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Portable Electric Bicycle Drive

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Abstract -A portable electric bicycle drive system is a compact, removable motor unit designed to convert a standard bicycle into an electric one. It typically includes a small electric motor, a battery pack, a controller, and a mechanism for throttle or pedal-assist, providing supplemental power to aid in pedaling. These systems are easily installed and removed, allowing users to switch between manual and electric cycling as needed. Ideal for commuters and recreational riders, they make it easier to tackle challenging terrain and long distances. The motor can be mounted on the rear wheel, front wheel, or crank set, offering flexibility for various bike types. With features like water resistance, customizable power modes, and regenerative braking, portable electric bicycle drives are becoming an increasingly popular, cost-effective, and eco-friendly solution for urban and outdoor cycling.

Key Words**:** Portable Electric Bicycle Drive. Lithium-ion battery, BLDC Motor, Speed Controller

1. INTRODUCTION

A portable electric bicycle drive is a compact, removable motor system that can be attached to a standard bicycle to convert it into an electric bike. These drives typically consist of a small, lightweight motor, a battery pack, and a controller that provides electric assistance when pedaling. The primary appeal of portable electric drives is their versatility, as they allow cyclists to maintain the functionality of a traditional bicycle while enjoying the benefits of electric assistance when needed. They are designed to be easy to install and remove, making them a flexible option for commuters, recreational riders, or those who want to switch between electric and manual cycling. With advancements in battery technology, these drives offer decent ranges, often between 20-50 miles per charge, and can be recharged using standard electrical outlets. Their portability also makes them convenient for storage and transportation, enhancing the flexibility and convenience of cycling. Portable Electric Bicycle Drives are highly adaptable to various bike types, including road bikes, mountain bikes, and hybrid models. They often feature different power modes, allowing riders to customize their level of electric assistance based on the terrain or their desired effort. Some models also include regenerative braking, which helps to recharge the battery while descending or slowing down. These drives can typically reach speeds of up to 15-20 mph, depending on the motor's power, making them ideal for urban commuting or long-distance rides without the strain of constant pedaling. Many systems are designed to be water-resistant, ensuring they can withstand a variety of weather conditions. The ability to transform a regular bicycle into an electric one without permanently altering its structure makes portable electric drives a cost-effective and eco-friendly solution for those seeking a greener, more efficient mode of transportation. With the growing emphasis on sustainable mobility, these drives are becoming increasingly popular among urban cyclists and outdoor enthusiasts alike. A portable electric bicycle drive system is a compact, battery-powered motor unit designed to assist in propelling a bicycle. This system typically includes a small electric motor, a battery pack, a controller, and a throttle or pedal-assist mechanism. It can be easily attached to an existing bicycle, usually on the rear wheel, front wheel, or crank set, allowing riders to convert their regular bicycle into an electric one. The motor provides supplemental power, making it easier to tackle hills, long distances, and challenging terrain. Most portable systems are designed for ease of installation and removal, making them ideal for users who want the flexibility of an electric assist without permanently modifying their bicycle.

This paper is organized as follows: Section II present the description of the system. Section III presents the Energetic Macroscopic Representation (EMR) and the model of the charging station. Section IV introduces the energy management for both operation modes, isolated and grid-tie. Section IV presents simulation results and Section V presents the conclusions and future directions of the research.

1. METHODOLOGY

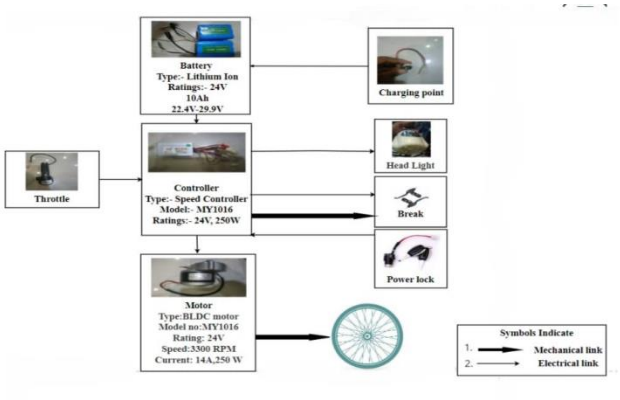

Figure No.1

His block diagram illustrates an electric vehicle or electric bicycle setup, detailing the major components and their connections. Here's an explanation of each part:

i. **Battery**:

Type: Lithium-Ion Battery

Ratings: 24V, 10Ah, providing a voltage range of 22.4V to 29.9V.

