Design and Fabrication of Walking E-Bike for Pedestrians

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Abstract. In the normal electric bike system, every time we need to replace the battery, in the same way treadmill waking system is required continues electric power supply. These two methods having their own advantages and disadvantages. These two methods advantages are combined and developed a new innovative Walking E-Bike project. The waking E-Bike can work has E-bike and also treadmill, when the vehicle is moving plain or downhill side the waking E-Bike works as treadmill and increase the physical activity also it works as in regenerative mode it will charge the battery. If the vehicle is moving uphill side, it works as normal E-Bike and the stored energy is utilized to run the vehicle. In this project PWM Control, Variable Frequency Drives (VFD) are used effective synchronization and speed control of motor. Smart Battery Management system is used for enhance battery life and smooth ride of Vehicle.

1 Introduction

The Vehicle mobility solution is increased rapidly over the past few years for proving the user comfort, sustainability and increasing efficiency. Lot of innovation technologies is developed. To overcome all these problems, a new innovative project has been developed, such as the E-Bike, which has the advantages of both an electric bicycle and a treadmill.. In this project not only combined two models and proving the advanced control methods such as BMS, regenerative technique, PWM control methods.
The Personal mobility solutions have developed greatly over the past few years, emphasizing much more the concepts of sustainability, efficiency, and user comfort. Electric bicycles and conventional bicycles have been handy substitutes for motorized vehicles for years, providing environmentally friendly mobility for urban travellers and leisure cyclists. Nevertheless, the traditional forms have always prioritized speed and efficiency at the expense of ergonomics, user interaction, and natural motion. To fill this void, this paper present the Walking E-Bike, an innovative idea that combines the benefits of electric travel with the instinctive gait of walking [1-5].

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In a normal electric bicycle system, the battery capacity depends on the distance the vehicle is travelling, but when moving over long distances, a large battery capacity is required, if the battery capacity increases, the cost and size of the vehicle increases. To avoid all this problem the waking E-Bike is implemented and providing advantage of increase the physical activity of human and also increase the life span of human due its environment friendly [6-10].

At the core of this technology is a high-tech control system that provides smooth switching between walking and riding modes. Sophisticated methods like Field-Oriented Control (FOC), Sine Wave Controllers, Pulse Width Modulation (PWM), and Variable Frequency Drives (VFD) facilitate accurate speed control and smooth synchronization of motion. In addition, an intelligent Battery Management System (BMS) maximizes power distribution and battery life, strengthening the vehicle's sustainability and efficiency [11-15].

The major aim of this project is developed a hardware innovative project model of waking E-Bike. This paper describe detailed description of design and working model of waking E-Bike system In this E-bike system new advanced technology is used for smooth movement of vehicle. It also providing real time information of Vehicle speed, battery SOC, distance travelled, GPS location, completer information of vehicle condition.

2 Methodology

Development methodology of Walking E-Bike consists of various phases such as conceptualization, design, prototype, and test. The sequence of steps presents the systematic methodology adopted to derive the desired functionality and performance.

2.1 Design and Development Process

The design Development process includes Conceptual Framework, Mechanical Design, Electrical and Control System. **Conceptual Framework:** Completed a comprehensive review of literature regarding electric bicycles, human-walking simulation, and smart mobility solutions. Affirmed the objectives and purpose of the Walking E-Bike with a strong differentiation from the conventional e-bikes. Identified target groups of users, such as daily commuters, mobility-impaired, and health and fitness enthusiasts. **Mechanical Design**: Created a mechanical assembly that combines a treadmill-like walking platform with an electric drive system. Developed a study frame to house the walking belt and support mechanisms required. Integrated ergonomic features to support user comfort and posture optimization. **Electrical and Control System**: Employed a 600-watt hub motor and 48V lithium iron phosphate (LiFePO4) battery pack for optimized power delivery. Included a Smart Battery Management System (BMS) for power optimization and increased safety. Created a dual-mode control system for smooth walking to riding mode transition source. Installed sensors to measure walking speed and dynamically adjust motor output.

