IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 12, Issue 4, April 2024
DOI: 10.17148/IJIREEICE.2024.12427

Electric Kick Scooter for Campus Drive

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Abstract: Today, an important part of the continuously developing electric vehicle technology is light electric vehicles. Electric kick scooters are one of the most basic types of light electric vehicles and their usage areas are increasing day by day. Especially for personal use and shared transportation systems. Electric kick scooters have an important place. The existing kick scooter has two wheels, a platform called a deck, and handlebars for steering. They differ from the non motorized kick scooters of the 90s due to the addition of a battery, electronics, larger (often air-filled) tires, and an electric motor.This system's benefits include inexpensive cost, superior battery backup, source compatibility, and high motor power. Its inability to move steep terrain and impossibility of long-distance travel are its limits. Government attention is now focused on electric vehicles due to growing concerns about climate change and rising pollution. E-scooters are less expensive in terms of operational expenses.The cost of one kilometer is over 0.20 rupees. Kick scooters can also be folded up and stored in a bag, which solves the issue of bike theft.

Poorer battery backup, poorer tire traction for riding on wet surfaces, an inflexible handle, a relatively high price, and weight are the drawbacks of the current method. The kick scooter's folding design, ease of carrying, and carbon neutrality make it a socially feasible product. Bidirectional charging, and an adjustable handle are the features of kick scooter's proposed system.

I. INTRODUCTION

Today if any product is developed or about to develop, then the main concern for engineers is the consequences that the product brings on the environment. But this is an obligation for the automotive industry. Now people's awareness on environmental protection is getting higher and higher. Traditional fossil fuels are gradually withdrawing from people's lives. The use of electric energy is becoming more and more extensive. Motor-cycles are traditional fossil fuel vehicles. So thus, all the companies investing billions in the research and development for reducing carbon footprints, how-ever many companies have already released and some other companies are about to release their electric vehicles in-to the market with-in few years. And the other problem that most of the cities globally face is traffic congestion as population increases rapidly. According to reports, about 1.3 million people move into cities every week, the world population expands by 83 million per year and by 2040, 65 percent of the population lives in cities. By observing that data it can be predicted that there will be more traffic congestions in future. Overall, both pollution and traffic congestion, challenges the people living in urban areas. As a solution to this, Micro-Mobility or last mile transportation came in-to existence with an idea of using electric bikes, electric kick scooters etc. MicroMobility is nothing but transportation, if the travelling is less than 5 miles. So that this micro-mobility can reduce the carbon footprint by replacing the conventional vehicles with new age vehicles. Sharing system is the main aspect in micro-mobility, which involves sharing the vehicle when needed using the app provided. Many start-ups are making billions using this idea and providing sharing service to the people in urban areas. The core of this graduation project is to design a new type of electric vehicle. It has a smaller size than a bicycle. More environmentally friendly than motorcycles. So, the Micro-Mobility, especially the electric kick scooter, changes the phase of the most polluted and populated cities and can bring comfortable, enjoyable lifestyles in the urban areas. How-ever, according to our view, present electric kick scooters need to be improved by customizing the design.

II. OBJECTIVE

The goal of this project is to create an electric kick scooter that is user-friendly, efficient, and sustainable.It has features like adjustable handle bars, foldability, and two-way charging all of which are useful for charging electronic devices.
Additionally, it seeks to meet the growing demand for environmentally friendly modes of transportation and offer a practical answer for short-distance commutes.

PROBLEM DEFINITION: In big campuses, there is a major problem with micro mobility. Using vehicles is highly expensive and causes pollution. Parking of these vehicles is also difficult.

PROPOSED SOLUTION: Electric kick scooter with foldable facility is proposed.As it is electric, it is eco friendly in nature**.**

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CHALLENGES: Addressing safety standards and building infrastructure to handle the increasing number of electric kick scooters on the road are obstacles for these vehicles. Furthermore, it is essential to maintain and service scooters properly to avoid problems like motor malfunctions and battery deterioration. To enable the widespread use of electric scooters, resolving the issue of limited range and battery life as well as streamlining the charging infrastructure present additional challenges. Finally, since electric scooters have to be usable by a variety of users, there can be issues with accessibility and price.

