[1] Joselin Retna Kumar G

[2]Harish kumar J

[3] Vikraman N

[4] Mukesh R

Design and Development of Roadside Wheeler

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Abstract: - This project presents the design, development, and testing of a self-balancing hoverboard optimized for short-distance urban travel. The hoverboard features a lightweight, durable alloy frame capable of supporting various rider weights while remaining portable. A gyroscope-based balancing system with integrated sensors ensures stability during motion, enhancing the user experience. The propulsion system is powered by a Brushless DC (BLDC) motor, providing smooth and precise speed control. A custom Battery Management System (BMS) manages energy efficiently, extending the battery life with power-saving modes during idle periods. The hoverboard is equipped with a rechargeable Lithium-ion battery, offering a balance between weight and performance for daily commuting. Safety and security are prioritized through an RFID lock and GPS tracking, allowing users to monitor the device via a mobile app. Extensive testing validated the hoverboard's stability across diverse surfaces and rider weights, as well as its energy efficiency and suitability for urban transportation. This work demonstrates the potential of affordable, user-friendly, and energy- efficient self-balancing vehicles as practical solutions for urban mobility.

Keywords: Self-balancing hoverboard, urban transportation, gyroscopic balancing system, Brushless DC motor, Battery Management System, Lithium-ion battery, energy-efficient mobility, RFID lock, GPS tracking, electric vehicle design.

I. Introduction

The rapid urbanization of cities and the increasing number of internal combustion engine (ICE) vehicles have led to significant environmental concerns, particularly related to air pollution and traffic congestion. These issues have sparked interest in cleaner and more efficient transportation alternatives, especially for short-distance travel. Personal electric vehicles (PEVs), like hoverboards, have emerged as promising solutions due to their compact size, zero emissions, and ease of use. However, many existing self-balancing hoverboards face challenges related to high costs and complex components, which limit their accessibility for everyday users. This project addresses these challenges by developing a self-balancing hoverboard that emphasizes affordability, user friendly controls, and energy efficiency. The hoverboard integrates a gyroscopic stabilization system that ensures smooth and intuitive balance for the rider, allowing the device to adjust to shifts in weight and maintain stability automatically. This feature makes the hoverboard suitable for urban commuters who need a practical solution for navigating crowded streets and pathways. A key focus of the project is optimizing the electronic control systems to deliver precise movement while keeping costs low. The design incorporates a Brushless DC (BLDC) motor, which offers efficient power use and smooth acceleration, paired with a custom- designed Battery Management System (BMS). The BMS not only extends battery life by optimizing power consumption but also includes a power-saving mode for periods of inactivity, making the hoverboard more energy efficient. Additionally, the project aims to incorporate essential safety features, such as an RFID lock and GPS tracking, providing enhanced security and user control. By balancing performance, safety, and cost, this self-balancing hoverboard aims to become a viable alternative for short distance urban transportation. It offers an eco-friendly and cost-effective solution that meets the growing demand for cleaner transportation options, making personal electric vehicles more accessible to a wider audience.

1 [1] Department of Electronics and Instrumentation Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai Tamil Nadu, India. joselinr@srmist.edu.in

2 Department of Electronics and Instrumentation Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai Tamil Nadu, India. hr5759@srmist.edu.in

3 Department of Electronics and Instrumentation Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai Tamil Nadu, India. vn3593@srmist.edu.in

4 Department of Electronics and Instrumentation Engineering, SRM Institute of Science and Technology, Kattankulathur, Chennai Tamil Nadu, India. mr9712@srmist.edu.in

II. Components used

1) 360W, 36V motor : It is an electric motor that operates on a 36-volt power supply and generates 360 watts of power. It is often used in applications such as electric bikes, scooters, and other small electric vehicles. The 36V refers to the voltage required for the motor to function properly, while the 360W indicates the power output, making it suitable for moderate-speed operations. The motor typically draws about 10 amps of current when running at full capacity. This type of motor offers a good balance between efficiency and performance, making it ideal for light transportation and other moderate power needs.

2) PID Controller : A PID controller or Proportional-Integral-Derivative controller, is a control system used to automatically regulate processes by adjusting the output based on feedback. It combines three key components: the proportional part, which responds to the current error between the desired setpoint and the actual value; the integral part, which accumulates past errors to eliminate any lingering offset; and the derivative part, which predicts future errors to smooth out the system's response. By balancing these three elements, a PID controller helps systems quickly reach their target and maintain stability with minimal oscillation or error, making it ideal for applications like temperature regulation, motor control, and robotics.

