

# Restoration and Enhancement of an Electric Bicycle with Overcharging Protection System

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**Abstract**—This paper presents the rebuilding and improvement of a already created electric bike that had ended up non- functional due to drawn out inertia and component corruption. The essential objective was to reestablish the bicycle’s usefulness by testing each component, recognizing issues, and supplanting or overhauling imperfect parts. Key components such as the PMDC engine, lead-acid battery, controller, throttle, electric brakes, and Arduino Uno were assessed and coordinates into a total framework. Also, a dynamo was joined to present a fundamental regenerative charging highlight, contributing to made strides vitality effectiveness. The electrical framework was rewired and reconfigured to guarantee smooth control stream, speed control, and security amid operation. The fruitful testing and integration of all components come about in a completely operational electric bike, illustrating both natural and financial benefits. This venture not as it were restores a student-built model but moreover advances the utilize of economical transportation through down to earth advancement.

**Index Terms**—electric bike, restoration, dynamo, battery charging, sustainable transport

## I. INTRODUCTION

Electric bikes have progressively risen as a practical and maintainable elective to customary modes of transportation, especially in urban settings tormented by blockage and contamination. An electric bike coordinating a conventional bike outline with an electric engine and rechargeable battery, advertising motor-assisted pedaling that diminishes physical strain on the rider. This combination not as it were encourages smoother and speedier travel but too essentially brings down the natural impression when compared to fuel-powered vehicles. In later a long time, electric bikes have picked up footing due to rising fuel costs, expanded urbanization, and developing mindfulness approximately climate alter. As they radiate no tailpipe poisons and require negligible vitality for operation, electric bikes show an naturally dependable arrangement for brief- to medium-

distance commuting.

Within the scholarly year 2018–19, a gather of final-year understudies from the Office of Electrical Building created an electric bike as portion of their capstone venture. In any case, due to drawn out dormancy, the bike inevitably got to be non-functional. A few components, counting the battery, controller, and mechanical drive frameworks, have since de- graded or fizzled. This term paper centers on reestablishing the usefulness of the bike and updating its center components to make strides execution, unwavering quality, and security. The consider points to reestablish the utility of the prior show whereas modernizing it to adjust with current benchmarks in electric portability.

The inspiration for this work stems from the got to empower the utilize of clean, effective, and reasonable modes of transport, particularly within the setting of scholastic and urban situations. The rebuilding and improvement of an existing electric bike not as it were underpins supportability but too represents a clever approach by building upon already executed ventures. Besides, it gives current understudies with an opportunity to lock in in viable, hands-on learning and frameworks building. The venture, be that as it may, presents a few challenges. Documentation from the first construct is restricted, requiring the creators to analyze and translate the framework design from scratch. Compatibility between modern and existing components must be carefully overseen to preserve framework astuteness. It is expected that the outline and essential mechanical structure stay intaglio and can back the upgraded plan without critical adjustments. This paper is structured as follows:

The starting areas depict the foundation and inspiration for the ponder, taken after by the recognizable proof and investigation of existing deficiencies within the framework. Consequent segments expand on the update strategy, component choice, and execution prepare. Execution assessments and comparisons between the first and

restored models are displayed, together with the watched changes. At last, the think about concludes with a rundown of discoveries and proposals for future improvement. Through this inquire about, the creators look for to advance the appropriation of electric bikes and highlight the significance of reestablishing existing frameworks as a cost-effective and naturally neighborly designing hone.

## II. LITERATURE REVIEW

In order to improve performance and sustainability, power- assisted electric bicycles, or pedelecks, have recently added sophisticated mechanical transmission systems and centrally positioned motors. One such advancement is a low-cost torque measurement system that, with the use of a specially designed testing setup, allows for accurate performance analysis under actual riding situations. When compared to traditional e- bikes, these developments have demonstrated increased energy efficiency, tracking precision, and overall performance.