FUTURE SCOPE: The potential for electric kick scooters is really bright. We may anticipate advancements in battery technology, resulting in increased range and quicker charging times, as technology progresses. Improvements in motor efficiency might also result in even higher power and energy efficiency for electric scooters. For a better user experience, we might also see the addition of intelligent features like app integration, GPS tracking, and connectivity possibilities. All things considered, the future of electric kick scooters appears bright, with room for expansion and increased innovation.

SOCIAL RELEVANCE: Because they lower carbon emissions, promote sustainable modes of transportation, and ease traffic congestion in cities, electric kick scooters are extremely relevant to society. For brief commutes, they offer a practical and environmentally responsible form of transportation that helps to create a cleaner, greener world. For people without access to a car or who would rather not use public transportation, electric kick scooters also provide an inexpensive and practical form of transportation. They can be an enjoyable way to see the city and encourage an active lifestyle. All things considered, electric kick scooters have the potential to improve mobility options, encourage sustainability, and lessen pollution in our society.

III. BLDC MOTOR

The Brushless DC (BLDC) motor represents a significant advancement in electric motor technology, offering improved efficiency, reliability, and precise control over its brushed counterparts. At its core, the working principle of a BLDC motor revolves around the fundamental principles of electromagnetism, seamlessly integrating key components to deliver rotational motion.

In the anatomy of a BLDC motor, two primary elements stand out: the stator and the rotor. The stator, the stationary part of the motor, houses coils of wire wound around iron cores. These coils are strategically positioned and connected to the power supply. On the other hand, the rotor, the rotating component, is typically equipped with permanent magnets or electromagnets. The rotor is mounted on a shaft, which becomes the output shaft of the motor responsible for producing mechanical motion.

Crucial to the operation of a BLDC motor are Hall Effect sensors embedded within the stator. These sensors serve the pivotal role of detecting the position of the rotor as it rotates. The information gathered by the Hall Effect sensors is vital for the motor's control system to determine precisely when and how to energize the stator coils. Unlike brushed DC motors, which use brushes and a commutator to switch the direction of current in the coils, BLDC motors utilize electronic methods to achieve this, eliminating the friction and wear associated with brushes.

The Electronic Speed Controller (ESC) acts as the brain of the BLDC motor system. It interprets the feedback received from the Hall Effect sensors and orchestrates the timing and sequence of energizing the stator coils. This process is critical for generating a rotating magnetic field that interacts with the permanent magnets on the rotor. The ESC ensures that the magnetic fields generated by the stator coils align with the magnetic poles of the rotor, causing the rotor to turn and producing the desired rotational motion.

The working sequence of a BLDC motor can be summarized in several key steps. The motor begins from a standstill, and during this initialization phase, the Hall Effect sensors detect the initial position of the rotor. As the rotor starts to rotate, the Hall Effect sensors continuously monitor its position, providing real-time feedback to the ESC. This information enables the ESC to determine which stator coils need to be energized and precisely when to do so.

The sequential energization of the stator coils is orchestrated by the ESC, creating a rotating magnetic field that interacts with the permanent magnets on the rotor. This interaction induces a torque on the rotor, causing it to rotate. The process continues as long as power is supplied to the motor, resulting in continuous and controlled rotation.

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IV. HARDWARE BLOCK DIAGRAM

DC-DC Buck Converter: The DC-DC buck converter in electric kick scooters is an important component that helps regulate the voltage. It takes the higher voltage from the battery and converts it to a lower voltage that is suitable for powering various components of the scooter, such as the lights or the control system. This conversion is necessary because different components require different voltage levels to operate efficiently. The buck converter efficiently steps down the voltage while minimizing power loss.

Li-ion Battery: Li-ion batteries are commonly used in electric kick scooters due to their high energy density, lightweight design, and long lifespan. They provide a reliable and efficient power source for the scooter's electric motor. Li-ion batteries have a high energy-to-weight ratio, allowing the scooter to have a decent range while keeping the overall weight manageable for easy maneuverability. Additionally, Li-ion batteries have a low self-discharge rate, meaning they can hold their charge for longer periods when not in use.

