

Design and development of hybrid bicycle: A Review

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Abstract - The hybrid bicycle is a concept that operates not only on battery power but also on human energy (pedaling). Our project focuses on integrating manual pedaling with battery-operated electric propulsion to create an efficient hybrid bicycle. This bicycle increases travel speed, reduces physical effort, and protects the environment. Considering the rising prices of petrol and diesel, along with increasing pollution, a hybrid bicycle is an excellent, healthy, and

1. INTRODUCTION

The bicycle is a highly significant human invention, but it can be exhausting for long-distance travel. On the other hand, fuel-powered vehicles cause large-scale pollution, and fuel prices are increasing day by day. Saving fuel and reducing emissions are the primary goals of modern vehicle design.

To overcome both of these problems, a 'Hybrid Bicycle' is a highly effective alternative. This bicycle can be driven using both electric energy and human effort (pedalling). Considering the traffic and parking issues in urban areas, developing a hybrid bicycle is the need of the hour for low-cost and pollution-free travel.

1.1 Hybrid Bicycle

A hybrid electric bike is just like a normal bike but equipped with an electric motor that gives you additional power to your pedalling action. This can help you get some exercise or move around quicker and more comfortably. Electric hybrid bicycle also works well for commuters who aren't pressed for parking space and want a little assistance when cycling to work. A basic electrical bicycle runs on a BLDC motor, is powered by batteries and controlled from an electronic unit.

A very basic block diagram of a hybrid electric bike is as shown in Fig. 1, which shows the basic speed control and the transfer of power,

affordable alternative for daily commuting. It achieves a perfect balance between an electric motor and human power.

Key Words: Hybrid Electric Bicycle, BLDC Hub Motor, Pedal Assist System (PAS), Lithium-ion Battery.

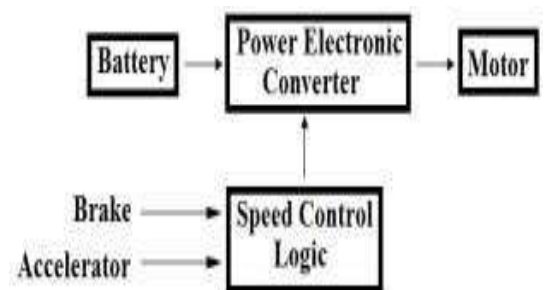


Fig 1: Block Diagram of a Hybrid Electric Bicycle

1.1 Electric Mode

In this mode, the bicycle runs entirely on the battery and the BLDC hub motor. The rider can control the speed using a throttle mounted on the handlebar. This requires no physical effort (pedalling) to drive the bicycle. The motor is generally mounted in the rear wheel hub and is regulated by a controller.

1.2 Manual/Pedal Mode

In this mode, the bicycle's motor is turned off. The rider pedals the bicycle just like a conventional bicycle. This mode can be used if the battery runs out or if the rider wants to exercise.

1.3 Pedal Assist Mode / Hybrid Principle

This is the main and most efficient operating mode of a hybrid bicycle. It utilizes a 'Pedal Assist Sensor' (PAS). When the rider starts pedalling, the sensor detects the motion and sends a signal to the motor. The motor then assists the rider in pedalling by providing additional propulsion. As a result, longer distances can be covered faster with very little effort, and battery life is conserved

2. LITERATURE REVIEW

[1].Design Of Novel Hybrid Electrical Bicycle: A Review by Youssef Makari, Peter Tawadros: This research paper discusses the core principles and advancements in Electric Bicycles (E-bikes), specifically addressing the novelty and optimization of hybrid power systems as outlined in the title "Design of Novel Hybrid Electric Bicycle."

[2].Hybrid Electric Bicycle a New Transportation for Future Smart Grid by amadhan.S. Avhad, Tushar.P. Tidke, Nayan.S. Sathe: This paper presents the paper provides a strong foundation for a literature review, as it covers the design, development, and system integration of a hybrid electric bicycle with a focus on sustainable energy (solar) and future grid applications.