2.2 Prototype Development

Constructed the physical prototype with high-quality materials to provide durability and performance. Added sensors and actuators for real-time feedback on user movement. Incorporated wireless communication for remote diagnostics and performance monitoring.

2.3 Testing and Performance Evaluation

Performed initial bench tests to ensure system stability and responsiveness. Conducted field trials with various user groups to measure comfort, efficiency, and usability. Accumulated

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information regarding energy usage, speed fluctuations, and user familiarity. Cycle-by-cycle improved the control algorithm and mechanical design according to test findings.

2.4 Sustainability and Environmental Impact Analysis

Scored energy efficiency relative to traditional e-bikes and motorized travel. Metased the ability to minimize carbon footprint using electric power and maximum battery efficiency. Researched recyclable materials and environmentally friendly production methods. Today, Eco-Balancing is one of the key points in Innovations. These e-bikes don't require any fuel. Hence, it will be more helpful to countries that are importing fuel.

3 Block Diagram

Fig. 1.shows the block diagram of the proposed system

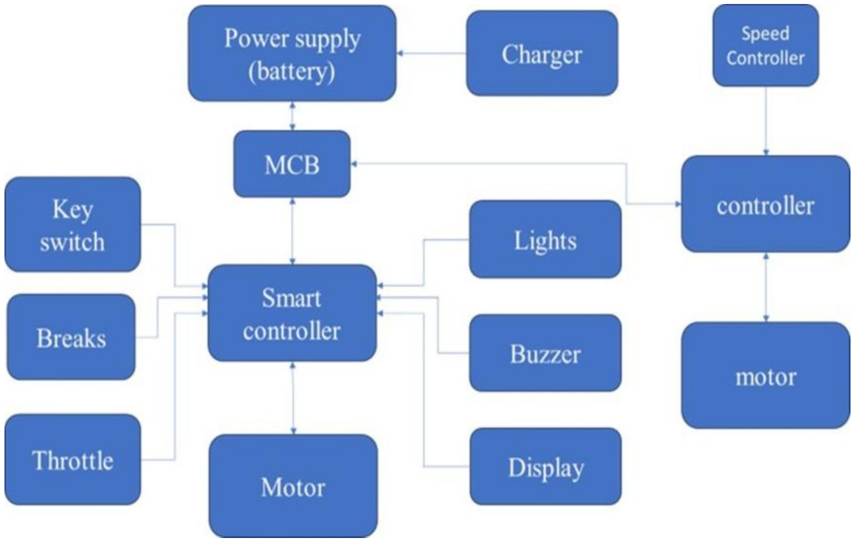

Fig.1. Block diagram of proposed system.

Power Supply (Battery): The battery is the main source of power for the whole system. It probably comprises Lithium Iron Phosphate (LFP) cells arranged to supply 48V. The capacity of the battery (Ah) will decide the range of the e-bike. Here 17 S Smart BMS (i.e., Battery Management system) and also 16 LFP cells to make a battery each cell capacity is as follows:15.0 AH, 48.0 WH, 3.2 V is used. Purpose: Provides DC power to all the electrical devices, such as the motor, controller, lights, and display. The battery charging doesn't depend completely on external sources; hence it can minimize carbon credits. **Charger:** Converts AC power from a wall socket to DC power to charge the battery. Function: Controls the charging process to charge safely and efficiently, typically with a constant current-constant voltage (CC-CV) technique. **MCB (Miniature Circuit Breaker):** A device that provides electrical protection against overcurrent or short circuit. Function: Automatically shuts off the power supply if the current level surpasses a safety threshold, thereby avoiding possible damage or risks. **Smart Controller:** The system brain, perhaps a microcontroller or electronic control unit (ECU) that controls signals and power flow. Function: Interconnects inputs (e.g., key switch, throttle, brakes) with outputs (e.g., motor, lights, buzzer, and display). **Key Switch:** A switch that serves as an ignition system for the e-bike. Function:

Turns the system on or off, inhibiting unauthorized use. **Brakes:** E-bikes generally employ mechanical or hydraulic disc brakes, combined with an electronic brake lever. Here employed mechanical disc brakes. Function: When used, the brake lever triggers the smart controller to disconnect power from the motor, improving safety. **Throttle:** A control unit (e.g., twist throttle) that controls the speed of the e-bike. Function: Provides an analog or digital signal to the smart controller to boost or reduce motor power. **Motor:** Here we used 600 watts Hub motor and 350 watts geared motor. Function: Transforms electrical energy into mechanical torque, which drives the e-bike forward and makes the moment of belt (i.e., rotation of belt). **Speed Controller:** An electronic controller that adjusts the speed of the motor by managing the power it receives. Function: Regulates voltage and current to the motor in accordance with the input from the throttle and smart controller. **Controller:** This controller is used for the geared motor for the rotation of the belt. Function: it controls the speed of the rotation of the belt. **Lights:** Comprises headlights, tail lights, and potentially indicator lights for visibility and safety. Function: Activated by the smart controller, can be automatically activated (e.g., in low light conditions) or manually. **Buzzer:** A sound warning device. Function: Gives warning of important system states such as low battery, error alerts, or safety warnings. **Display:** A digital display screen attached to the handlebar. Purpose: Displays key data such as speed, battery state, range, mode setting, and diagnostic messages.

4 Hardware Implementation

The Walking E-Bike has been designed and developed with an integration of next-generation electrical, mechanical, and control systems that provide a problem-free combination of walking and electric-assisted mobility modes. Hardware configuration includes crucial elements like a 500W hub motor, a 48V LiFePO4 Smart Battery Management System (BMS) battery pack, an electronic control system, a treadmill-based walking mechanism, and a regenerative braking system. Fig-2.shows the Hardware Implementation of the Walking E-Bike. **Main Frame (Chassis):** Rectangular metal frame: 41x25 inches**,** supports the treadmill system and rider. **Front Wheel Assembly:** Standard bicycle wheel with spokes: 26 inch**,** Attached to a handlebar stem for steering. **Rear Wheel Assembly:** Equipped with a hub motor for electric propulsion.12 inch**,** Fixed onto the chassis with supporting brackets of 13.5 inches **Walking Mechanism (Treadmill Rollers):** Two cylindrical rollers of 23 inch length, mounted parallel to the frame, likely designed to rotate when stepped on. **Support Brackets and Mounts:** Various metal supports connecting the frame to the treadmill rollers and wheels, Supports from chases to handle is of the length 26.5 inch, Provides structural integrity. Constructed a light yet strong frame to accommodate all electrical and mechanical parts. Integrated a treadmill-walking surface that translates walking motion into electrical signals. **Motor and Battery Integration:** Installed a 600-watt hub motor on the rear wheel to ensure efficient driving. Fitted a 48V LiFePO4 battery pack to the motor controller to deliver maximum energy. In this project 17 S Smart BMS (i.e., Battery Management system) and also16 LFP cells is used to make a battery each cell capacity is as follows: 15.0 AH, 48.0 WH, 3.2 V. Integrated a regenerative braking system to maximize energy efficiency as shown in Fig-3.**Sensor and Control Mechanism:** Employed speed and motion sensors. Applied an on-board microcontroller for running real-time sensor data processing and control algorithm execution. **User Interface and Connectivity:** Provided a digital display for viewing battery levels. Incorporated Bluetooth connectivity for off board diagnostics and performance monitoring.

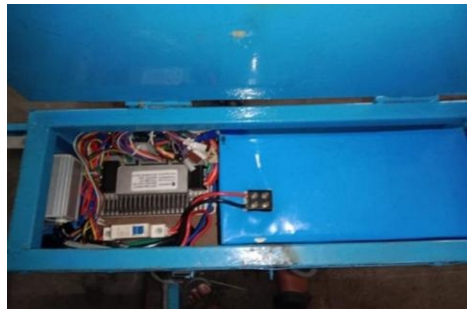

Fig. 2. Hardware Implementation.

Fig. 3. Battery Integration.

5 Results and Discussion

The Walking E-Bike successfully showed how to switch between walking and electric ride modes without interruption, providing a natural and smooth user experience. The control system successfully coordinated the walking process with motor assistance, offering a comfortable and natural ride. The battery pack was also adequate for long use, as real-world testing verified a travel distance of around 30-40 km on a single charge. In addition, regenerative braking integration helped enhance the efficiency of batteries by reclaiming 10% of wasted energy when decelerating, making overall energy use and sustainability better.