Buck-Boost Converter: It is used to regulate the voltage and can step up or down the battery voltage as needed. This flexibility allows the scooter to efficiently utilize the battery power and optimize performance. The buck-boost converter is particularly useful when the battery voltage fluctuates during different stages of charge or discharge. It helps ensure that the various components of the scooter receive the appropriate voltage for their operation.

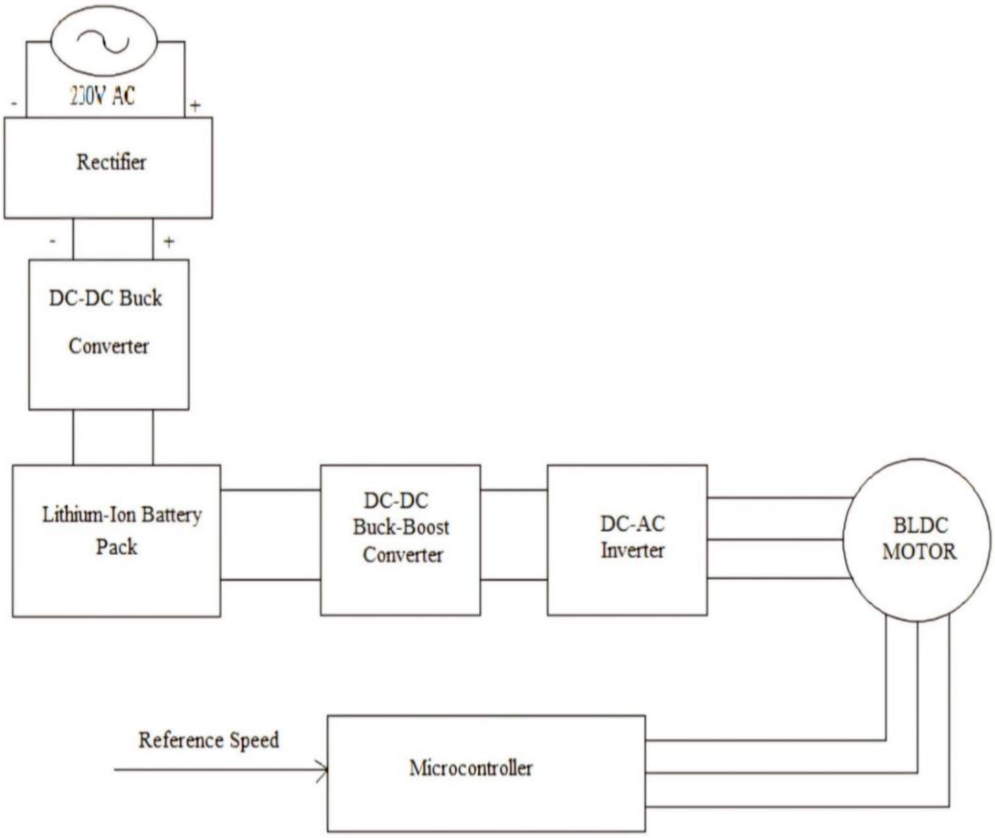

Fig. 1 Hardware Block Diagram

BLDC Motor: It offers several advantages over traditional brushed motors, including higher efficiency, longer lifespan, and smoother operation. BLDC motors use electronic commutation instead of brushes, which reduces friction and wear. This results in improved energy efficiency and less maintenance. The motor integration in electric kick scooters allows for precise control of acceleration and speed. It plays a crucial role in providing a smooth and responsive riding experience.

DC AC Inverter: It takes the higher voltage from the battery and converts it to a lower voltage that is suitable for powering various components of the scooter, such as the lights or the control system. This conversion is necessary because different components require different voltage levels to operate efficiently. The DC-DC converter efficiently steps down the

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voltage while minimizing power loss. It plays a crucial role in optimizing the overall performance and power consumption of the electric kick scooter.
Battery management system (BMS) is technology dedicated to the over-sight of a battery pack, which is an assembly of battery cells, electrically organized in a row x column matrix configuration to enable delivery of targeted range of voltage and current for a duration of time against expected load scenarios. BMS refers to a management scheme that monitors, controls, and optimizes an individual's performance or multiple battery modules in an energy storage system. BMS can control the disconnection of the module from the system in the event of abnormal conditions. It is used to improve battery performance with proper safety measures within a system.
In a power system application, BMS is introduced to monitor, control, and deliver the battery's power at its maximum efficiency (battery life is also considered here). In automobile applications, BMS is used for energy management in different system interfaces and ensures the system's safety from various hazards.

