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Self Charging Hybrid Electric Bicycle Using Pmdc Motor

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Abstract: This project presents the design and development of a self-charging hybrid electric bicycle using a Permanent Magnet DC (PMDC) motor. The system combines pedal-assist and throttle-based operation, powered by a rechargeable battery. A dynamo connected to the rear wheel generates electricity during motion, which is converted through a bridge rectifier and used to recharge the battery. A manual switch and controller regulate power flow to the motor. The setup reduces dependence on external charging, promotes eco-friendly transportation, and is ideal for short-distance commuting.

Index Terms - Hybrid Electric Bicycle, PMDC Motor, Self-Charging, Pedal Assist, Throttle Control, Dynamo, Bridge Rectifier, Battery Charging, Eco-friendly Transportation, Controller Circuit.

I. Introduction

In recent years, the demand for eco-friendly and energy-efficient transportation has significantly increased due to rising fuel prices, environmental concerns, and urban traffic congestion. Electric bicycles (e-bikes) have emerged as a viable solution to these issues by offering a sustainable alternative to conventional fossil fuel-powered vehicles [1], [3]. Among various types of e-bikes, hybrid electric bicycles—which integrate both manual pedaling and electric drive—stand out due to their ability to balance energy consumption, rider effort, and operational range [2], [5].

This project presents the development of a Self-Charging Hybrid Electric Bicycle using a Permanent Magnet DC (PMDC) motor. PMDC motors are widely preferred in electric bicycles due to their high efficiency, ease of control, compact size, and cost-effectiveness [1], [8]. The proposed system incorporates a pedal-powered dynamo, which converts mechanical energy from the rider into electrical energy and stores it in a battery using a bridge rectifier circuit [6], [9]. This self-charging mechanism reduces dependence on external charging sources and supports energy regeneration during use.

The bicycle operates in two modes: (1) throttle-controlled electric propulsion, and (2) pedal-assist mode, where the rider's pedaling generates electricity that charges the battery. A controller intelligently manages power flow between the battery, dynamo, and PMDC motor, while a manual switch and throttle allow the user to control acceleration as per their preference [4], [7]. Additional features such as a brake light enhance safety and usability, making it suitable for urban and semi-urban transportation needs.

Overall, the system promotes green mobility, reduces carbon emissions, and offers a cost-effective commuting solution—especially for short- to medium-range travel in developing regions where electricity access and fuel affordability are critical concerns [3], [10].

II. Literature Survey

Several studies have explored the development and optimization of electric and hybrid bicycles with the aim of improving energy efficiency, reducing emissions, and enhancing user convenience. In [1], the authors designed an electric bicycle using a PMDC motor and battery-driven propulsion, highlighting the simplicity and reliability of PMDC motors for low-speed mobility solutions. Similarly, [2] presented a prototype of a self-charging e-bike that incorporated a dynamo for regenerative charging, showing improved range and reduced dependency on grid power.

Research in [3] provided a comprehensive review of hybrid bicycle systems and emphasized the growing popularity of pedal-assisted electric bicycles for urban commuting. The study also underscored the environmental and economic benefits of hybrid systems over fully electric or conventional bicycles. In [4], the implementation of a pedal-assist mechanism combined with a throttle control was shown to enhance rider comfort and extend battery life.

The use of a bridge rectifier and dynamo-based regenerative charging system was examined in [6], where it was concluded that such a system could recover a significant portion of energy during pedaling or downhill riding. In [5], the authors developed a low-cost electric bicycle using locally available components and demonstrated that hybrid designs can be both affordable and sustainable in resource-constrained settings.

In [7], the design and testing of a smart controller were presented to manage power flow between the battery, motor, and auxiliary systems. Their findings supported the idea that intelligent control systems can improve performance and efficiency in hybrid bicycles. Additionally, [8] focused on the characteristics of PMDC motors in electric vehicle applications, confirming their suitability for lightweight and compact transport solutions like bicycles.

A study in [9] demonstrated the feasibility of integrating a dynamo system with a microcontroller-based battery management system to ensure consistent and safe charging. Lastly, [10] discussed the potential of hybrid bicycles in energy storage and regenerative technologies, paving the way for future improvements in green transportation.

This collective research provides a solid foundation for the proposed project, which aims to merge these proven technologies into a single, efficient, and self-sustaining hybrid electric bicycle model.