Function: The battery stores and supplies electrical energy to power the motor and other components like the headlight and controller.

i. **Charging Point**:

Connected to the battery, this is where the battery can be recharged. When connected to an external charger, it supplies power to replenish the battery's stored energy.

iii. **Throttle**:

o The throttle is the user interface for controlling the vehicle's speed. It sends a signal to the controller when adjusted by the rider, indicating the desired speed.

iv. **Controller**:

o Type: Speed Controller

o Model: MY1016, with a rating of 24V and 250W.

o Function: The controller regulates the power flow from the battery to the motor based on the throttle's input. It adjusts the voltage and current supplied to the motor, thus controlling its speed and performance.

v. **Headlight**:

o This light is powered directly by the battery through the controller. It provides visibility for the rider in low-light conditions and increases safety.

vi. **Brake**:

The brake is connected to the controller. In many electric vehicle systems, the brake switch can signal the controller to cut power to the motor when activated, ensuring efficient and safe braking.

vii. **Power Lock**:

o Acts as a security switch. When turned on, it allows the flow of power from the

battery to the controller and other components. When off, it prevents the vehicle

from operating by cutting off power.

viii. **Motor**:

o Type: Brushless DC (BLDC) Motor

o Model: MY1016, rated at 24V.

o Specifications: Operates at 3300 RPM, with a power rating of 250W and a current draw of 14A.

o Function: This motor converts electrical energy into mechanical energy, propelling the vehicle. The controller supplies it with the necessary power, based on the throttle input.

ix. **Wheel**:

The motor drives the wheel mechanically, allowing the vehicle to move. The motor's power and speed are transferred to the wheel, making it the output that propels the vehicle. 2324

Symbol Key

 Mechanical Link (Black Arrow): Represents a physical connection, such as the motor turning the wheel.

 Electrical Link (White Arrow): Represents an electrical connection, like wiring from the battery to the controller or from the controller to the motor.

This diagram shows a streamlined system for an electric vehicle with safety (brake, power

lock) and usability (headlight, throttle) features. The controller is the central unit, coordinating power distribution to the motor and accessories based on the user's commands.

3. EQUIPMENT REQUREMENT

i. Brushless DC motor

Brushless DC electric motors also known as electronically commutated motors (ECMs, EC motors). Primary efficiency is a most important feature for BLDC motors. Because the rotor is the sole bearer of the magnets and it doesn't require any power. I.e no connections, no commentator and no brushes. In place of these, the motor employs control circuitry. To detect where the rotor is at certain times, BLDC motors employ along with controllers, rotary encoders or a Hall sensor. **Working Principle of Brushless DC motor**

BLDC motor works on the principle similar to that of a Brushed DC motor. The Lorentz force law which states that whenever a current carrying conductor placed in a magnetic field it experiences a force. As a consequence of reaction force, the magnet will experience an equal and opposite force. In the BLDC motor, the current carrying conductor is stationary and the permanent magnet is moving.

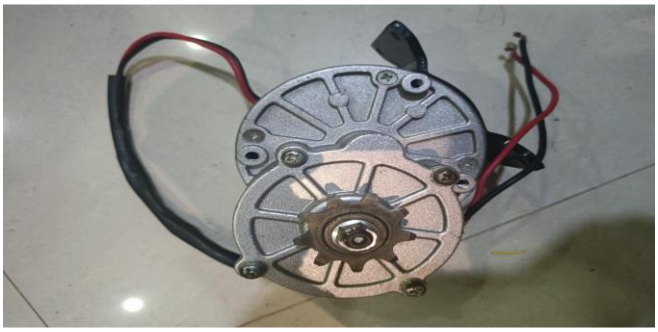

Figure No.2 BLDC Motor

When the stator coils get a supply from source, it becomes electromagnet and starts producing the uniform field in the air gap. Though the source of supply is DC, switching makes to generate an AC voltage waveform with trapezoidal shape. Due to the force of interaction between electromagnet stator and permanent magnet rotor, the rotor continues to rotate. With the switching of windings as High and Low signals, corresponding winding energized as North and South poles. The permanent magnet rotor with North and South poles align with stator poles which causes the motor to rotate.