V. CHARGING TIME

All kick-bikes currently on the market are powered by lithium batteries.

According to formula:

T1=(A*H) *cp/A

T1: Charging time

A*H: battery capacity

cp: Charging efficiency (generally lithium batteries 90%)

A: The ampere of charging

So, it is difficult to determine the charging time before determining the battery capacity. At the same time we use the reverse solution. Set the charging time first. The charging current is determined according to the charging time. If the current is smaller, the charging time is longer.

According to market research, the longest charging time is 10 hours and the shortest is 4 hours. Most concentrated around 6 hours. To make our products more competitive. Set the charging time to 4-5 hours.
Put the two conditions of time and battery capacity into the formula:

4(h)-5(h)=130.9/A

Result: A=2.925 A-2.34 A

When the current is between 2.925 A and 2.34 A for constant current charging.Charging time is 4 or 5 hours.

VI. BATTERY CAPACITY

According to market research, the longer the Mileage, the larger the battery capacity.40 KM--10.4 AH, 40 KM-50 KM--15.6 AH. In order to ensure product competitiveness, Mileage should be between 40 kilometers and 50 kilometers. So, our battery capacity should be between 10.4 AH and 15.6 AH. We add the two together to take the average. The obtained result is 13 AH as the final result.
Battery capacity: 13 AH.

VII. CC- CV CHARGING OF BATTERY

The Constant Current-Constant Voltage (CC-CV) charging method is widely used for charging lithium-ion (Li-ion) batteries, as it helps ensure a safe and efficient charging process. Li-ion batteries are common in various electronic devices, electric vehicles, and renewable energy systems. The CC-CV charging method consists of two distinct phases to optimize the charging process and extend the battery's lifespan.

1. Constant Current (CC) Phase:
In the initial stage of charging, the battery is charged with a constant current. This phase is designed to replenish the battery's capacity quickly without causing overheating or other safety concerns. During the CC phase, the charging

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current remains constant, and the voltage across the battery terminals gradually increases. The charging current is typically set based on the battery's capacity. For example, if you have a 2000mAh battery, a common charging rate might be 1C, which means a charging current of 2000mA or 2A. Higher or lower charging rates can be used depending on the battery specifications and the charging system's design.

2. Constant Voltage (CV) Phase:
Once the battery voltage reaches a predefined level (the "float" or "absorption" voltage), the charger switches to the Constant Voltage phase. During this stage, the charging voltage is kept constant, and the charging current gradually decreases as the battery approaches full capacity. The CV phase is crucial for preventing overcharging and ensuring that the battery reaches its maximum capacity without exceeding its voltage limits. The float voltage is typically set slightly below the battery's maximum voltage rating to provide a safety margin. The transition from the CC phase to the CV phase is often determined by the charging algorithm in the battery management system (BMS) or the charging controller. The BMS monitors parameters such as voltage, current, and temperature to control the charging process effectively.

BENEFITS OF CC-CV CHARGING:
1.Fast Charging: The CC phase allows for a high charging current, enabling a rapid replenishment of the battery's capacity.
2.Optimal Charging: The CV phase prevents overcharging by maintaining a constant voltage once the battery is nearly full.
3.Temperature Control: The charging process can be adjusted based on the battery's temperature, enhancing safety.
4.Extended Battery Life: The CC-CV method helps extend the lifespan of Li-ion batteries by avoiding stress-inducing charging conditions.

VIII. SIMULATION

A. Speed Control in BLDC motor

A BLDC motor is made up of a stator with three windings and a rotor with permanent magnets. BLDC motors employ electronic commutation to regulate the motor rather than brushes. The element that controls BLDC motors is the three-phase inverter. It transforms DC electricity (direct current) into three-phase AC power (alternating current), which is needed to supply the motor with the appropriate input. Three sinusoidal currents with a 120-degree phase difference are produced by the three-phase inverter.