3) Chasis: A chassis is the structural framework that supports and houses the main components of a vehicle or device. In the context of vehicles, the chassis is essentially the "skeleton" that holds the engine, wheels, transmission, and other key systems together, providing strength and stability. It also serves as the foundation for the vehicle's bodywork and suspension system. In electronic devices, such as computers or robots, the chassis refers to the frame or housing that supports internal components like circuit boards and wiring. A well-designed chassis is crucial for both safety and performance, ensuring that all components are properly aligned and protected.

4) Gyroscopic sensor : A gyroscopic sensor, or gyroscope, is a device that measures the orientation or angular velocity of an object. It detects changes in rotation or tilt by using the principles of angular momentum. When the object moves or rotates, the sensor captures the rate and direction of this movement. Gyroscopic sensors are commonly used in applications such as smartphones, drones, game controllers, and vehicle navigation systems to detect changes in orientation and help stabilize or guide the device. They are crucial for maintaining balance and providing precise control in systems that rely on accurate motion tracking

III. EXPERIMENTAL SETUP

During operation, the motors demonstrated responsive acceleration and deceleration, facilitating easy maneuvering. However, issues were noted with one of the motors occasionally stopping unexpectedly, causing the hoverboard to veer off course. This malfunction requires further investigation to determine the cause, potentially involving the motor's connection or control circuitry. Noise Levels: Initial tests indicated that the hoverboard operated quietly at startup, but after several minutes of use, an increase in motor noise was observed. This suggests that there may be mechanical wear or overheating issues that need addressing to ensure consistent performance. Battery Reliability: The battery management system functioned as intended, prolonging battery life during idle periods. However, inconsistent performance was noted in battery output during rides. While the battery typically provided adequate power, there were instances where it failed to deliver expected levels of thrust, raising concerns about battery health or potential connectivity issues within the circuitry. Debris and Performance: The hoverboard's wheels tended to collect dust and small debris, impacting performance over time. This accumulation hindered the caster's ability to swivel freely, making turns more difficult. Regular maintenance and cleaning protocols should be established to ensure optimal functioning. Overall, these observations will inform future iterations of the hoverboard, leading to improvements in design and functionality. Addressing the identified issues will enhance the rider experience and establish the hoverboard as a reliable and innovative solution for personal transportation.

IV. METHODOLOGY

This study outlines the design, analysis, and fabrication of a self-balancing hoverboard aimed at providing an efficient solution for short-distance personal transportation. The methodology encompasses three primary stages: design, electronic control system development, and testing. Each stage is essential for achieving stability, user safety, and energy efficiency.

4.1. Design and Simulation :

The hoverboard frame was designed using SolidWorks software, selecting lightweight alloy metals for their strength to-weight ratio, ensuring durability and ease of transport. The frame's design was optimized for balance and stability while supporting various user weights. Structural analysis was conducted using ANSYS software to evaluate the stress and load distribution across the frame under different conditions. The goal was to ensure that the frame could withstand dynamic forces encountered during use without compromising stability. The self-balancing mechanism relied on integrating gyroscopic sensors and accelerometers. These sensors provide real-time data on the hoverboard's tilt and motion, which are critical for the control system to adjust the motor speeds to maintain balance.

4.2. Development of the Electronic Assembly :

The electronic assembly was developed to integrate the control system with the Brushless DC (BLDC) motors and battery management system (BMS). Key components of the electronic assembly include: Control Circuitry: A microcontroller-based control unit processes the data from the gyroscope and accelerometer, adjusting motor outputs to maintain balance. The microcontroller executes real-time algorithms for processing tilt data and calculating the necessary adjustments for each wheel's speed. BLDC Motors: A pair of BLDC motors were selected for their high efficiency, smooth operation, and precise control capabilities. These motors provide the necessary torque and speed adjustments based on the rider's movement. Battery Management System (BMS): A custom-designed BMS manages the power flow from a rechargeable Lithium-ion battery pack. The BMS includes a power-saving mode that activates when the hoverboard is idle, reducing energy consumption and extending the battery life. The integration of an RFID lock and GPS tracking system provides security features. The RFID lock restricts access to authorized users, while the GPS tracker allows users to monitor the hoverboard's location through a mobile application.

