EBIKE Speed Controller by Using STM32FC3108T6 Microcontroller

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Abstract: **Ebikes are the transport medium of our future. We are moving towards the electric vehicles era leaving behind the fuel based mechanisms. Well in case of ebikes there are 3 major components required.**

- **Ebike Motor**
- **Ebike Battery**
- **Ebike Controller**

We here propose to develop and test a working ebike controller. The ebike controller will be performing the following operations:

- **Getting throttle inputs**
- **Controlling motor speed as per throttle**
- **Getting Speed Value's and displaying on display**
- **Starting and shutting down bike as per start switch**

The system makes use of an STM32 controller along with a throttle input, speed sensor for tyre speed, switch, motor driver, ebike motor, battery and OLED display to develop the system. We will hereby focus on throttling and speed display part of ebikes while developing this controller.

The STM controller constantly monitors the throttle values. The throttle consists of a throttle position sensor (TPS). Non contact type TPS work on the principle of Hall effect or inductive sensors, or magnetoresistive technologies, wherein by and large the magnet or inductive circle is the unique part which is mounted on the butterfly valve choke spindle/shaft gear and the sensor and sign handling circuit board is mounted inside the ETC gear box cover and is stationary. At the point when the magnet/inductive circle mounted on the spindle which is rotated from the lower mechanical stop to WOT, there is an adjustment of the magnetic field for the sensor. The adjustment of the magnetic field is detected by the sensor and the voltage created is given as the input to the ECU.

The Throttle signal is processed by the controller and it then operates the motor through motor driver. The motor voltage is varied as per throttle values in order to control its power and speed. Also the controller constantly monitor speed sensor values. The peed sensor works on hall effect principle to constantly transmit the wheel RPM.

This RPM value is displayed on the LCD display by the controller. The motor speed and sensor monitoring is turned off when the main switch s turned off. The complete process restarts as soon as the switch is turned on. Thus we successfully develop and test our own Ebike controller using STM32.

INTRODUCTION

In modern electric bicycles (e-bikes), efficient speed control is essential for performance, energy conservation, and rider safety. This project focuses on designing and implementing an e-bike speed controller using the STM32F103C8T6 microcontroller, a cost-effective and powerful 32-bit ARM Cortex-M3 chip widely used in embedded systems and motor control applications.

The STM32F103C8T6 offers high processing power, multiple I/O ports, PWM (Pulse Width Modulation) capabilities, ADC (Analog-to-Digital Converter), and communication interfaces (UART, I2C, SPI), making it ideal for controlling brushless DC motors (BLDC), which are commonly used in e-bikes.

The speed controller system is designed to:

Accurately read throttle input (analog or digital)

Generate precise PWM signals to drive a motor driver (such as MOSFET-based or external ESCs)

Monitor motor speed using sensors like Hall-effect sensors or back-EMF

Implement safety features such as overcurrent protection, temperature monitoring, and fault detection

With this system, riders can enjoy smooth acceleration, reliable braking, and overall better control of the e-bike. This solution also provides a flexible development platform for future upgrades, including regenerative braking, Bluetooth connectivity, or integration with mobile apps.

Proposed System

The proposed system is a microcontroller-based E-Bike Speed Controller using the STM32F103C8T6, which acts as the central control unit for managing throttle input, motor speed regulation, and safety mechanisms. The system is designed to control a Brushless DC (BLDC) motor, which is commonly used in electric bicycles due to its high efficiency and reliability.

Key Components of the System:

STM32F103C8T6 Microcontroller

Core controller for processing inputs and generating control signals

Performs PWM generation, speed sensing, and communication tasks

Throttle Input (Potentiometer or Hall-effect Throttle)

Provides analog input to the STM32 to determine rider's desired speed

BLDC Motor Driver Circuit (MOSFET-based or Dedicated Driver like L298)

Receives PWM signals from STM32 and drives the BLDC motor phases accordingly

Speed Sensor (Hall Effect Sensors)

Monitors the position/speed of the motor rotor

Provides feedback to STM32 for closed-loop control

PWM Control Logic

STM32 generates PWM signals with variable duty cycles to control motor speed

Implements six-step or sinusoidal commutation depending on the motor type

Battery Management Interface

Monitors voltage and current

Provides protection against undervoltage, overcurrent, and overheating

LCD/OLED Display (Optional)

Displays speed, battery level, and system status

Braking and Safety Features

Electronic braking via reverse PWM or regenerative methods

Emergency shutdown on fault detection

Working Principle:

The rider adjusts the throttle, which is read by the STM32 via its ADC pin.

Based on the throttle position, the STM32 calculates the required motor speed.

The microcontroller generates PWM signals to the motor driver, adjusting the duty cycle to control the motor’s power.