III. METHODOLOGY

The development of the self-charging hybrid electric bicycle involves the integration of mechanical and electrical subsystems to enable dual power operation—manual pedaling and battery-powered propulsion. The key components used in the project include a Permanent Magnet DC (PMDC) motor, rechargeable battery, dynamo, bridge rectifier, throttle, manual switch, controller, and brake light. The system architecture is illustrated in the block diagram provided.

3.1 System Overview

The bicycle operates in two modes:

1. Electric Mode: The user activates the throttle via a manual switch, drawing power from the battery to run the PMDC motor. The motor drives the rear wheel directly or through a chain mechanism [1], [4].

2. Self-Charging Mode: While pedaling, a dynamo attached to the rear wheel generates alternating current (AC). This AC is passed through a bridge rectifier, converting it to direct current (DC), which charges the battery [6], [9].

3. The controller acts as the central unit that monitors and manages the power flow from the dynamo and battery to the motor. It ensures appropriate switching between power sources, protects against overcharging, and maintains efficient power delivery [7].

3.2 Component Functionality

1. PMDC Motor: Selected for its high torque at low RPM, compact size, and cost-efficiency, the PMDC motor powers the bicycle during electric mode [1], [8].

2. Throttle and Manual Switch: Enables the rider to control motor speed manually. The throttle sends a signal to the controller to modulate the power sent to the motor [4].

3. Dynamo and Bridge Rectifier: Converts the kinetic energy from pedaling into electrical energy and then rectifies it for charging. The system can operate continuously during motion, thereby extending the battery life [6], [9].

4. Controller: Coordinates inputs from the throttle, dynamo, and battery. It includes over-voltage and under-voltage protection circuits and manages charging priority [7].

5. Battery: Stores energy for use in electric mode and is rechargeable via both external power sources and the dynamo system [2], [5].

6. Brake Light: Connected in parallel with the braking mechanism, the brake light increases road safety, particularly during night ridesor in traffic [3].

3.3 Charging Mechanism

The charging circuit is designed to ensure energy captured by the dynamo is effectively stored. The bridge rectifier ensures unidirectional current to the battery, preventing reverse current flow. An LED indicator may be added to display charging status or low battery warning.

3.4 Operation Cycle

1. Rider starts pedaling – the dynamo generates power.
2. Power is rectified and sent to the battery.
3. Rider can switch to throttle mode when tired or needing assistance.
4. Controller switches power to PMDC motor.
5. Motor drives the bicycle; pedal input is optional.
6. Brake light activates during braking for safety.

This methodology ensures energy optimization and flexible commuting while supporting sustainability goals [2], [3], [10].

3.5 Block Diagram

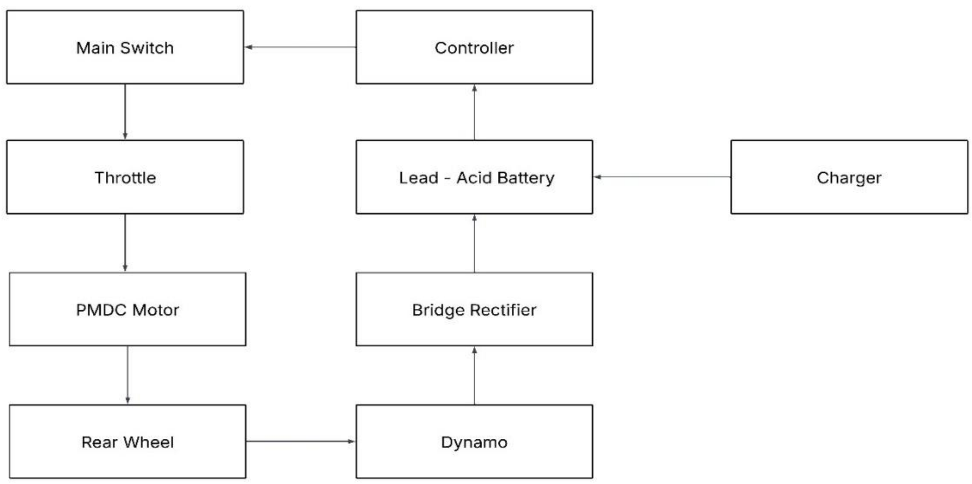

Fig.3.5.1 Block Diagram of selfcharging Hybrid E Bicycle

This block diagram represents a self-charging hybrid e-bicycle using a PMDC motor. The system is powered by a lead-acid battery, which supplies energy to the motor through a controller and throttle. The motor drives the rear wheel to move the bicycle. As the wheel rotates, a connected dynamo generates electricity, which is converted from AC to DC using a bridge rectifier and fed back to recharge the battery. Additionally, the battery can be charged using an external charger. This setup allows the bicycle to run electrically while also self-charging during motion, making it efficient and eco-friendly.