The classification of electric bicycles according to their motor position (front, rear, or mid-drive), drive type (pedal- assist or power-on-demand), and system layout (parallel or series) has also been the

TABLE I  
COMPONENT SPECIFICATIONS

Sr. No.	Component	Quantity	Specifications
1	PMDC Motor	1	250 W, 24 V, 10 A, 11.4 Nm
2	Lead-Acid Battery	2	12 V, 7 Ah (connected in series)
3	Throttle	1	Twist grip, 3-wire
4	Motor Controller	1	24 V compatible, throttle input
5	Bicycle Frame	1	Standard frame
6	Gear and Chain Set	1	Single-speed, motor-compatible
7	Electric Lock	1	Key-operated, 12 V
8	Electric Brakes	2	With motor cut-off switch
9	Dynamo	1	6 V AC output
10	Arduino Uno	1	ATmega328P, 5 V logic level

Explanation of Block Diagram:

1. AC Power Supply: This is the main external source used to charge the battery when the bike is plugged in.
2. Charger (Rectifier): Converts the incoming AC power to DC, which is what the battery needs for charging.
3. Battery: Stores the DC power and supplies it to both the motor and the controller when the bike is in use.
4. Throttle: Acts as the rider’s control over the

subject of much research. Permanent Magnet Synchronous Motors (PMSMs) are a notable option due to their high torque density and efficiency. In order to improve e-bike performance and optimize power consumption, the assessment also covers developments in battery technology, motor control methods, and energy management systems.

Another significant Norwegian study looked into how using an e-bike affected commuters’ daily routines. Researchers saw a notable increase in cycling frequency and distance, especially among women, after giving e-bikes to a test group and comparing their trip data with a control group. According to the findings, e-bikes can serve as a viable substitute for quick automobile trips, encourage regular riding, and be an essential component of sustainable urban mobility. Additionally, high-efficiency charging options, such as the interleaved boost converter bridgeless PFC rectifier, show how charging infrastructure can support objectives for improving energy efficiency and lowering system losses in improved electric bike systems.

## III. PROPOSED SYSTEM

5. bike’s speed by sending signals to the controller.
5. Controller: Takes input from the throttle and manages how much power is sent to the motor.
6. Motor: Converts the electrical energy from the battery into mechanical force to move the bike.
7. Wheel: Receives the rotational force from the motor, propelling the bicycle forward.
8. Dynamo: Generates electricity when the wheel spins, helping to partially recharge the battery during motion.

9. Charging Circuit: Regulates the power from the dynamo and safely routes it back into the battery.

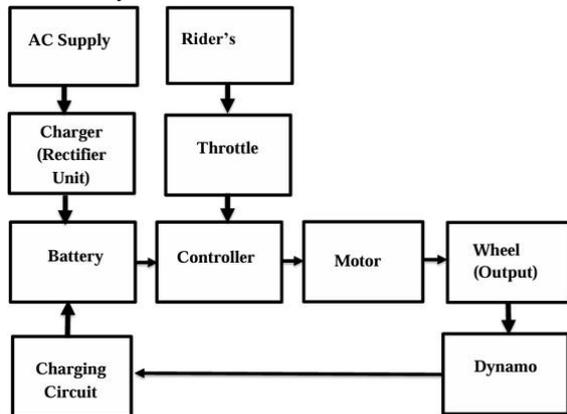
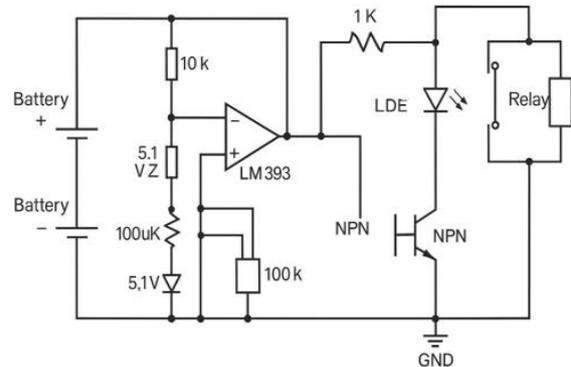


Fig. 1. Block Diagram of Electric Bicycle

Explanation of Circuit Diagram:

1. Voltage Divider Setup: A pair of 10k resistors is connected across the battery terminals to scale the voltage from its full range (12–14V) down to a safer level (around 6–7V), suitable for feeding into the comparator's input.
2. Reference Voltage: A stable reference voltage is provided to the inverting (–) terminal of the comparator. This can be set using either a 5.1V Zener diode or a voltage divider circuit with a fine-tunable potentiometer.
3. Comparator Configuration: The reduced battery voltage (from the voltage divider) is fed into the non-inverting (+) terminal of the comparator. The output from the comparator is then connected to the base of a transistor through a 1k resistor.
4. Transistor and Relay Connection: The transistor acts as a switch to drive the relay. The relay coil is powered through the transistor's collector, and a flyback diode is placed across the coil to protect the circuit from voltage spikes.
5. Charging Control: The relay's normally open (NO) contact is used to control the output of the charger. When the battery voltage rises above a set limit (typically around 14.2V), the comparator output goes low, turning off the transistor and cutting power to the relay—effectively stopping the charging process.
6. Tuning: The exact cutoff voltage (trip point) is adjusted using the potentiometer. A multimeter is used to monitor the battery voltage during this tuning process to ensure precise cutoff control.



