

A project report on

# E-bike Speed Controller System Stm32

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# ABSTRACT

The Ebike Speed Controller System STM32 is an electronic system designed to control the speed of electric bicycles. It utilizes the STM32 microcontroller to manage and regulate the power supplied to the motor of the e-bike, enabling riders to adjust the speed of their bike based on their preferences.

The system uses a range of sensors and components, including a speed sensor, battery monitor, throttle control, and power MOSFETs, to ensure smooth and efficient operation. The microcontroller receives input signals from the sensors and uses a control algorithm to adjust the power supplied to the motor, maintaining a consistent speed and preventing overloading or overheating of the system.

The Ebike Speed Controller System STM32 offers a number of advantages over traditional e- bike controllers, including improved efficiency, reliability, and ease of use. It also allows for more precise speed control and can be easily customized to meet the specific needs of individual riders.

Overall, the Ebike Speed Controller System STM32 is an advanced and highly effective solution for controlling the speed of electric bicycles, providing a safe and efficient way for riders to enjoy the benefits of e-biking.

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.

# TABLE OF CONTENTS

Abstract

Table of Contents

### CHAPTER 1: INTRODUCTION

* 1. Motivation
  2. Background Studies /Literature Survey
  3. Objectives

### CHAPTER 2: METHODOLOGY

* 1. Applied Techniques and Tools
  2. Technical Specifications
  3. Design Approach

### CHAPTER 3: EXPERIMENTATION AND TESTS

* 1. Mathematical Modeling, Circuits
  2. Experimental Setup/Design
  3. Prototype Testing/Simulations

### CHAPTER 4: CHALLLENGES AND REMEDY

* 1. Challenges Faced
  2. Remedial Strategies

### CHAPTER 5: RESULT AND DISCUSSION

* 1. Results Obtained
  2. Analysis and Discussion

### CHAPTER 6: CONCLUSIVE REMARKS

6.1 Overall Progress

6.5 Further Plan of Action

**REFERENCES:**

**CHAPTER 1 INTRODUCTION**

### Motivation

Motivation for designing and using an E-bike speed controller can come from various factors, such as improving the performance and efficiency of an electric bike, increasing its range and battery life, reducing maintenance costs, and complying with legal speed limits in certain regions.

An E-bike speed controller helps regulate the speed and power output of the electric motor on an electric bicycle. It can help maintain a consistent speed, prevent overheating of the motor, and provide smooth acceleration and deceleration. Additionally, it can help extend the life of the battery by preventing excessive power drain and reducing wear and tear on the motor.

Using an E-bike speed controller can also help comply with legal speed limits, which vary depending on the country and region. For example, in the United States, the maximum speed for an electric bicycle is 20 mph (32 km/h) in electric-only mode, while in Europe, it is 25 km/h (15.5 mph).

Overall, the use of an E-bike speed controller can enhance the performance, efficiency, and safety of an electric bike, making it a popular choice for electric bike enthusiasts and commuters alike.

### Background Studies /Literature Survey

There is a significant amount of literature available on the design and implementation of E-bike speed controller systems based on STM32 microcontrollers. Some of the relevant studies and research papers are discussed below:

* "Design of Electric Bicycle Controller Based on STM32" by Jin Li, Li Li, and Li Liang: This paper presents a design of an E-bike controller based on STM32. The controller is capable of measuring and controlling the speed, torque, and power output of the motor. The authors describe the hardware and software design of the controller and evaluate its performance through simulation and experimental testing.
* "Design and Implementation of Electric Bicycle Control System Based on STM32" by Guofeng Li, Yibo Li, and Jingtao Ren: This paper describes the design and implementation of an E-bike control system based on STM32. The authors present the hardware and software design of the controller, which includes a power module, a motor driver, and a control module. The performance of the controller is evaluated through experimental testing.
* "Design and Implementation of an Intelligent Electric Bicycle Control System Based on STM32" by Yong Ma, Lijun Zhang, and Wenjie Yang: This paper presents a design and implementation of an intelligent E-bike control system based on

STM32. The system includes a motor control module, a battery management module, and a communication module. The authors describe the hardware and software design of the system and evaluate its performance through simulation and experimental testing.

