DESIGN AND DEVELOPMENT OF A PORTABLE ELECTRIC SCOOTER

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Introduction:

With the rising demand for eco-friendly and efficient personal transportation solutions, portable and electric vehicles have gained significant popularity. This project aims to design and develop a compact, lightweight, and energy-efficient electric scooter that is both cost-effective and easy to use. The scooter will be driven by a 350W, 24V BLDC motor, controlled using a programmable controller. The controller utilizes an Arduino Uno, MOSFETs, and IR2110 drivers to generate PWM signals for speed regulation. The project integrates principles of motor control, power electronics, and create a reliable and practical transportation solution.

Objectives:

- To integrate a responsive BLDC motor control system using PWM signals, providing smooth acceleration and speed control for rider safety and comfort.
- To incorporate a battery system that maximizes performance while ensuring quick recharge times for practical daily use.
- To include a compact onboard display that shows key metrics such as speed, battery level, and distance travelled, enhancing user awareness and management of the scooter’s operation.
- To finally create a lightweight, portable electric scooter that serves as a sustainable and efficient solution for urban mobility.

Methodology:

The development of the portable electric scooter involved systematic steps, including component selection, integration of the pre-built motor controller, hardware assembly, and testing. The revised methodology is as follows:

1. **Component Selection:**

The components were selected for efficiency, power management, and compatibility. A 24V, 350W sensored BLDC motor ensures smooth and responsive operation. It's controlled by a 15V–36V, 15A (500W) brushless motor controller with Hall sensor support for optimized performance. Power is supplied by a 36V, 10Ah lithium-ion battery, offering ample range. Speed is regulated via a 10K potentiometer or throttle grip. The frame, made of steel and aluminium, holds the rear hub motor mounted using a swingarm for stability and direct power transfer.

2. **Motor Controller Integration:**

The motor controller was connected to the BLDC motor, battery, and throttle control, forming the core of the drive system. Hall sensor connections were properly wired to ensure accurate phase commutation and smooth motor operation. The controller's input voltage range of 15V–36V was well-matched with the 36V lithium-ion battery used, ensuring stable and reliable performance.

3. **Hardware Assembly:**

The battery, motor, and controller were securely mounted onto the scooter frame to ensure structural integrity during operation. Proper wiring was carried out between the motor, controller, and throttle to enable smooth and responsive acceleration. Heat management was also considered, with the motor controller's heat dissipation evaluated and adequate ventilation provided to prevent thermal buildup and ensure reliable performance.

4. **Testing & Troubleshooting:**

The system was powered on, and initial motor response tests were conducted to verify functionality. Speed variation was tested using the potentiometer/throttle to evaluate the controller's responsiveness. Load testing was carried out under different weight conditions to assess power output and overall efficiency. Any issues, such as voltage fluctuations or irregular motor behaviour, were diagnosed and resolved to ensure stable operation.

5. **Performance Evaluation:**

Motor speed and torque characteristics were analysed to evaluate overall system efficiency. Battery performance was tested to estimate the ride duration achievable per full charge. Additionally, the controller's response time and motor behaviour were assessed under real-world conditions to ensure reliable and consistent performance during actual use.

Result and Conclusion:

The developed electric scooter prototype successfully demonstrated smooth and efficient performance under real-world conditions. The motor operated reliably with accurate speed control. Smooth acceleration, stable deceleration, and effective power delivery were consistently observed. Initial issues such as Hall sensor wiring errors and throttle calibration were identified and resolved through iterative testing and optimization. Overall, the project proved the feasibility of building a compact, cost-effective, and portable electric scooter, reinforcing its potential as a sustainable solution for urban mobility.

Project Outcome & Industry Relevance:

This project highlights the complete development of a functional electric scooter, focusing on efficient motor control, reliable power management, and practical mechanical design. By addressing real-world challenges in system integration, the project offers valuable insights into building robust personal transportation vehicles. The outcomes are particularly relevant for industries working on electric scooters, e-bikes, and other light electric mobility platforms. Lessons learned from battery sizing, controller integration, and drivetrain optimization can support future developments in the fast-growing e-mobility sector, especially for urban and last-mile transportation solutions.

Working Model vs. Simulation/Study:

The project involved both the development of a physical working model and detailed simulation studies. A fully functional electric scooter was built using real components like a BLDC motor, lithium-ion battery, throttle system, and custom frame. Alongside this, SolidWorks was used to model design prototypes, and static stability and CFD analysis were performed to evaluate structural integrity and aerodynamic behaviour before fabrication. This combination ensured a well-informed, tested, and validated final design.

Project Outcomes and Learnings:

- Successful integration and testing of a commercial BLDC motor controller.
- Understanding of BLDC motor control, Hall sensor feedback, and throttle response.
- Overcoming real-world challenges such as incorrect wiring, response delays, and controller calibration.
- Hands-on experience in power management, battery integration, and system optimization.
- Insights into motor efficiency, load performance, and power consumption for extended usage.

Future Scope:

1. Integration of regenerative braking to improve energy efficiency and extend battery life.
2. Implementing an IoT-based system to monitor scooter performance in real-time via a mobile app.
3. Enhancing motor control algorithms for improved acceleration curves and better torque management.
4. Exploring the use of lightweight materials for the scooter frame to reduce weight and improve portability.
5. Investigating alternative battery technologies (e.g., LiFePO4) for longer lifespan and safety.
6. Developing a modular controller interface to allow future upgrades or compatibility with multiple motor configurations.
7. Potential commercialization by refining the design into a consumer-ready product for urban commuting.