[3].Hybrid Powered Electric Bicycle by Mr. Prashant Kadii Mr. Shrirang Kulkarni: This paper discusses the anchored by the principles of sustainable and efficient personal mobility, drawing heavily on research into self-charging and multi-source electric bicycles. The paper "Hybrid Powered Electric Bicycle" establishes.

[4].Hybrid Bicycle by Darshil G. Kothari, Jaydip C. Patel, and Bhavik R. Panchal: This paper presents the research on electric vehicles and sustainable transport, with a strong focus on self-sustaining hybrid power systems. The paper "Hybrid Bicycle" by Panchal K. and others provides essential design parameters and technical.

[5].Hybrid Bicycle by Basil P Elias, Dino Devassykutty, John George, Akhila K: This paper presents the centred on the concept of sustainable, efficient, and self-recharging personal electric vehicles. The paper "Hybrid Bicycle" by Elias B. and colleagues provides a strong technical basis.

3. COMPONENTS

Components Used and Its Specifications.

S.No.	Components	Specification	Quantity
1	Brushless DC Hub motor	36V 250W	1
2	Pedal assets	-	1
3	Battery	36V, 7.5Ah	1
4	Battery charger	36V	1
5	Key lock with digital volt meter	-	1
6	Head light, Horn	12V	1
7	Electric throttle	-	1
8	Cut off brake	-	1Pair
9	Cables	Copper	-
10	Conventional Bicycle	-	1

3.1 BLDC Hub Motor

A gearless rear-hub BLDC motor (36V, 250W) was selected for its high efficiency, silent operation, and zero maintenance requirements. The rear-hub placement ensures better traction and weight distribution. It utilizes internal Hall-effect sensors to determine the rotor's position, allowing the controller to deliver smooth and precise power.



3.2 Battery

A high-density Lithium-ion battery pack (36V, 7.5Ah) serves as the primary energy source. It was chosen for its superior energy-to-weight ratio and low self-discharge rate. An integrated Battery Management System (BMS) is included to protect the cells from overcharging, deep discharging, and thermal runaway, ensuring a safe lifecycle.



3.3 Motor Controller

Acting as the central processing unit of the bicycle, the electronic motor controller regulates the high-current power flow from the battery to the motor using Pulse Width Modulation (PWM) and robust MOSFETs. The controller features critical safety protocols, including a Low-Voltage Disconnect (LVD) to prevent irreversible battery damage and an automatic current limit to protect the motor from overheating under heavy loads. It dynamically processes simultaneous inputs from various sensors, primarily the PAS and the manual throttle, to dictate the motor's speed and torque output efficiently.



3.4 Throttle & PAS

The throttle (Thumb or Twist type) is mounted on the handlebar and is used to manually increase the bicycle's speed. The PAS sensor is mounted near the pedal crank to detect the cadence of the rider's pedalling and activate the motor accordingly.

3.5 Break

When the rider applies the brakes, a micro-switch inside the brake lever sends a signal to the motor controller to immediately cut off the power supply to the BLDC motor. This prevents the motor from fighting against the mechanical brakes, ensuring better braking performance and protecting the motor from overheating.



4. WORKING MECHANISM

The bicycle operates in three distinct modes:

4.1 Manual Mode: The electrical system is turned off, and the bicycle is propelled entirely by the rider's pedalling effort.

4.2 Throttle Mode: The rider uses the handlebar throttle to drive the motor, functioning similarly to an electric scooter.

4.3 Pedal-Assist Mode: As the rider pedals, the PAS sensor detects the motion. The controller then supplies power to the motor to assist the rider, reducing the physical effort required. This mode optimizes battery life and extends the vehicle's range.

5. CALCULATIONS

Calculations for a hybrid bicycle 250W motor and a 36V battery

5.1 Hub Motor Calculation

- Power (P) = 250 W
- Voltage (V) = 36 V
- Power Equation: $P = V * I$
 $250 = 36 * I$
 $I = 6.94 \text{ Amps}$
- This means the motor will draw a continuous current of approximately 6.94 Amps under full load

5.2 Battery Calculation

- Assuming a 36 V and 7.5 Ah battery is used alongside your 250 W motor
- Total Energy Capacity = $36 \times 7.5 = 270 \text{ Watt-hours (Wh)}$
- Battery running time (at full continuous motor speed) = $270 \text{ Wh} / 250 \text{ W} = 1.08 \text{ Hours}$
- This means the battery will last for approximately 1.08 hours of continuous throttle usage. If pedal assist is used, this operating time can easily double.