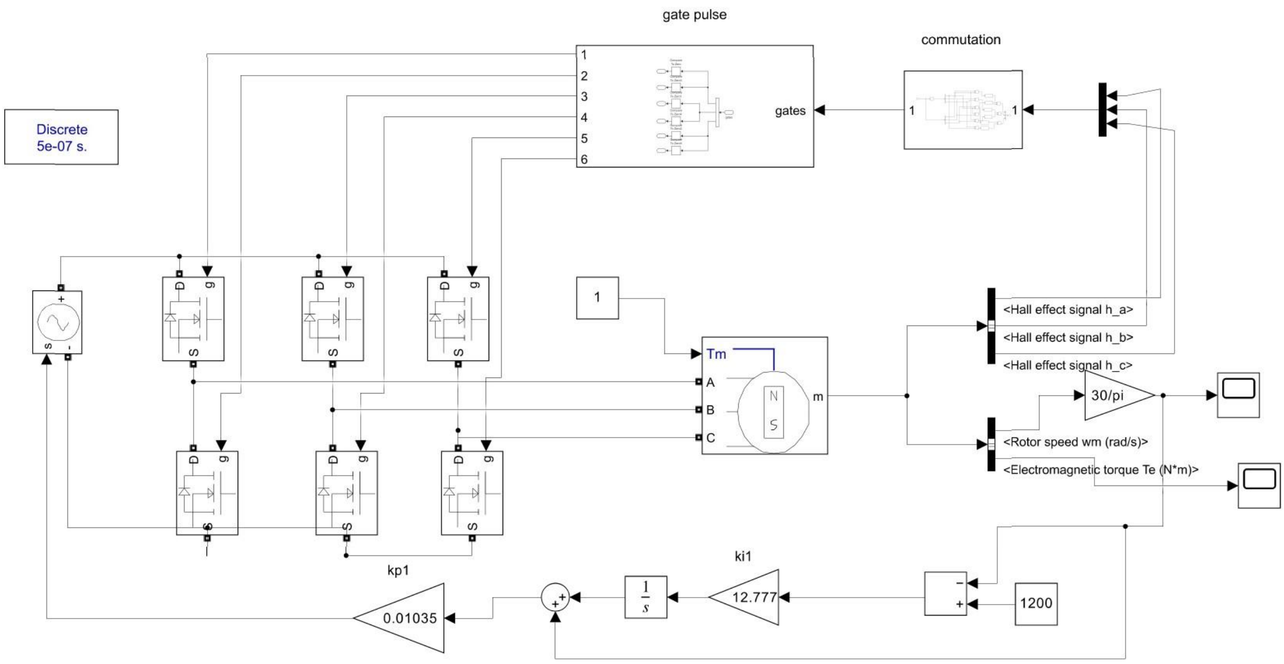

Fig 2 : Speed Control Simulation

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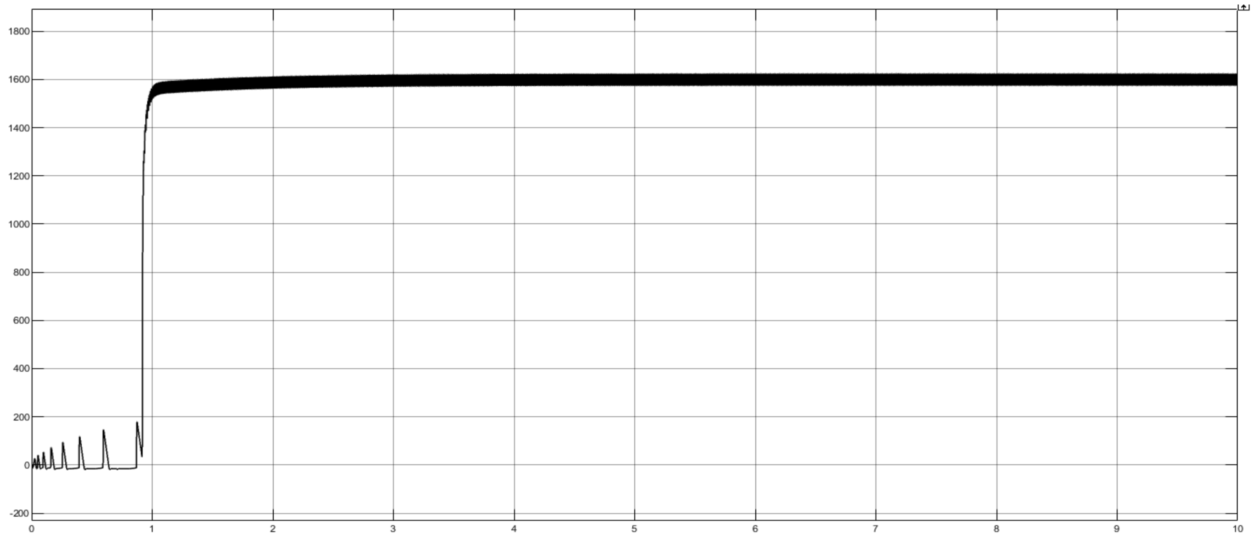
The BLDC motor's rotation speed and direction are managed by the inverter through modifications to the amplitude and frequency of these currents. The rotor position dictates the order in which the inverter energizes the stator windings. The winding carrying current is changed to the next one during commutation to guarantee