Automatic trip circuit für 12V lead-acid battery

Fig. 2. Circuit Diagram of Overcharging Protection

#### IV. METHODOLOGY

The development of the electric bicycle was carried out in two major phases to achieve the objectives of the project.

**Step 1: Component Testing** Each key component—motor, battery, controller, throttle, dynamo, and braking system—was individually tested to ensure proper functionality. This step was crucial to confirm that all parts were operational and suitable for integration into the system.

**Step 2: System Integration and Replacement** Any components found to be faulty or underperforming were either redesigned or replaced. Once verified, the electrical system was assembled by correctly wiring the battery, motor, controller, and throttle to enable smooth speed control and reliable operation. A dynamo was also incorporated to aid in partial battery recharging during movement, thereby improving overall energy efficiency.

**Step 3: Pre-Repair Testing** A thorough visual inspection was carried out to identify any physical or electrical issues. The bicycle frame was examined for structural damage, the battery was checked for swelling or leakage, and all wiring was inspected for fraying or loose connections. Additionally, components such as tires, brakes, and the chain were reviewed for wear and proper alignment.

**Step 4: Functional Testing** The e-bike was powered on to observe startup behavior. Battery voltage and capacity were measured to assess health. The motor's performance was tested for smooth and stable operation, while the throttle, pedal-assist system, and brakes were checked for responsiveness, control, and safety.

**Step 5: Repair and Upgrade Implementation** Based on testing results, faulty components were repaired or replaced. The battery was upgraded to increase the travel range, and the motor was either

repaired or enhanced for improved performance. Wiring and the controller were also checked, and necessary updates were made to ensure stable and efficient operation.

## V. IMPLEMENTATION

**Battery Testing and Analysis:** The original 12V lead-acid battery was tested using a voltmeter. The reading showed only 0.56V, far below the expected value, indicating that the battery was completely discharged or damaged and required replacement.

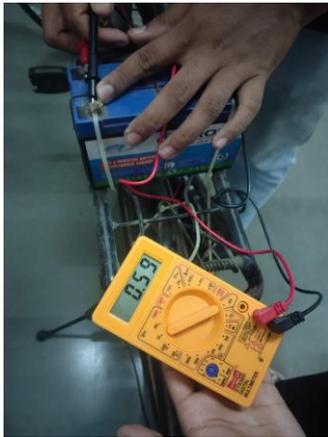


Fig. 3. Circuit Diagram of Overcharging Protection

**Motor Testing and Verification:** The 250W, 24V, 10A motor with a torque rating of 11.4 Nm was tested using an external DC power supply. It ran smoothly without any noise or vibration, confirming that the motor was in good condition. **Throttle and Circuit Testing:** The throttle was tested and confirmed to provide accurate and smooth speed control. However, the trip circuit and charging circuit showed no response during testing, indicating internal faults that needed to be addressed.

**Design and Testing of Circuits:** New versions of both the trip circuit and charging circuit were designed, implemented, and successfully tested. The trip circuit now effectively disconnects the charger once the battery reaches its full voltage, ensuring safe charging. The charging circuit, powered by a dynamo and stabilized using a 7812 voltage regulator, was also tested successfully and provided a consistent output for battery recharging during motion.

## VI. RESULTS

Testing Components Findings:

- The battery displayed 0.59V rather than the

anticipated 12V, necessitating replacement. • During testing, the controller, throttle, and motor all worked. • The charging and trip circuits passed testing and operated as planned.