6. ANALYSIS AND RESULT OF VEHICLE

Compared to a regular motorcycle, the running cost of a hybrid bicycle is negligible (costing only a few paise per kilometre)

- Battery Charging Cost: Approximately 3 to 5 Rupees (for one full charge).
- Mileage (Range): With a 7.5Ah battery on a full charge, a distance of about 20 to 25 km can be covered using only the throttle, and 30 to 40 km can be achieved using the pedal assist (Hybrid mode).
- Speed: For safety and legal compliance, the maximum speed of the bicycle is restricted to 25 – 30 km/hr.

7. Advantages & Disadvantages

- **Advantages** - From a Design and Development Perspective:
 1. **Standardized Components:** 250W hub motors and 36V batteries are industry standards. You will have a massive selection of off-the-shelf controllers, throttles, pedal-assist sensors (PAS), and displays that are guaranteed to be "plug-and-play" compatible.
 2. **Regulatory Compliance:** In many regions (including India and the EU), a 250W motor with a speed cap (usually 25 km/h) classifies the vehicle as a bicycle rather than a motor vehicle. This means you do not need to design around strict homologation rules, license plates, or insurance requirements.
 3. **Lightweight Form Factor:** A 36V 7.5Ah Lithium-ion battery is physically small and lightweight (usually around 1.5 to 2 kg). This keeps the overall weight of the bicycle low, making it easy to pedal even when the battery is dead.
 4. **Energy Efficiency:** A 250W motor draws relatively low current. When paired with a pedal-assist system, it provides a very smooth, natural riding experience that encourages physical exercise while eliminating the sweat factor on commutes.
- **Disadvantages** - From a Design and Development Perspective:
 1. **Weight Distribution:** Hub motors are heavy and sit entirely in the wheel. If you put the motor in the rear wheel and mount the battery on a rear rack, the bike will be very back-heavy, which can negatively affect handling and design aesthetics.
 2. **Wiring Complexity:** You must carefully design the routing for the motor cable, battery wires, and controller. Waterproofing these connections and keeping the aesthetics clean on a standard bicycle frame can be challenging.
 3. **Limited Range:** The battery capacity is Assuming a standard consumption of about 10 to 15Wh per kilometre, the real-world range will only be about 18 to 27 kilometres on full throttle, or maybe up to 40 kilometres on low pedal assist.
 4. **Low Torque for Hills:** A 250W hub motor generally produces between

30Nm and 45Nm of torque. While great for flat city roads, it will struggle significantly on steep inclines or if the rider is carrying heavy cargo.

7. CONCLUSION

A hybrid bicycle is a highly convenient, eco-friendly, and cost-effective alternative for daily commuting. In urban areas with heavy traffic congestion, utilizing an electric bicycle is far more beneficial than burning fossil fuels.

Because this bicycle includes a 'pedal assist' option, the rider gets the benefit of physical exercise without extreme fatigue. To curb increasing pollution and achieve excellent travel range without compromising on health, the 'Hybrid Bicycle' will play a very important role in the future of personal transportation.

8. REFERENCES

- [1]. Design Of Novel Hybrid Electrical Bicycle in 2015 A Review by Youssef Makari, Peter Tawadros
- [2]. Hybrid Electric Bicycle a New Transportation for Future Smart Grid in 2017 by amadhan.S. Avhad, Tushar.P. Tidke, Nayan.S. Sathe
- [3]. Hybrid Powered Electric Bicycle in 2016 by Mr. Prashant Kadi1 Mr. Shrirang Kulkarni
- [4]. Hybrid Bicycle in 2014 by Darshil G. Kothari, Jaydip C. Patel, Bhavik R. Panchal
- [5]. Hybrid Bicycle in 2017 by Basil P Elias, Dino Devassykutty, John George, Akhila K