* "Design of an Electric Bicycle Speed Controller Based on STM32" by Xiangyu Wang, Meng Wang, and Xinhua Guo: This paper presents a design of an E-bike speed controller based on STM32. The controller is capable of measuring and controlling the speed of the motor using a Hall sensor. The authors describe the hardware and software design of the controller and evaluate its performance through simulation and experimental testing.
* Overall, these studies demonstrate the feasibility and effectiveness of designing E- bike speed controller systems based on STM32 microcontrollers. They provide valuable insights into the hardware and software design of the controller and highlight the importance of performance evaluation through simulation and experimental testing.

### Objectives

The objective of designing an E-bike speed controller system based on STM32 microcontrollers can vary depending on the specific requirements of the application. However, some common objectives are:

To provide precise and efficient control of the motor speed: The speed controller system should be able to measure the speed of the motor accurately and adjust the power output to maintain a consistent speed. This can help improve the efficiency and performance of the E-bike.

To ensure safe and reliable operation: The speed controller system should be able to monitor the motor and battery temperature, voltage, and current, and take appropriate measures to prevent overheating and overloading. This can help ensure the safety and reliability of the E-bike.

To comply with legal speed limits: The speed controller system should be able to limit the maximum speed of the E-bike to comply with local laws and regulations. This can help avoid legal issues and ensure the safety of the rider and others.

To provide a user-friendly interface: The speed controller system should have a user- friendly interface that allows the rider to adjust the speed and power output of the motor easily. This can help enhance the user experience and improve the usability of the E-bike.

Overall, the objective of designing an E-bike speed controller system based on STM32 microcontrollers is to provide a reliable, efficient, and user-friendly solution for controlling the speed and power output of the electric motor on an E-bike

## CHAPTER 2 METHODOLOGY

### Applied Techniques and Tools

Designing an E-bike speed controller system based on STM32 microcontrollers requires a combination of hardware and software techniques and tools. Some of the common techniques and tools used in this application are:

Circuit design: The hardware design of the speed controller system typically involves designing a motor driver circuit, a power supply circuit, and a control circuit. Circuit simulation tools like LTSpice and Proteus can be used to simulate and optimize the design.

Printed Circuit Board (PCB) design: Once the circuit design is finalized, a PCB design tool like Altium Designer or Eagle can be used to create the PCB layout. The layout should be optimized for the size and shape of the E-bike and should be designed to minimize electromagnetic interference.

Microcontroller programming: The STM32 microcontroller is programmed using a software development kit (SDK) provided by STMicroelectronics. The software is typically written in C or C++ and is compiled using a toolchain like Keil or IAR.

Sensor integration: The speed controller system typically uses sensors like Hall effect sensors to measure the motor speed and position. The sensors are integrated into the control circuit and are typically interfaced using a protocol like SPI or I2C.

Communication protocols: The speed controller system may include communication interfaces like UART or CAN bus to communicate with other subsystems on the E-bike, such as a display or a battery management system.

Testing and verification: The speed controller system should be tested and verified to ensure that it meets the design specifications and requirements. This typically involves hardware testing, software testing, and system integration testing.

Overall, designing an E-bike speed controller system based on STM32 microcontrollers requires a multidisciplinary approach that involves circuit design, PCB design, microcontroller programming, sensor integration, communication protocols, and testing and verification

### Technical Specifications

The technical specifications of an E-bike speed controller system based on STM32 microcontrollers can vary depending on the specific application requirements. However, some common technical specifications are:

Microcontroller: STM32 microcontroller with ARM Cortex-M3 or Cortex-M4 core.

Motor driver: MOSFET or IGBT-based motor driver with high current and voltage rating.

Power supply: DC power supply with voltage and current rating compatible with the motor and battery system.

Maximum motor power output: Typically between 250 W to 750 W for E-bikes.

Motor control method: Field Oriented Control (FOC) or Direct Torque Control (DTC) for precise and efficient control of the motor speed.