4.3. Prototyping and Testing:

A functional prototype of the hoverboard was fabricated, incorporating the designed frame and electronic components. The prototype underwent a series of tests to evaluate its performance across several criteria: Stability Tests: The gyroscopic balancing system's response to various weights and riding speeds was tested. The system's ability to maintain stability during sudden accelerations, decelerations, and turns was evaluated on both smooth and uneven surfaces. Energy Efficiency: Battery life tests were conducted to measure the effectiveness of the BMS and power-saving features. The hoverboard's operational time under typical urban commuting conditions was recorded. Control Responsiveness: The user interface, which allows control through subtle shifts in body weight, was assessed for intuitiveness and responsiveness. This included evaluating how quickly the hoverboard responded to changes in the rider's balance.

4.4. Safety Enhancements :

To enhance user safety, additional testing focused on the performance of the security features. The RFID lock's reliability was tested under various conditions to ensure that unauthorized access was effectively prevented. The GPS tracking system was evaluated for real-time location accuracy and integration with the mobile app. 5. Data Analysis and Optimization Data collected from the stability, energy, and control tests were analyzed to identify areas for improvement. Adjustments were made to the gyroscopic algorithms and control logic to enhance balance performance and reduce motor overheating during extended use. Further iterations of the frame design focused on improving the distribution of weight and enhancing the structural integrity of the hoverboard.

A. 4.5. Block diagram :

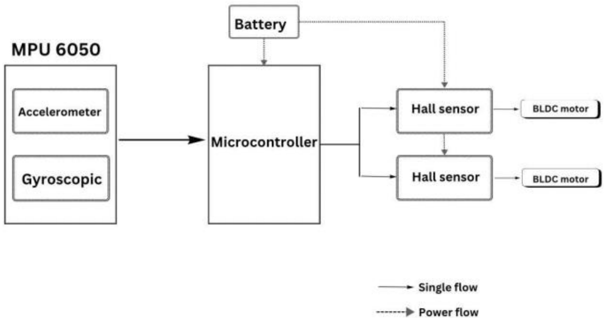

Figure:4.5.1 block diagram

4.6. Flow diagram:

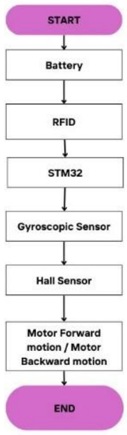

Figure:4.6.1. Flow diagram

V. OBSERVATION

Initial testing of the hoverboard revealed several insights regarding its performance and user interaction:

Stability and Balance: The self-balancing mechanism effectively maintained stability during testing. Users reported a smooth riding experience on flat surfaces, although difficulties arose when navigating uneven terrain. The gyroscopic stabilization proved effective in minimizing tilt, but additional calibration may be necessary to improve performance on inclines or rough surfaces.

Motor Performance: During operation, the motors demonstrated responsive acceleration and deceleration, facilitating easy maneuvering. However, issues were noted with one of the motors occasionally stopping unexpectedly, causing the hoverboard to veer off course. This malfunction requires further investigation to determine the cause, potentially involving the motor's connection or control circuitry.

Noise Levels: Initial tests indicated that the hoverboard operated quietly at startup, but after several minutes of use, an increase in motor noise was observed. This suggests that there may be mechanical wear or overheating issues that need addressing to ensure consistent performance.

Battery Reliability: The battery management system functioned as intended, prolonging battery life during idle periods. However, inconsistent performance was noted in battery output during rides. While the battery typically provided adequate power, there were instances where it failed to deliver expected levels of thrust, raising concerns about battery health or potential connectivity issues within the circuitry.

Debris and Performance: The hoverboard’s wheels tended to collect dust and small debris, impacting performance over time. This accumulation hindered the caster's ability to swivel freely, making turns more difficult. Regular maintenance and cleaning protocols should be established to ensure optimal functioning. Overall, these observations will inform future iterations of the hoverboard, leading to improvements in design and functionality. Addressing the identified issues will enhance the rider experience and establish the hoverboard as a reliable and innovative solution for personal transportation.

