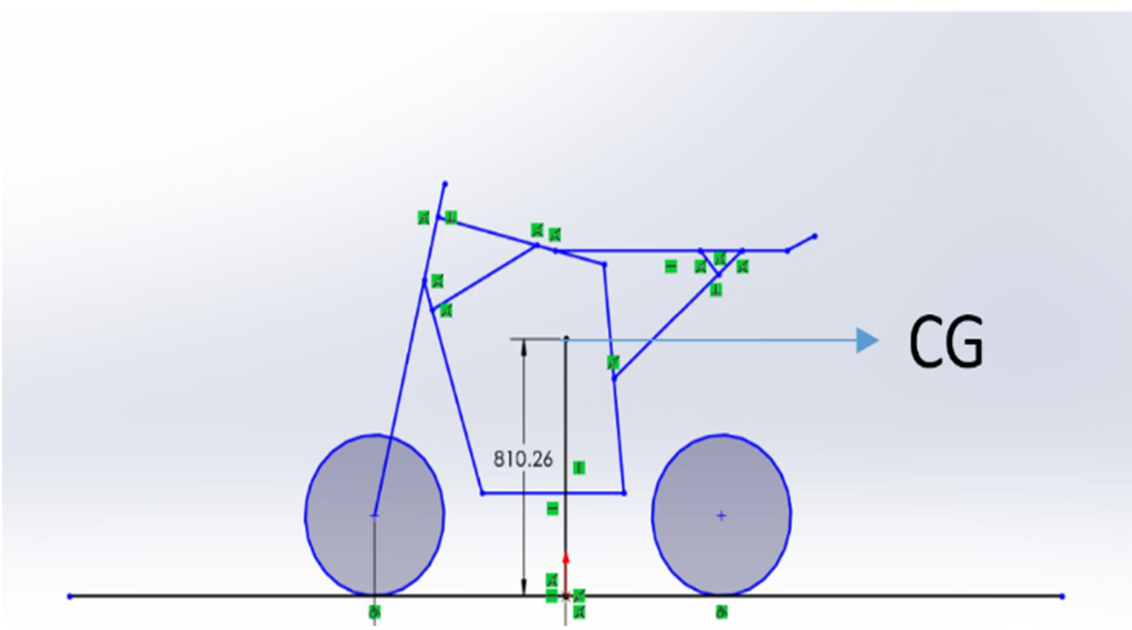


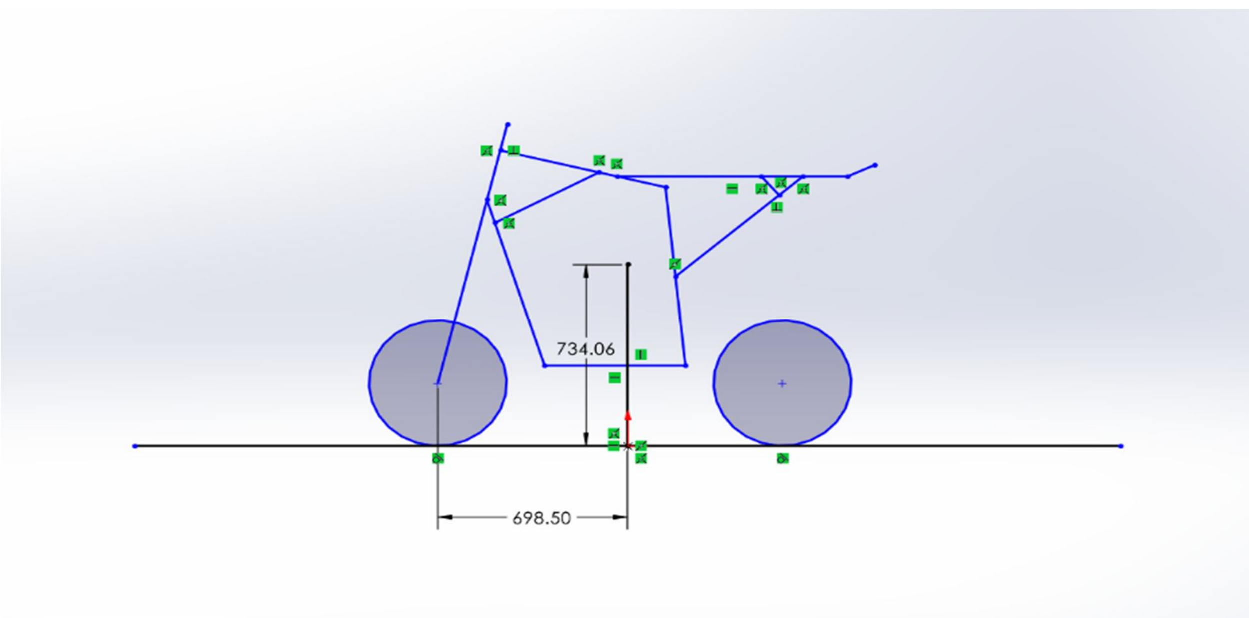
Fig 4. CG of IC Engine Operated Vehicle

CENTER OF GRAVITY CALCULATIONS: (When IC engine is replaced with Battery)
HORIZONTAL LOCATION OF CG
Wheelbase (WB) = 1270 mm
Weight (including driver) = 225 kg
Weight percentage = 55 – 45 (R-F)
Weight on Front (Wf)= 102 kg
Weight on Rear (Wr)= 123 kg
From above we came to know that 55% of weight is on the rear wheel. Thus, the Horizontal location of the CG will 55% of the Wheelbase i.e., 50*0.55= 698.5 mm

VERTICAL LOCATION OF CG
- Height of CG =H1+(WfxL1xLn) / (WtxH2)
- L1 = Length of wheelbase = 1270 mm

H1 = Height of front hub off the ground = 330.2 mm
H2 = Height of the rear wheel hub relative to the front wheel hub = 355.6 mm
W1 = Weight of front wheel = 102 kg
W2 = Weight of rear wheel = 123 kg
W3 = Weight of front wheel when bike is lifted = 140 kg
Wt = Total bike weight = W1 + W2 = 225 kg
Wf = Weight increase on the front wheel due to lifting = W3 - W1 = 38 kg
Ln = New wheelbase = √ (L1^2 - H2^2) = 1219.2 mm