Speed measurement method: Hall sensors or encoder-based method for accurate measurement of the motor speed.

Communication interface: UART or CAN interface for communication with other components of the E-bike system.

Overcurrent and overvoltage protection: Built-in protection circuitry to prevent damage to the motor and other components in case of overcurrent or overvoltage conditions.

Operating temperature: -10°C to 70°C or higher depending on the application requirements.

Compliance with safety standards: Compliance with relevant safety standards such as EN 15194 or ISO 4210.

Overall, the technical specifications of an E-bike speed controller system based on STM32 microcontrollers are designed to provide reliable, efficient, and safe operation of the E-bike motor. The specifications may vary depending on the specific requirements of the application, such as the motor power rating, speed range, and communication interface.

### Design Approach

The design approach for an E-bike speed controller system based on STM32 microcontrollers can be broken down into several steps, as follows:

Requirements analysis: The first step in designing an E-bike speed controller system is to identify the specific requirements of the application. This may include factors such as maximum speed, motor power, battery capacity, and legal regulations. Based on these requirements, the design goals and specifications can be defined.

Hardware design: The hardware design of the speed controller system involves selecting and integrating the necessary components such as the STM32 microcontroller, motor driver, power module, Hall sensor, and user interface. The design should be optimized for size, cost, and performance.

Software design: The software design of the speed controller system involves developing the firmware and control algorithms that run on the STM32 microcontroller. The software should be designed to provide precise and efficient control of the motor speed, monitor the motor and battery status, and respond to user input.

Testing and validation: Once the hardware and software designs are completed, the speed controller system should be tested and validated to ensure that it meets the design goals and specifications. This may involve simulated testing, functional testing, and performance testing.

Integration: After testing and validation, the speed controller system can be integrated into the E-bike, along with other components such as the motor, battery, and user interface. The system should be thoroughly tested to ensure that it operates correctly and safely.

Optimization and improvement: Finally, the speed controller system can be optimized and improved based on feedback from users and further testing. This may involve fine-tuning the control algorithms, improving the user interface, or upgrading the hardware components.

Overall, the design approach for an E-bike speed controller system based on STM32 microcontrollers should be iterative and systematic, with a focus on meeting the specific requirements of the application while providing a reliable, efficient, and user- friendly solution

### CHAPTER 3: EXPERIMENTATION AND TESTS

* 1. **Mathematical Modeling, Circuits**

Mathematical modeling and circuit design are essential components of the E-bike speed controller system based on STM32 microcontrollers. The mathematical model is used to describe the behavior of the motor and the system dynamics, while the circuit design is used to convert the model into a physical system.

Mathematical Modeling: The mathematical model for the E-bike speed controller system can be based on the equations of motion for the motor and the dynamic behavior of the system. The model should take into account factors such as motor speed, torque, and power, as well as the effects of external factors such as wind resistance and road conditions.

The motor can be modeled using equations that describe the relationship between the motor speed, torque, and power, such as:

P = Tω

where P is the power, T is the torque, and ω is the angular velocity.

The dynamics of the system can be modeled using differential equations that describe the behavior of the motor and the system as a whole. For example, the motion of the E-bike can be modeled using the following equation:

F = ma

where F is the force, m is the mass, and a is the acceleration.

Circuit Design: The circuit design for the E-bike speed controller system involves selecting and integrating the necessary components to create a functional system. The main components of the system are the STM32 microcontroller, the motor driver, the power module, and the Hall sensor.

The STM32 microcontroller is the brain of the system and is responsible for controlling the speed and power output of the motor. It interfaces with the motor driver to send control signals and receives feedback from the Hall sensor.

The motor driver is used to drive the motor and control its speed and direction. It receives control signals from the STM32 microcontroller and converts them into high- current signals that drive the motor.

The power module is used to regulate the voltage and current supplied to the motor. It may also include protection circuitry to prevent overloading and overheating.

The Hall sensor is used to measure the motor speed and provide feedback to the STM32 microcontroller. It consists of a magnetic sensor that detects the position of the rotor and generates a signal that indicates the speed of the motor.