In order to energize the stator windings in a sequence that powers the rotor, BLDC motors use electrical technologies that require exact commutation. Hall-effect sensors are frequently used by BLDC motors to detect the rotor position and enable precise commutation. These sensors pick up the rotor magnets' magnetic field and alert the controller to change the stator windings appropriately. Pi controller—that regulates the motor's speed. It is done in order to quickly reach the rated speed and cut down on the amount of time. The signal's mistake is first fixed by the integral block, and only then is it sent to the proportional block for signal strengthening.



. Fig 3 : Speed Vs Time

B. IP and PI controller

This is how the PI and IP controllers are compared. The MATLAB software successfully completes the MATLAB simulation for both the IP and PI controller. Thus, it can be concluded that the Integral-Proportional controller outperforms the Proportional-Integral controller in terms of performance. Even yet, the steady-state error is eliminated by the proportional-integral controller. There is an overshoot in the response. A modified Proportional-Integral controller, also known as an Integral-Proportional controller, can be used to avoid this problem. Using an IP controller significantly reduces overshoot and shortens the time it takes the system to reach the target value.

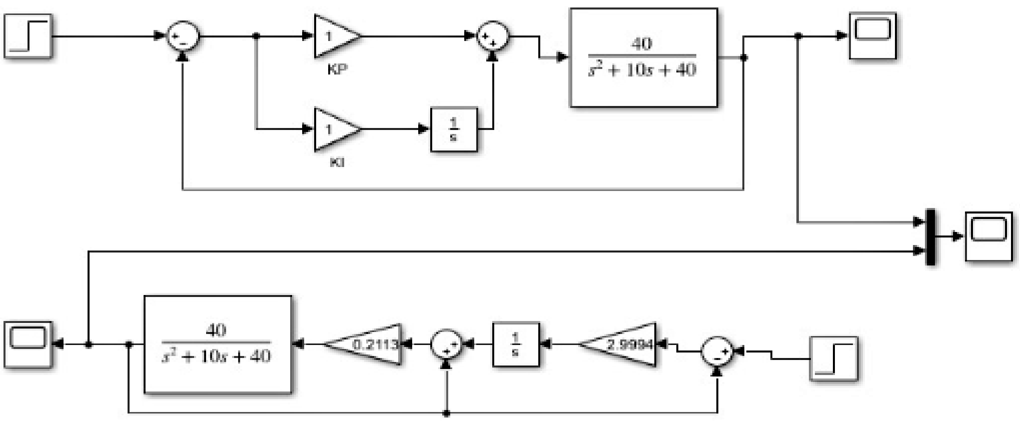


Fig 4: Comparison between IP and PI controller

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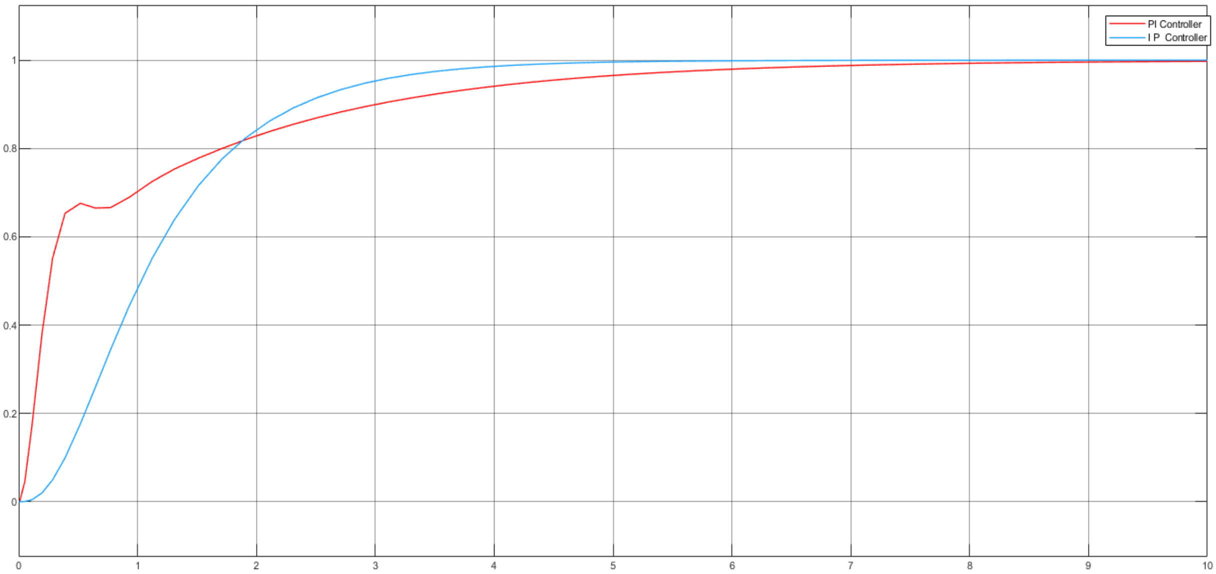

Fig 5: Output of comparison of PI and IP controller

IX. RESULTS AND INFERENCE

The final prototype underwent testing on a road within the college premises. The system proved to be quite stable, and the motor provided sufficient power to keep the structure moving even under high pressure. The larger deck also ensured that the rider could comfortably ride the scooter. The BLDC hub motor that drives the scooter functioned properly, and the rider could easily control its speed. The braking system was also functional. One full charge of the battery provides a mileage of 20 km and it can vary according to the weight of the driver. It took approximately three hours to fully charge the battery.