Table No.1 BLDC Motor Specification

Specification	Details
Rated Voltage	24 Volt DC
Rated Power	250W
RPM	400rpm
Rated Current	10.41 A
Full Load Current	14.2 A
Under Voltage Protection	20.5V
Current Limiting Protection	20A

ii. Speed Controller

The speed controller in a portable electric bicycle drive regulates the power flow from the battery to the BLDC motor, ensuring smooth and efficient operation. It uses Pulse Width Modulation (PWM) to control motor speed and allows for precise acceleration and deceleration. Key features include current limiting to prevent overheating and overloading, and often, regenerative braking to recharge the battery during braking. The controller also offers protection against over-voltage, under-voltage, and short circuits, ensuring safe operation. Additionally, it may provide user-friendly interfaces for selecting speed modes and monitoring battery levels.

Figure No.3 Speed Controller

Table No.2 Speed Controller Specification

Specification	Details
Voltage	DC 24 V
Under Voltage	20V
Current Limit	21A
Level Brake	Low Level
Power	250W

iii. **Throttle Set**

The throttle set in a portable electric bicycle drive allows the rider to control the motor's power output and, consequently, the bicycle's speed. Typically, it is a handlebar-mounted component that functions like a motorcycle throttle, providing variable speed control based on how much it's twisted or pressed. Throttles can be of different types, such as thumb, twist, or half-twist designs. They are usually connected to the speed controller, which adjusts the motor's power according to the throttle input. Many throttles also include built-in safety features, like automatic cut-off when released, ensuring smooth and controlled riding.

Figure No.4 Throttle Set

iv. **Lithium Ion Battery**

Lithium-ion batteries are commonly used in portable electric bicycle drives due to their high energy density, which allows them to store more energy in a compact, lightweight form. This is essential for keeping electric bicycles portable and providing long ranges on a single charge. They have a longer lifespan compared to other battery types, with many charge cycles before degradation.Additionally, lithium-ion batteries offer faster charging times and maintain a stable output voltage, ensuring consistent motor performance. Their low self-discharge rate also helps retain charge over extended periods, making them ideal for electric bicycles, where efficiency, weight, and reliability are critical.

Figure No.5 Lithium Ion Battery

Table No.3 Lithium Ion Battery Specification

Specification	Details
Voltage	22.4 to 29.4 V
Battery Type	Lithium Ion
Pack Type	7sx4p
Cell Type	18650

v. Brake Lever

The brake lever in a portable electric bicycle drive is a crucial safety component that not only controls the mechanical braking system but often integrates with the motor to enhance safety. Many e-bike brake levers are equipped with a motor cut-off function, which instantly disconnects power to the motor when the brakes are applied. This prevents the motor from working against the brakes and ensures quicker, safer stops. Brake levers are typically designed for easy operation, offering responsive braking with minimal effort. They contribute to overall rider control, especially at higher speeds or in emergency situations. In electric bikes, this dual functionality—braking and motor cut-off—ensures both mechanical and electronic safety, making the ride smoother and more secure.

Figure No.6 Brake Lever

vi. Corrugated Tube

Corrugated tubes are used in portable electric bicycle drives to provide protection and organization for electrical wiring. The flexible, ridged design of these tubes allows them to bend easily, accommodating the movement and folding mechanisms often found in portable e-bikes without damaging the internal wires. They protect the wiring from environmental factors such as water, dust, and debris, helping to prevent short circuits or wire damage. Additionally, corrugated tubes offer insulation, reducing the risk of electrical hazards. Their durability and flexibility make them ideal for managing cables in confined spaces, contributing to the overall reliability and safety of the electric bicycle.

Figure No.8 Corrugated Tube

vii. Lithium Ion Battery Charger

A Lithium-ion battery charger is used in portable electric bicycle drives because it is specifically designed to charge lithium-ion batteries efficiently and safely. These chargers provide controlled charging, ensuring that the battery receives the correct voltage and current, which helps extend battery life and prevent overcharging or overheating. They often include features like automatic cut-off once the battery is fully charged, protecting it from damage. Lithium-ion chargers are typically lightweight and portable, matching the needs of a portable electric bicycle. Their fast-charging capability ensures minimal downtime, making the bike more convenient for users who rely on it for regular transportation.