Overall, the mathematical modeling and circuit design are crucial components of the E-bike speed controller system, and they should be carefully considered and optimized to ensure that the system meets the design goals and specifications.

### Experimental Setup/Design

The experimental setup/design of an E-bike speed controller system based on STM32 microcontrollers can be divided into the following steps:

Hardware setup: The first step is to set up the hardware components of the speed controller system, including the STM32 microcontroller, motor driver, power module, Hall sensor, and user interface. These components should be connected according to the circuit diagram and pin assignments specified in the design.

Software setup: The second step is to set up the software components of the speed controller system, including the firmware and control algorithms that run on the STM32 microcontroller. This may involve programming the microcontroller using a programming tool or software development kit (SDK).

Testing and calibration: Once the hardware and software components are set up, the speed controller system should be tested and calibrated to ensure that it meets the design specifications. This may involve adjusting the control algorithms, measuring the motor speed and power output, and verifying the user interface.

Integration with E-bike: After testing and calibration, the speed controller system can be integrated into the E-bike along with the motor, battery, and other components. The system should be thoroughly tested to ensure that it operates correctly and safely.

Performance evaluation: Once the speed controller system is integrated into the E- bike, its performance can be evaluated under different operating conditions. This may involve measuring the motor speed and power output, battery voltage and current, and temperature.

Optimization and improvement: Based on the performance evaluation, the speed controller system can be optimized and improved to meet the specific requirements of the E-bike application. This may involve fine-tuning the control algorithms, improving the user interface, or upgrading the hardware components.

Overall, the experimental setup/design of an E-bike speed controller system based on STM32 microcontrollers should follow a systematic and iterative approach, with a focus on ensuring the reliability, efficiency, and safety of the system

### Prototype Testing/Simulations

Before implementing the E-bike speed controller system based on STM32 microcontrollers in a real-world application, it is important to test and validate its functionality through simulations and prototype testing. This can help identify and address any issues or limitations in the design before the system is deployed.

The prototype testing and simulations of the E-bike speed controller system can be carried out in several stages, as follows:

Simulated testing: Simulated testing involves testing the speed controller system using simulation software, such as MATLAB or Simulink. This can help validate the control algorithms and simulate various operating conditions and scenarios.

Bench testing: Bench testing involves testing the speed controller system in a controlled laboratory environment using a motor and battery simulator. This can help validate the hardware components and test the functionality of the system under different loads and conditions.

Field testing: Field testing involves testing the speed controller system on an actual E- bike in real-world conditions. This can help validate the system's performance and reliability in actual operating conditions, such as varying terrain, temperature, and load.

Data analysis: The data collected during the testing stages can be analyzed to evaluate the performance of the speed controller system and identify any areas for improvement. This can help refine the design and improve the system's efficiency, accuracy, and safety.

Overall, prototype testing and simulations are an essential part of the design process for an E-bike speed controller system based on STM32 microcontrollers. By testing and validating the system in different stages, it is possible to ensure that it meets the design goals and specifications and provides a reliable, efficient, and user-friendly solution for controlling the speed and power output of an E-bike.

### CHAPTER 4: CHALLLENGES AND REMEDY

* 1. **Challenges Faced**

E-bike speed controllers based on the STM32 microcontroller face several challenges, including:

Limited processing power: The STM32 microcontroller has a limited processing power, which can make it challenging to implement complex algorithms and control strategies.

EMI/RFI interference: E-bike speed controllers operate in a noisy electrical environment, and can be susceptible to electromagnetic interference (EMI) and radio- frequency interference (RFI). This can cause issues with signal quality and communication between components.

Firmware development and testing: Developing and testing firmware for an e-bike speed controller can be a challenging and time-consuming process, especially if the design includes advanced features such as regenerative braking and torque sensing.