- H = 13+(38x50x48) / (225x14) = 91213 / 3150 = 734.06 mm

The above calculation refers that for a battery-operated vehicle, the CG is situated at a height of 810.26 mm and distance of 698.5 mm form the front wheel.



IX. POWERTRAIN CALCULATIONS

A. Force Calculations

Mass of the vehicle and rider = 120 + 100 = 220 Kg
Velocity = 35 Kmph = 9.7 m/s

1) *Rolling Resistance:*
   Fr = μ * m * g

= 0.02 * 220 * 9.81
= 43.16 N

2) *Gradient Force:*
Average gradient force is taken at 0 deg (ground level) and 5 deg.

Fg = m * g * sin θ
= 220 * 9.81 *sin (5)
= 148.24 N

Fg = m * g * sin θ
= 220 * 9.81 * sin (0)
= 0 N

Fg (avg) = (0 + 128.24)/2
= 74.12 N

3) *Aerodynamic force:*
Fa = 0.5 * ρ * Cd * A * v2
= 0.5 * 1.23 * 0.353 * 0.8 *(9.7)2 = 16.34 N

4) *Acceleration force:*
F = m * a
= 220 * 0.97
= 213.4 N

5) *Total Force:*
FT = Fr * Fg(avg) * Fa * F
= 29.43 + 64.12 + 16.34 + 145.5
= 347.01 N

6) *Power:*
P = FT * v
= 303.21 * 9.7 = 3365.9 W

7) *Torque:*
T = (P * 60) / (2 * Pi * N)
= (3365.9 * 60) / (2* Pi * 432.98)
= 59.3 Nm (Peak Torque Needed)