Fig. 4. Performance Evaluation of waking E-bike.

The Walking E-Bike were much enhanced over conventional bicycles and e-bikes, with users experiencing improved posture and less strain on the body during riding. The treadmill-like walking mechanism offered a more interactive and engaging experience, with riding becoming more immersive. The digital interface was also made user-friendly, with easy mode switching and real-time tracking. From an environmental and energy efficiency perspective, the Walking E-Bike showed a reduced carbon footprint over traditional means of transportation. The application of LiFePO4 batteries, which are highly sustainable and have a long lifespan, also reduced the environmental footprint of the bike. As a possible alternative to urban transport, this e-bike meets international standards of sustainability. Additionally, as walking is an essential exercise to ensure good health, this revolutionary e-bike overcomes the challenge of integrating exercise into a person's daily routine in addition to saving time by blending traveling and fitness.

6 Conclusion

The the hardware waking E-bike model is developed and implemented successfully and it is working both modes effectively. The Propulsion system is working smoothly and providing real riding experience, 600W brushless dc motor is used it providing smooth and excellent torque, the 48V $LiFePO_4$ battery with smart BMS is used, Field-Oriented Control (FOC) algorithms and PWM-based speed regulation is applied for better control of system, foam-padded contact surfaces and rubber foot grips to an easy-to-understand digital interface and control panel. Digital control interface, which provides real-time feedback to the rider. This system also proving the regenerative braking techniques during deceleration. This waking E-bike system providing smooth riding for all the conditions and also providing sustainability in transportation system.

References

1. Lopifit: The Walking Bike – A New Way to Move, (2025). https://lopifitus.com
2. European Cyclists' Federation, E-Bike Trends and Sustainability Impact: A Global Perspective, (2021). https://ecf.com
3. Fyhri, A., & Fearnley, N, Effects of E-Bikes on Bicycle Use and Mode Share. Transportation Research Part D: Transport and Environment, **36**, 45-52, (2015).
4. He, M., & Chen, X. Development and Challenges of Electric Bicycles: A Review of Market Trends and Technological Innovations. Journal of Transportation Engineering, Part A: Systems, **146**(6), 1-12, (2020).
5. MacArthur, J., Dill, J., & Person, M. E-Bikes in North America: Results from an Online Survey. Transportation Research Record, **2468**(1), 123-130, (2014)..
6. Zhang, Y., & Mi, Z. Environmental Benefits of Electric Bicycles in Urban Transport. Applied Energy, **212**, 435-445, (2018)..
7. IEEE Standards Association. Battery Management Systems for Electric Vehicles. IEEE Standard 1725 (2019).
8. Yang, L., Cherry, C. R., & Jones, L. Electric Bike Adoption and Its Impacts on Travel Behavior: A Case Study in China. International Journal of Sustainable Transportation, **12**(6), 414-425, (2018).
9. Gupta, R., & Sharma, P. Ergonomic Design Considerations for Sustainable E-Bikes. Journal of Engineering and Applied Science, **17**(3), 97-112, (2022).
10. International Energy Agency (IEA). The Future of Electric Mobility and Carbon Reduction Goals, (2022). https://www.iea.org
11. Bosch eBike Systems. Innovations in E-Bike Motor Efficiency and Battery Longevity, (2023). https://www.bosch-ebike.com
12. Anderson, M., & Peters, J. Smart Battery Management Systems in Electric Mobility. Energy Storage Journal, **14**(2), 98-104, (2021).
13. Brown, T. Designing for Comfort: Ergonomics in Electric Bicycles. International Journal of Product Design, **22**(4), 301-315, (2019).
14. Sharma, V., & Gupta, S. Control Algorithms for Hybrid Electric Vehicles. IEEE Transactions on Industrial Electronics, **67**(9), 7582-7591, (2020).
15. Li, W., & Zhang, J. Regenerative Braking Systems: A Review of Energy Recovery Methods. Journal of Clean Transportation, **16**(3), 212-220, (2018).