Figure No.7 Lithium Ion Battery Charger

viii. LED Head Light With Horn

The LED headlight with a horn is used in portable electric bicycle drives to enhance both safety and visibility. The LED headlight provides bright, energy-efficient lighting, allowing riders to see clearly in low-light conditions, such as at night or in fog. LEDs are preferred because they consume less power, preserving the battery life of the e-bike. The integrated horn adds an audible safety feature, enabling riders to alert pedestrians or other vehicles of their presence. Together, the headlight and horn improve rider safety, particularly in urban environments where visibility and communication are crucial.

Figure No.9 LED Head Light With Horn

viii. Freewheel

A freewheel is used in portable electric bicycle drives to allow the rider to pedal without engaging the motor when coasting or descending. This feature enables smooth and efficient pedaling, as it prevents the motor from providing resistance when the cyclist is not actively pedaling. The freewheel mechanism helps conserve battery power during downhill rides and allows for better control and maneuverability. Additionally, it reduces wear on the motor and drivetrain by minimizing unnecessary load. Overall, the freewheel enhances the riding experience by providing a natural cycling feel and optimizing energy usage in various riding conditions.

Figure No.10 Freewheel

ix. Long Axle

A long axle is used in portable electric bicycle drives to provide enhanced stability and support for the bike's frame and components. By extending the distance between the wheels, a long axle helps distribute weight more evenly, improving balance and handling, especially during turns or when carrying loads. This design also allows for compatibility with wider tires, which can enhance traction and comfort on various terrains. Additionally, a long axle can accommodate various gear systems and brakes, providing flexibility in design and performance options. Overall, using a long axle contributes to a safer and more enjoyable riding experience.

Figure No.11 Long Axle

x. Chain

The chain in a portable electric bicycle drive is used to transmit power from the pedals to the rear wheel, enabling efficient movement. It allows for smooth gear shifts, providing versatility in speed and torque to accommodate different riding conditions. Chains are lightweight yet durable, making them ideal for portable applications where minimizing weight is crucial. They require less maintenance compared to belt systems and can handle high torque loads, essential for electric bicycles. Additionally, the use of a chain provides a more traditional cycling experience, allowing riders to engage in manual pedaling while still benefiting from electric assistance. Overall, the chain system enhances both the performance and functionality of electric bicycles.

Figure No. 3.13 Chain

xi. Mounting Plate

The mounting plate in a portable electric bicycle drive serves as a critical component for securely attaching various parts of the e-bike, including the motor, battery, and controller. It provides a stable and robust platform that helps maintain the alignment and integrity of these components during operation. By using a mounting plate, manufacturers can simplify the assembly process, ensuring that each part is easily accessible for maintenance and repair. Additionally, the mounting plate helps distribute the forces exerted on the bike frame, reducing stress and potential damage over time. This feature also contributes to the overall durability and reliability of the electric bicycle, ensuring that it can withstand the rigors of daily use. Overall, the mounting plate plays a vital role in the structural integrity and performance of portable electric bicycles.

Figure No.12 Mounting Plate

4. PURPOSED HARDWARE MODEL

Figure No.13

The above figure are shown to the implementing the all equipment of portable electric bicycle drive like battery,controller,motor ,power lock ,this all equipment are arrnange in the metal box then connect all the equipment of the drive.and then after the implenmenting of all device in the box then we can attached the portable drive of cycle.for small testing purpose The above figure shows the mechanical connection of the drive,firstly we can attached the mounting plate of the drive they can fix the motor in they metal box.then next part is we can attached the long axel to the rare wheel of the bicycle for creating a space for aalignment of the wheel.Then we can atthched the freewheel to rare wheel then we can attached the small freewheel to the motor shaft to rotating the bicycle wheel using the chain spocket.this are all part about the mechanical connection of the drive.then we can use the corrugated tube for protection of wiring which we can connect to the outdoor part of the device.After successfully fabrication our electric bicyle drive we started to test the battery performance to determined the maximum distance which can be travelled in single charge.we also tested the prototype has coverd 10 to 15 km and tested the maximum speed caqn achive ,we determine the riding of bicycle.