X. CIRCUIT DIAGRAM

HIGH VOLTAGE CIRCUIT

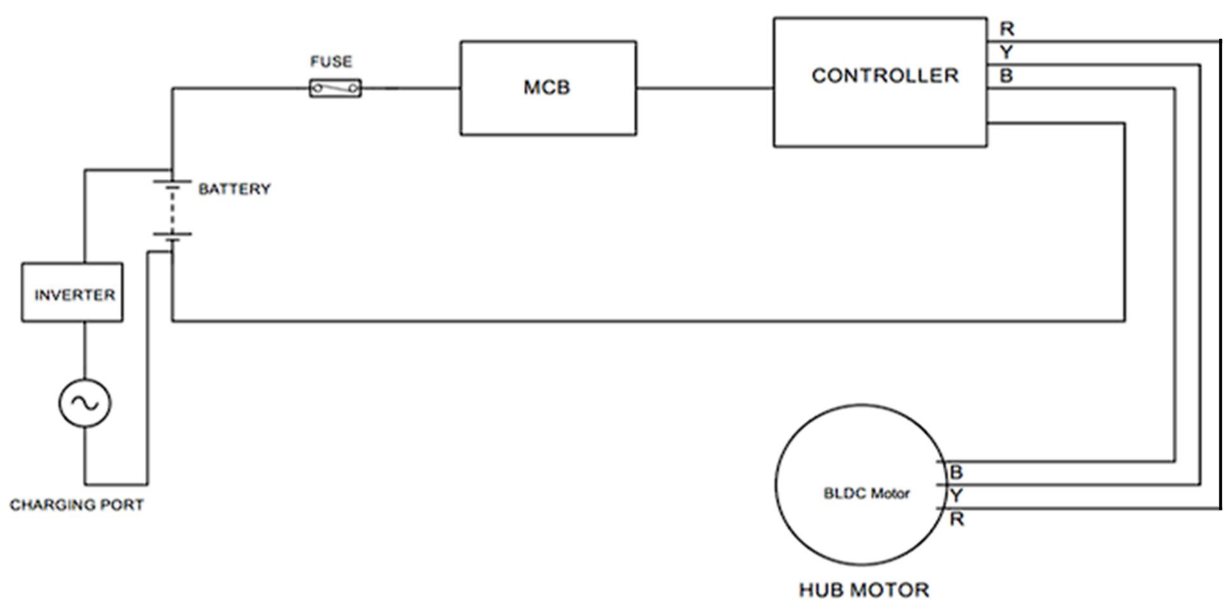


Fig 6. High Voltage Circuit

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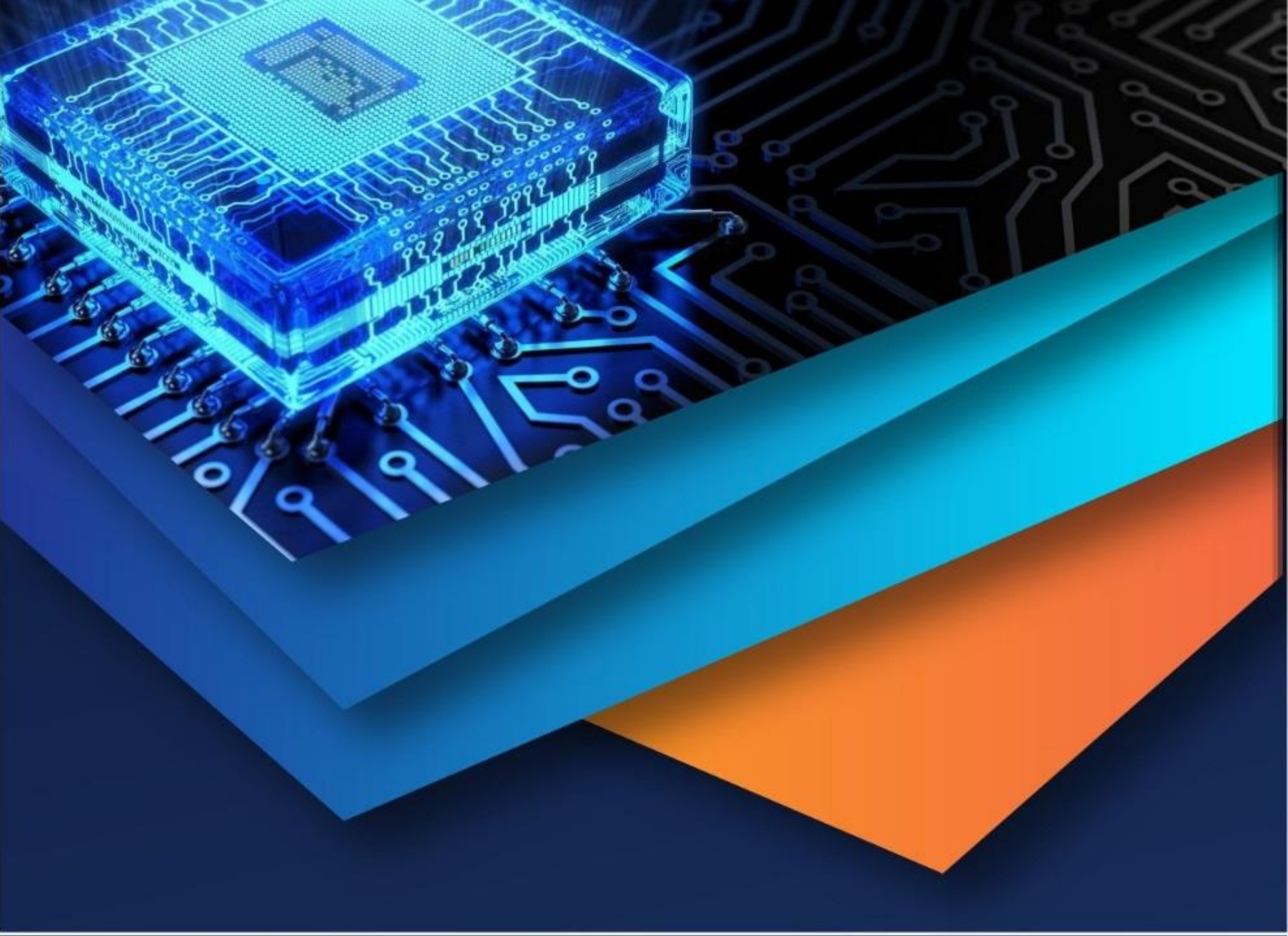

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