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ELECTRIC BIKE SPEED CONTROLLING SYSTEM USING STM-32

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ABSTRACT:

Electric bicycles (e-bikes) have emerged as an efficient and sustainable solution for modern urban transportation. This paper presents the design and development of an intelligent speed controlling system for an electric bike using the STM32F103C8T6 microcontroller. The system employs a Brushless DC (BLDC) motor driven by a three-phase MOSFET inverter and controlled through high-frequency Pulse Width Modulation (PWM). Real-time monitoring of throttle input, battery voltage, motor current, and temperature is implemented using sensors such as Hall-effect sensors and ACS712 current sensors. A closed-loop control algorithm ensures smooth acceleration, precise speed regulation, and efficient power utilization. Safety features including low-voltage cut-off, over current protection, and thermal monitoring are incorporated to enhance reliability. Experimental results demonstrate accurate speed control, improved efficiency, and robust system performance. The proposed system offers a scalable and cost-effective solution for intelligent electric mobility applications.

KEYWORDS:

ELECTRIC BIKE, STM32, BLDC MOTOR, PWM CONTROL, SPEED CONTROL, EMBEDDED SYSTEMS, HALL EFFECT SENSOR, ENERGY EFFICIENCY, ELECTRIC VEHICLE, MOTOR CONTROLLER.

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INTRODUCTION

The global shift towards sustainable transportation has accelerated the development of electric mobility solutions such as electric bicycles [1]. E-bikes provide an efficient and eco-friendly alternative to conventional vehicles by reducing emissions and energy consumption [2]. The integration of advanced electronic control systems has significantly improved the performance and reliability of these systems [3].

Speed control is a critical aspect of electric bike operation, ensuring safety, efficiency, and user comfort [4]. Brushless DC (BLDC) motors are widely used in e-bikes due to their high efficiency, low maintenance, and superior torque characteristics [5]. The use of Pulse Width Modulation (PWM) techniques allows precise control of motor speed and reduces energy losses [6].

Modern embedded systems, particularly STM32 microcontrollers, provide high computational capability and advanced peripherals required for real-time motor control [7]. Feedback-based control systems using sensors enable closed-loop operation, improving system stability and responsiveness [8]. Additionally, monitoring of voltage and current is essential for battery protection and efficient energy management [9].

Despite these advancements, many existing systems lack real-time diagnostics, efficient control strategies, and robust safety mechanisms [10]. This work proposes an STM32-based intelligent speed control system that addresses these limitations through advanced control algorithms and integrated monitoring features.

MATERIALS AND METHODS:

The proposed system was developed using a combination of hardware and software components integrated into a closed-loop control architecture. The core of the system is the STM32F103C8T6 microcontroller, which processes sensor inputs and generates PWM signals to control the BLDC motor. A three-phase MOSFET inverter bridge is used to drive the motor, while Hall-effect sensors provide rotor position feedback for proper commutation. The throttle input is sensed using a Hall-effect throttle mechanism, and battery voltage is monitored through a voltage divider circuit connected to the microcontroller's ADC. Motor current is measured using an ACS712 current sensor to enable real-time current monitoring and protection.

The system operates using a closed-loop control algorithm, where the STM32 continuously adjusts the PWM duty cycle based on throttle input and feedback signals. The control strategy ensures smooth acceleration, stable speed under varying loads, and efficient power delivery. Safety mechanisms such as low-voltage cut-off, over current protection, and thermal monitoring are implemented within the firmware to protect system components. Additionally, an LCD display module is used to provide real-time information such as voltage, current, and power to the user. The entire system was designed, implemented, and tested to evaluate its performance under different operating conditions.

RESULTS:

The developed STM32-based speed control system was tested under laboratory conditions to evaluate its performance. The system demonstrated precise speed regulation with smooth throttle response and stable motor operation. The PWM-based control achieved efficient power conversion with minimal energy loss. The BLDC motor operated with reduced noise and improved efficiency.

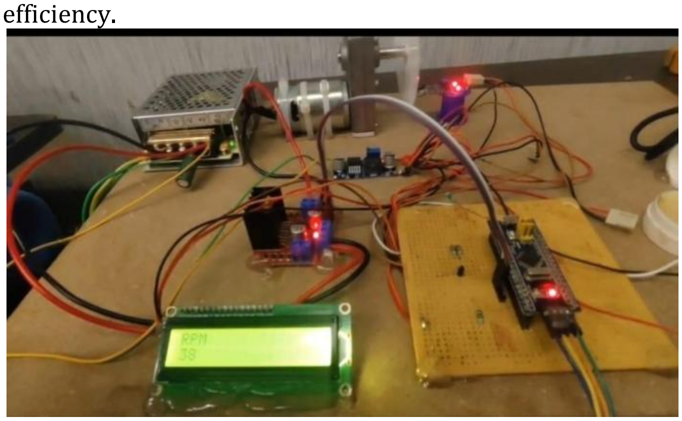

FIG. 1: *HARDWARE PROTOTYPE IN OPERATION — SHOWING I2C LCD DISPLAYWITH LIVE V, A, AND W READOUTS.*

Voltage and current monitoring provided accurate real-time measurements, enabling effective battery management and protection. The system responded quickly to fault conditions such as over current and low voltage, ensuring safe operation. The LCD display successfully provided real-time telemetry including voltage, current, and power.

The experimental results confirm that the system achieves reliable performance, efficient energy utilization, and improved control accuracy compared to conventional controllers.

CONCLUSIONS:

The proposed system demonstrates significant improvements over traditional e-bike controllers. The use of a 32-bit STM32 microcontroller enhances computational efficiency and enables advanced control algorithms. Closed-loop control provides better speed stability compared to open-loop systems. The integration of sensors allows real-time monitoring and intelligent decision-making, improving system reliability and safety. The PWM-based control reduces power losses and enhances overall efficiency. However, the system complexity is higher compared to basic controllers, and proper calibration of sensors is required. Future improvements may include implementation of advanced control techniques such as Field-Oriented Control (FOC), IoT-based monitoring, and regenerative braking systems

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