Fig 6: Final Product

X. CONCLUSION

An inventive and intriguing answer to the problems associated with urban mobility are electric kick scooters. Their compact size, user-friendliness, and eco-friendly electric power make them a practical substitute for short-distance transportation in densely populated urban areas. These scooters help to promote sustainable mobility options, lessen emissions, and lessen traffic congestion.It's crucial to remember, meanwhile, that the growing popularity of electric kick scooters has sparked questions about infrastructure, safety, and legal issues. In order to guarantee the long-term viability and incorporation of electric scooters into urban transportation systems, it will be imperative to tackle these obstacles. Encouraging public awareness initiatives, well-defined rules, and adequate infrastructure can all help promote safer and more conscientious scooter use. Improvements in battery efficiency, range, and safety features are anticipated as

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technology develops, which will increase the allure and sustainability of electric kick scooters. Effective cooperation among transportation authorities, city planners, and scooter-sharing companies is vital to establish a cohesive and well-functioning system that serves the interests of the urban environment and riders alike. Although electric kick scooters present a promising answer to problems with urban mobility, their successful integration necessitates a comprehensive strategy including public awareness campaigns, legal frameworks, and technological advancement in order to establish a safe and sustainable urban transportation environment

ACKNOWLEDGMENT

We owe a debt of gratitude to our project guide **Mrs. Caroline Ann Sam** and our faculties especially our Head of Department of electrical and electronics engineering **Dr. Rinu Alice Koshy** for all of their help and assistance in getting the project completed, as well as for their guidance and constant oversight. We want to thank our parents for their wonderful support and encouragement, which have enabled us to finish this project.

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