Hall sensors provide feedback on the motor's position/speed for accurate commutation.

The system continually monitors battery parameters and system temperature to ensure safe operation.

Benefits of the Proposed System:

Precise speed control with high efficiency

Low-cost and compact controller design

Scalability for advanced features (Bluetooth, GPS, app connectivity)

Improved rider experience with smoother acceleration and safer operation

Working Theory

The STM32F103C8T6 microcontroller plays a central role in the e-bike speed controller by processing throttle input, controlling motor speed through PWM, and ensuring safety through real-time monitoring. The system operates based on the following working principles:

1. Throttle Input and Signal Acquisition

The rider controls speed using a throttle (typically a Hall-effect throttle or potentiometer).

The throttle outputs an analog voltage (usually between 0.8V to 4.2V).

This analog voltage is fed to the STM32’s ADC (Analog-to-Digital Converter) to convert it into a digital value that represents the rider's desired speed.

2. Motor Commutation and PWM Generation

The motor used is usually a 3-phase BLDC motor.

The STM32 generates PWM signals to control the power delivered to each phase of the motor through a motor driver circuit (MOSFET bridge or driver ICs like L298).

PWM duty cycle is adjusted based on the throttle input — higher throttle = higher duty cycle = faster motor rotation.

3. Rotor Position Sensing

The BLDC motor has built-in Hall-effect sensors to detect rotor position.

These sensors send signals to the STM32, which uses them to determine which motor phase to energize next (commutation).

The microcontroller uses six-step (trapezoidal) or sinusoidal commutation to rotate the motor smoothly and efficiently.

4. Closed-loop Speed Control (Optional)

Using the rotor position and timing data, the STM32 can calculate the actual speed of the motor.

It compares the actual speed with the desired speed (from throttle) and adjusts PWM duty cycle accordingly to maintain a stable output (feedback control).

5. Safety and Protection Mechanisms

Overcurrent Protection: STM32 can monitor current using a shunt resistor and op-amp, and shut down the motor if the current exceeds limits.

Overtemperature: Temperature sensors can be used to prevent motor or driver overheating.

Undervoltage/Overvoltage: Battery voltage is monitored, and the system can cut off to protect the battery pack.

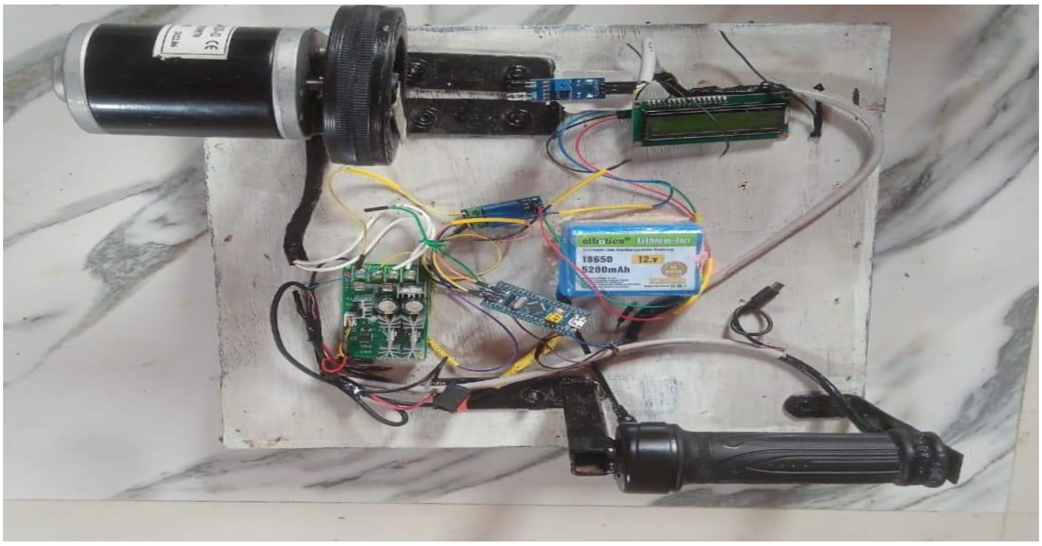
Braking: Controlled braking is implemented via reverse PWM or regenerative braking logic.

6. User Interface

An LCD Display can be used to display speed

MODEL PICS

OUTPUT PICS



CONCLUSION

In conclusion, the e-bike speed controller developed using the STM32F103C8T6 microcontroller successfully regulates motor speed with precision and efficiency. By utilizing PWM signals and real-time feedback, the controller ensures smooth acceleration and reliable performance. The STM32F103C8T6's processing capabilities, low power consumption, and integrated peripherals make it an ideal choice for compact and cost-effective electric vehicle applications. This project demonstrates a practical and scalable solution for modern e-bike control systems.