5. RESULT

i. **Power Output and Speed**: The BLDC motor used in the system was a 250W model, providing sufficient power for speeds up to 25-30 km/h. The BLDC motor is highly efficient, offering smooth acceleration and consistent performance across varying terrain. It was particularly effective in urban environments, providing a comfortable and easy ride, even when starting from a standstill or on moderate inclines. The motor's torque performance was notably smooth, with minimal resistance when the motor was off (in pedal-assist mode), contributing to a natural cycling experience.

ii. **Range and Battery Performance**: The system was powered by a high-performance **24V lithium-ion battery** with a capacity of 10Ah. The battery provided a range of 25-35 km on a full charge, depending on factors such as rider weight, terrain type, and whether the bike was used in throttle mode or pedal-assist mode. In regenerative braking mode, a small amount of energy was returned to the battery during braking, helping extend the range, especially in city commuting conditions where frequent stops are common. The battery also supported multiple charge cycles with minimal loss in performance, showing excellent longevity.

iii. **Battery Charger**: The lithium-ion charger used for the system was designed to quickly recharge the 24V battery within approximately 3-4 hours. The charger provided a steady current to the battery, ensuring an efficient and safe charge. Lithium-ion charging technology minimizes the risk of overcharging and overheating, prolonging battery life. The charger included an indicator light that showed the charging status (charging, fully charged, or fault), providing users with clear feedback on the battery's charge level.

iv. **Weight and Portability**: The motor, battery, and charger system were all designed to be lightweight, with the total added weight of the motor and battery being around 3.5-4 kg. This weight allowed for easy installation and detachment, providing users with a convenient, portable solution. The battery could be easily removed and charged separately, which adds flexibility and security for users who wish to store the battery indoors.

v. **Speed Controller Functionality**: The **speed controller** managed the motor's power output based on the chosen riding mode: throttle or pedal-assist. The controller offered smooth speed modulation, with gradual acceleration and deceleration. It allowed for dynamic control over the motor's power, enabling users to conserve battery power on flat terrain or use the full throttle on steeper inclines. Additionally, the controller supported regenerative braking, which helped to recover energy during braking events and contributed to battery recharging.

vi. **Safety Features**: The lithium-ion battery system included several safety features, such as over-voltage, over-current, and temperature protection to prevent damage to the battery. The controller also featured low-voltage protection, automatically cutting off power when the battery charge reached a critical level, ensuring that the battery wasn't drained excessively.

vii. **User Experience and Feedback**: Riders appreciated the smooth and silent operation of the BLDC motor, especially in the pedal-assist mode, which provided a natural cycling experience. The battery range was sufficient for most daily commutes, and the quick recharging time made it ideal for city users. Users also liked the convenience of the detachable motor and battery system, which made storing the bike or securing the system against theft easier. The lightweight design of the motor and battery did not compromise the handling of the bicycle, which remained nimble and responsive.

6. DISCUSSION

The portable electric bicycle drive utilizing a BLDC motor**,** lithium-ion battery**,** and lithium-ion charger demonstrates a successful combination of high efficiency, portability, and ease of use for urban commuters. The BLDC motor is particularly effective in this setup, as it offers high torque and efficiency, providing adequate power without overburdening the battery. Lithium-ion technology, known for its light weight and long lifespan, is a perfect match for this portable drive system. The ability to easily remove and charge the battery separately enhances the overall user experience.

Challenges and Areas for Improvement: While the system offers a solid range of 16-25 km, extending the range for longer commutes could be beneficial. This could be achieved by integrating a higher-capacity lithium-ion battery or offering users the option to purchase an additional battery for longer rides. The charging time of 3-4 hours is acceptable for most users, but for those who need faster turnaround times, a high-speed charger could be developed to reduce this period.

In terms of motor performance, while the system is effective for moderate inclines, steep hills may cause the motor to lag in power delivery. A more powerful motor could be incorporated to improve performance on hilly terrain, although this may increase weight and reduce portability. Additionally, integrating smart features like battery management systems (BMS) that optimize charging cycles and provide detailed feedback on battery health could further improve performance.

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