VI. RESULTS

The prototype hoverboard underwent extensive testing to evaluate its performance, stability, and ease of use. Key findings include:

- **Stability and Control:** The gyroscopic system, paired with accelerometer-driven adjustments, maintained balance effectively across various rider weights (50–90 kg) and uneven surfaces. The Brushless DC (BLDC) motor ensured precise speed control during acceleration, deceleration, and turns.

- **Power Management:** The Battery Management System (BMS) extended battery life with a power-saving mode, achieving a range of 15–18 km per charge, depending on rider weight and terrain.

- **Security Features:** The RFID lock and GPS tracking enhanced safety by preventing unauthorized access and enabling real-time location monitoring.

The hoverboard demonstrated strong stability, efficient power management, and reliable security features, making it suitable for urban commuting. Challenges with motor overheating were mitigated with improved ventilation, though future iterations may explore advanced cooling solutions. Overall, the hoverboard provides a cost-effective, energy-efficient, and secure option for short- distance travel, with potential for further optimization.

Figure.6.1. front view of roadside wheeler

Figure.6.2. side view of roadside wheeler

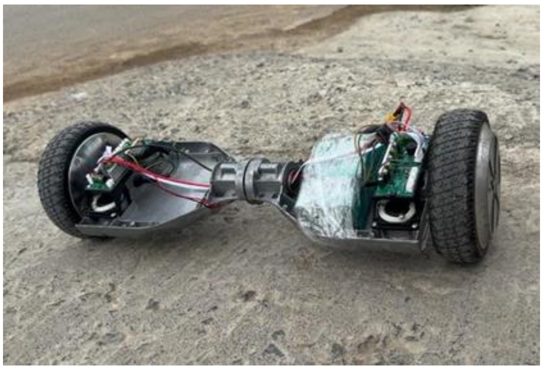

Figure.6.3. bottom view of roadside wheeler

VII. FUTURE WORK

The future of self-balancing hoverboards holds great potential for advancing urban transportation. As demand for compact, eco- friendly vehicles grows, key areas for innovation include: Battery Technology: Advances like solid-state batteries could offer higher capacity and faster charging, improving range and reducing weight. Enhanced Battery Management Systems (BMS) can optimize energy use, extending battery life. AI and Machine Learning: AI can adapt hoverboards to various conditions, providing better balance and stability based on the rider's style and terrain. It also enables predictive maintenance, reducing repair costs. Advanced Control Systems: Using adaptive PID or fuzzy logic controllers could refine balance and responsiveness. Developing sensorless control methods can lower costs and simplify design. Safety Improvements: Incorporating features like collision detection, LIDAR sensors, and rider position monitoring can enhance safety in crowded areas and prevent accidents. Connectivity and IoT: IoT integration allows remote monitoring, location tracking, and smart city integration, making hoverboards more user-friendly and suitable for shared mobility services. Sustainable Materials: Using recyclable or biodegradable materials can reduce the environmental impact, attracting ecoconscious consumers. Market Accessibility: Decreasing component costs can lead to more affordable models, expanding accessibility to a wider range of users, including younger riders and those with disabilities. Autonomous Hoverboards: Future models could navigate independently for short-distance transport of goods, requiring advances in obstacle detection and navigation. These innovations can make hoverboards smarter, safer, and more adaptable, meeting the need for sustainable urban transportation.

VIII. CONCLUSION

This study successfully designed and developed a self-balancing hoverboard aimed at providing an affordable, efficient, and safe mode of short-distance transportation. Through the integration of gyroscopic stabilization systems, BLDC motor control, and an advanced Battery Management System (BMS), the hoverboard achieved reliable balance and energy efficiency. The use of a lightweight alloy frame and intuitive user interface ensures that the device is both durable and user-friendly, making it suitable for urban commuting. The testing phase demonstrated the hoverboard's ability to maintain stability under various conditions, including different rider weights and surface irregularities. The BMS's powersaving mode further enhanced the hoverboard's practicality by extending battery life during periods of inactivity. Additionally, the inclusion of security features such as RFID locking and GPS tracking improved the overall safety and usability of the device. While the project achieved its primary goals, future work could focus on optimizing the thermal management of the motor and exploring the use of more advanced materials for further weight reduction. Additionally, incorporating machine learning algorithms could enable the hoverboard to adapt more effectively to varying riding conditions. Overall, the developed hoverboard offers a promising solution to the challenges of urban transportation, providing a cleaner and more accessible alternative to traditional motorized vehicles.

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