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E-Bike Speed Controlling Using STM32

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Abstract: *This project presents the design and implementation of an E-Bike speed control system using an STM32 microcontroller for efficient and reliable motor control. The system regulates motor speed by processing throttle input and generating appropriate PWM signals to the motor driver. Speed feedback from sensors enables precise control and improved riding safety. Protective features such as braking control and over-speed limitation are incorporated to enhance reliability. The proposed system offers high performance, low power consumption, and flexibility for future upgrades in electric vehicle applications.*

Keywords: Automation, Embedded system, IOT, efiiciency

I. INTRODUCTION

Electric bikes (E-bikes) have emerged as an efficient and eco-friendly mode of transportation, where precise speed control is essential for rider safety, comfort, and energy efficiency. An E-bike speed control system regulates the motor speed based on rider input, road conditions, and safety constraints.

The STM32 microcontroller, developed by STMicroelectronics, is widely used for E-bike speed control due to its high performance, low power consumption, and advanced control peripherals. In this system, STM32 reads inputs from the throttle and speed sensors, processes them using control algorithms, and generates Pulse Width Modulation (PWM) signals to control the motor driver..

II. PROBLEM STATEMENT

Conventional E-bike speed control systems often suffer from inaccurate speed regulation, jerky acceleration, inefficient power utilization, and limited safety features. Many low-cost controllers lack the flexibility to adapt motor speed based on real-time riding conditions, rider input, and battery status, leading to reduced riding comfort and decreased battery life.

There is a need for a compact, efficient, and reliable speed control system that can precisely regulate the E-bike motor speed while ensuring rider safety and energy efficiency. The challenge is to design an intelligent controller using the STM32 microcontroller from STMicroelectronics that can process throttle inputs, monitor speed feedback, and generate accurate PWM signals for smooth and stable motor control.

III. LITERATURE REVIEW

The global energy crisis is a major challenge that requires efficient utilization rather than increased energy generation. Energy wastage can be reduced by continuously monitoring consumption, but consumers are often unaware of their usage due to monthly billing systems. In India, electricity bills are issued once a month, leaving consumers uninformed about real-time energy usage. Online monitoring through IoT-based smart meters can help users track consumption anytime and anywhere. Since most people are constantly connected to the internet, this approach can greatly improve energy management. Reducing household energy consumption is an effective way to address the energy crisis

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IV. METHODOLOGY

The throttle input is sensed using a Hall-effect sensor and read by the STM32 through its ADC.
Motor speed feedback is obtained from Hall sensors mounted on the BLDC motor.
The STM32 compares the reference speed with the actual speed and processes the error using a PID control algorithm.
Based on the controller output, PWM signals are generated using STM32 timers.
These PWM signals control the motor driver to regulate the BLDC motor speed smoothly.
Safety features such as brake cut-off and overcurrent protection are also implemented..

V. WORKING

The E-Bike speed control system works on a closed-loop control principle using an STM32 microcontroller from STMicroelectronics.
The throttle provides a voltage signal representing the rider's desired speed, which is read by the STM32 through its ADC.
A speed sensor continuously measures the actual motor or wheel speed and sends feedback to the controller.
The STM32 compares the desired speed with the actual speed and processes the error using control logic.
Based on this, PWM signals are generated to control the motor driver.
This ensures smooth acceleration, accurate speed regulation, and safe E-Bike operation.

VI. BLOCK DIAGRAM

COMPONENTS USED:
STM32 MICROCONTROLLER
BLDC MOTOR
MOTOR DRIVER/INVERTER
THROTTLE
HALL SENSOR
BATTERY PACK UNIT

VII. COMPONENTS DESCRIPTION

BLDC MOTOR
A Brushless DC motor is used for propulsion due to its high efficiency, high torque, and low maintenance. Its speed is controlled electronically by varying the supplied PWM signals.

STM32 MICROCONTROLLER
The STM32 acts as the main control unit of the system. It reads throttle and speed sensor inputs, executes the control algorithm, and generates PWM signals to regulate motor speed.

MOTOR DRIVER/INVERTER
The motor driver interfaces between the STM32 and the BLDC motor. It amplifies low-power PWM signals into high-power three-phase signals required to drive the motor.

VIII. ADVANTAGES

• High performance control: STM32 offers fast processing, enabling precise and smooth speed control of the BLDC motor.
• Built-in peripherals: Integrated ADCs, PWM timers, and communication interfaces reduce external hardware requirements.
• Energy efficient: Optimized control algorithms help improve battery efficiency and extend riding range.
• Flexible and scalable: Supports advanced control methods like PID, adaptive, and sensorless control.
• High reliability: Suitable for real-time applications with robust performance under varying load conditions.

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IX. LIMITATIONS

1. Programming complexity: Requires good knowledge of embedded C and STM32 architecture.
2. Higher initial cost: Slightly costlier compared to basic microcontrollers for simple applications.
3. Debugging difficulty: Motor control systems can be complex to debug in real-time conditions.
4. Learning curve: Configuration of timers, ADCs, and interrupts can be challenging for beginners..

X. CONCLUSION

The E-Bike speed controlling system using STM32 successfully demonstrates an efficient, reliable, and flexible approach to managing electric bicycle speed. By utilizing the high-performance features of STM32 microcontrollers—such as precise PWM generation, fast ADC processing, and real-time interrupt handling—the system ensures smooth acceleration, stable speed regulation, and enhanced rider safety. Integration of throttle input, speed sensors, braking logic, and display units results in accurate monitoring and control under varying riding conditions. Overall, this project proves that STM32-based control is a cost-effective and scalable solution, making it suitable for modern e-bikes and future upgrades like regenerative braking, IoT connectivity, and advanced motor control algorithms..

XI. FUTURE SCOPE

The future scope of E-Bike speed controlling using STM32 is broad and promising due to its flexibility and processing capability. Advanced motor control techniques such as FOC (Field-Oriented Control) can be implemented to improve efficiency, torque control, and ride comfort. Integration with IoT and mobile applications can enable real-time speed monitoring, remote diagnostics, and firmware updates. Safety can be enhanced through adaptive speed limiting, collision avoidance sensors, and GPS-based geofencing for speed regulation in restricted zones. Additionally, features like regenerative braking, battery health management, and AI-based riding pattern analysis can further optimize energy usage and extend battery life, making the system more intelligent, eco-friendly, and suitable for next-generation smart e-bikes. .

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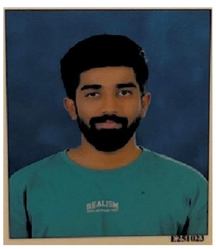	Name-Prem Kiran Designation- Student USN- 3VC23EE444 Phone Number-6360548456 E-mail id –premkiran1316@gmail.com
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