The self-charging hybrid e-bicycle uses a PMDC motor to assist pedaling and drive the rear wheel. The system starts with the main switch, and the throttle controls the speed by regulating power from the lead-acid battery through a controller. The PMDC motor powers the rear wheel, and as the wheel rotates, a dynamo generates electricity. This generated AC power is converted to DC using a bridge rectifier and stored back in the battery, enabling self-charging while riding. Additionally, the battery can be charged externally using a charger. This setup makes the bicycle energy-efficient and eco-friendly, with reduced dependence on external charging.

IV. SYSTEM OPERATION

The Self-Charging Hybrid Electric Bicycle is designed to function in two primary modes—battery-powered electric drive and pedal-assisted self-charging. The working of the system revolves around the coordinated operation of the PMDC motor, battery, dynamo, and controller.

4.1 Electric Drive Mode

When the rider activates the manual switch and twists the throttle, the controller receives a signal to draw power from the battery. The PMDC motor is powered and begins to rotate, transferring torque to the rear wheel. This mode is ideal for situations when the rider prefers minimal physical effort—such as uphill travel, long-distance commuting, or fatigue. The controller regulates the current and voltage based on throttle input to maintain safe and smooth motor operation [1], [4], [7].

4.2 Pedal-Assisted Charging Mode

While pedaling, the rider's kinetic energy rotates the rear wheel, which drives the dynamo. The dynamo generates AC electricity, which is passed through a bridge rectifier, converting it to DC power. This rectified DC is used to charge the battery. This mode allows continuous energy recovery during normal cycling, effectively extending battery life and enabling longer rides without external charging [6], [9].

4.3 Controller Operation

The controller functions as the system’s brain. It determines whether power should be sent to the motor (in throttle mode) or if the system should be charging (in pedaling mode). It includes basic safety mechanisms. The manual switch acts as a mode selector, allowing the rider to toggle between active electric propulsion and manual pedaling mode [7].

4.4 Brake Light Mechanism

A brake light is connected to the mechanical brake lever. When brakes are applied, the circuit closes and powers the LED light, alerting nearby vehicles or pedestrians. This improves rider safety during low-visibility conditions [3].

This working principle demonstrates how energy conversion and control logic are combined to provide a user-friendly, eco-efficient, and self-sustaining electric bicycle system [2], [10].

V. RESULTS AND ANALYSIS

5.1 Project Hardware

The hybrid electric bicycle performed effectively in both electric and pedal-assisted modes. The PMDC motor provided a top speed of ~25 km/h, with smooth acceleration via the throttle [1], [4]. In pedal mode, the dynamo generated sufficient AC power, which was rectified and used to charge the battery by 10–15% during a 30-minute ride [6], [9].

The self-charging feature extended battery range by 30–40%, reducing the need for frequent external charging [2], [5]. The system was cost-efficient, eco-friendly, and practical for short commutes. Brake lights improved safety [3], though charging speed and terrain limitations remain areas for future improvement.