System Integration:

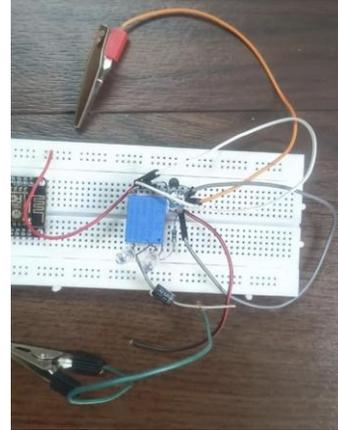


Fig. 4. Circuit of Overcharging Protection

- Every part was effectively attached to the bicycle frame.
- The throttle-controlled motor drive operates smoothly. • Dynamo-assisted charging worked while moving.

Final Outcome:

- The improved electric bicycle is completely functional and exhibits improved sustainability, safety, and efficiency in comparison to the original.



Fig. 5. Electric Bicycle

## VII. CONCLUSION

The project's goal of repairing and improving an electric bicycle that had not been working before was accomplished. Functional portions like the motor, throttle, and controller were kept and reintegrated, while defective parts like the battery

were found and replaced through methodical testing. Further- more, specially created trip and charging circuits were successfully installed and tested, improving the system’s overall functionality and security. A simple regenerative feature was added by including a dynamo-powered charging circuit, which increased operational energy efficiency. With its smooth speed control, safety features, and partly self-charging capability, the updated e-bike is now dependable. This work highlights the importance of maintaining and improving current systems for useful and environmentally friendly mobility in addition to showcasing the possibilities of sustainable transportation alternatives.

### VIII. REFERENCES

- [1] Fietsberaad, *Cycling facts: Use of electric bicycles in the Netherlands*, 2013. [Online]. Available: <https://www.fietsberaad.nl/>
- [2] OECD/ITF, *Cycling, Health and Safety*, International Transport Forum, 2013. [Online]. Available: <https://www.itf-oecd.org/cycling-health-and-safety>
- [3] J. Dill and G. Rose, "Electric bikes and transportation policy: Insights from early adopters," *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2314, no. 1, pp. 1–6, 2012, doi: 10.3141/2314-01.
- [4] J. Dave, "Energy efficiency comparison of e-bikes and other modes of transport," *Clean Technica*, 2010. [Online]. Available: <https://cleantechnica.com/>
- [5] D. P. Kothari and I. J. Nagrath, *Electric Machines*, 4th ed. New Delhi, India: Tata McGraw-Hill, 2011.
- [6] B. L. Theraja and A. K. Theraja, *A Textbook of Electrical Technology, Vol. 2: AC and DC Machines*, New Delhi, India: S. Chand, 2005.
- [7] Texas Instruments, *Understanding and Designing Battery Charging Circuits*, Application Note, 2015. [Online]. Available: <https://www.ti.com/>
- [8] Texas Instruments, *LM393 Low Power Dual Comparator*, Datasheet, 2022. [Online]. Available: <https://www.ti.com/lit/ds/symlink/lm393.pdf>
- [9] STMicroelectronics, *7812 Voltage Regulator Datasheet*, [Online]. Available: <https://www.st.com/resource/en/datasheet/17812cv.pdf>
- [10] C. Abagnale, M. Cardone, P. Iodice, R. Marialto, S. Strano, M. Terzo, and G. Vorraro, "Design and development of an innovative e-bike," *Energy Procedia*, vol. 101, pp. 774–781, 2016, doi: 10.1016/j.egypro.2016.11.098.
- [11] N. B. Hung and O. Lim, "A review of his- tory, development, design and research of electric bicycles," *Applied Energy*, vol. 260, p. 114323, 2020, doi: 10.1016/j.apenergy.2019.114323.
- [12] E. Salmeron-Manzano and F. Manzano-Agugliaro, "The electric bicycle: Worldwide research trends," *Energies*, vol. 11, no. 7, p. 1894, 2018, doi: 10.3390/en11071894.
- [13] A. Trivin˜o-Cabrera, J. M. Gonz´alez-Gonz´alez, and J. A. Aguado, "Design and implementation of a cost-effective wire- less charger for an electric bicycle," *IEEE Access*, vol. 9, pp. 85277–85288, 2021, doi: 10.1109/ACCESS.2021.3088127.
- [14] A. Muetze and Y. C. Tan, "Electric bicycles— A performance evaluation," *IEEE Industry Applications Mag- azine*, vol. 13, no. 4, pp. 12–21, Jul.–Aug. 2007, doi: 10.1109/MIA.2007.4283984.