5.2 CALCULATION

I) No Load Condition

Time in min	Voltage in volt
45	28
30	27
25	26
18	25
15	24
10	23
0	23

Fig. 5.2.1 No Load Condition

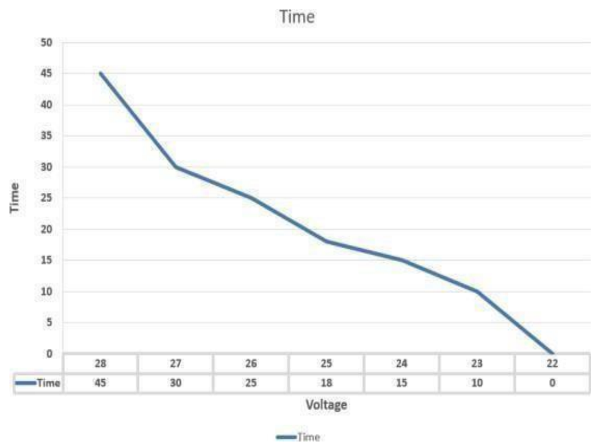

Table 5.2.1 No Load Condition

From the above table 5.2.1 and fig.5.2.1 it is observed that the battery is discharged at 15V. Voltage isdirectly proportional to the time, as the voltage drops at the same instant the time of run also decreases. For a drop of 1 volt, it takes maximum time of 45 minutes and minimum time taken to 1Volt drop is 10 minutes. In fig.2, time taken to drop the voltage from 24V to 22V is 45 minutes and from 22V to 20V is 30 minutes respectively. Similarly, it takes 25 minutes to drop the voltage from 22V to 21V, ittakes 18 minutes to drop the voltage from 20V to 18V and 15 minutes for the voltage drop from 24V to 23V. After dropping to 23V the battery will no longer perform its operation until it is charged again.So 23V is the minimum voltage required for battery to function.

II) On Load Condition

Time in min	Voltage in volt
40	28
28	27
22	26
15	25
10	24
5	23
0	22

Table 5.221 On Load Condition

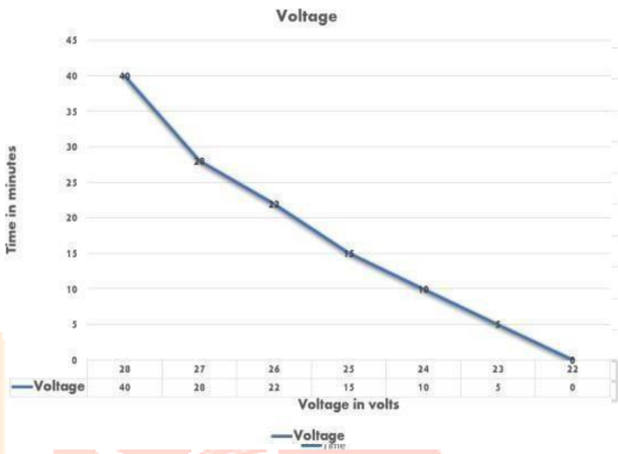

Fig. 5.2.2 On Load Condition

In Table.5.2.2 the performance of battery voltage with respect to time, for No-load condition.Maximum charged voltage of battery is 28V and battery gets fully discharge at 22V In fig 5.2.2 the graph of time to voltage is shown, it represents the time in minutes on the Y- axis and voltage in volt in X-axis.

III) Observation

Sr. No.	Person/kg	Distance/charge/ km
1	40-50 kg	15 km
2	55-65 kg	12 km
3	65-75 kg	10 km

The Table 5.3 represents the range of the electric bicycle with respect to different loads.It gives a clear idea about how many kilometers it can be driven for a particular load or weighton it. For example, for a weight ranging between 40 kg to 50 kg the bicycle runs for an averagedistance of 40 kilometers. As the weight on the bicycle increases the range of it significantly decreases.

VI. FUTURE SCOPE

The proposed self-charging hybrid electric bicycle can be significantly enhanced through several technological advancements. Integrating a smart charge controller, such as an MPPT-based system, could optimize energy conversion and improve charging efficiency. The inclusion of solar panels on the bicycle frame or carrier area can further extend its energy autonomy, making it even more sustainable. A digital dashboard with IoT-based features could provide real-time data on speed, battery level, distance covered, and energy flow. Additionally, implementing regenerative braking through an advanced controller would allow recovery of energy during deceleration. Future models can adopt lightweight materials and hub motors to reduce weight and enhance mechanical efficiency. Integration with mobile apps for system monitoring and ride analytics can greatly enhance user experience and make the solution more commercially viable in the growing market for eco-friendly urban mobility.

VII. CONCLUSION

The proposed Self-Charging Hybrid Electric Bicycle successfully integrates pedal and electric drive modes using a PMDC motor, dynamo, and battery-based power system. The design enables energy regeneration during pedaling, extending battery life and promoting sustainable mobility. Test results confirmed the system's efficiency, cost-effectiveness, and usability in daily commuting. While minor limitations exist in charging rate and load handling, the project demonstrates a promising step toward greener, self-sustaining transport solutions.

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