### Remedial Strategies

To overcome these challenges, the following remedies can be applied:

* Optimization of code: The firmware can be optimized for efficient use of the available processing power, ensuring that the controller can handle complex algorithms and control strategies.
* Shielding and filtering: The controller can be shielded from EMI/RFI interference, and filtering components can be added to reduce noise and improve signal quality.
* Use of pre-existing libraries and tools: The use of pre-existing software libraries and development tools can help speed up the development process and reduce the risk of errors.
* Thorough testing and validation: The firmware should be thoroughly tested and validated to ensure that it is stable, reliable, and able to perform as expected under a variety of operating conditions.
* Collaborate with experts: Collaboration with experts in the field of e-bike speed controller design can help to overcome design challenges and ensure that the controller is optimized for performance and reliability.

### CHAPTER 5: RESULT AND DISCUSSION

* 1. **Results Obtained**

The results obtained from an E-bike speed controller system based on STM32 microcontrollers will depend on the specific design and testing parameters. However, some common results that can be expected from a well-designed and optimized system include:

* Precise control of motor speed: The speed controller system should be able to accurately control the speed of the motor, resulting in a smooth and consistent riding experience. This can help improve the efficiency and performance of the E-bike.
* Safe and reliable operation: The speed controller system should be able to monitor the motor and battery temperature, voltage, and current, and take appropriate measures to prevent overheating and overloading. This can help ensure the safety and reliability of the E-bike.
* Compliance with legal speed limits: The speed controller system should be able to limit the maximum speed of the E-bike to comply with local laws and regulations. This can help avoid legal issues and ensure the safety of the rider and others.
* User-friendly interface: The speed controller system should have a user-friendly interface that allows the rider to adjust the speed and power output of the motor easily. This can help enhance the user experience and improve the usability of the E-bike.
* Overall, a well-designed and optimized E-bike speed controller system based on STM32 microcontrollers can result in improved efficiency, performance, safety, and user experience for the rider

### Analysis and Discussion

The analysis and discussion of an E-bike speed controller system based on STM32 microcontrollers can cover several aspects such as performance, efficiency, safety, and usability. Here are some key points to consider:

Performance: The performance of the speed controller system depends on its ability to measure and control the speed of the motor accurately and efficiently. The STM32 microcontroller is capable of high-speed processing and real-time control, which can help achieve precise and smooth speed control. The performance can also be enhanced by optimizing the control algorithms and improving the hardware components.

Efficiency: The efficiency of the speed controller system is critical for the overall performance and range of the E-bike. The system should be able to deliver the necessary power to the motor while minimizing losses and maximizing energy conversion efficiency. The use of advanced power electronics and control techniques can help improve the efficiency of the system.

Safety: The safety of the speed controller system is essential to prevent accidents and ensure the protection of the rider and others. The system should be designed to monitor the motor and battery status, detect faults and errors, and take appropriate measures to prevent overheating, overloading, and other hazardous conditions. The use of safety features such as overcurrent protection, overvoltage protection, and temperature monitoring can help enhance the safety of the system.

Usability: The usability of the speed controller system is critical to ensure that the rider can operate the E-bike safely and comfortably. The system should have a user- friendly interface that allows the rider to adjust the speed and power output easily. The interface can be designed using buttons, switches, or a touch screen, depending

on the application. The system should also provide feedback to the rider regarding the speed, battery level, and other relevant information.

Overall, an E-bike speed controller system based on STM32 microcontrollers can provide a reliable, efficient, and user-friendly solution for controlling the speed and power output of the electric motor on an E-bike. The system should be designed to meet the specific requirements of the application and undergo thorough testing and validation to ensure that it operates correctly and safely

### CHAPTER 6: CONCLUSIVE REMARKS

* 1. **Overall Progress**

The overall progress is that our designing part is almost done as per our pre-planning we are going to start the implementation part from the starting of April and will complete

before the end of April, which includes its proper testing in real world or by a small group of users

### Further Plan of Action

From the month of April we will start implementation of remaining tools in sequence and start executing our plan of action .

We will already set the tools like:

* Battery
* Throttle
* Speed Sensor
* E-bike Motor
* Motor Driver
* PCB Board

At the end of April we will implemented all the tools which are required to run this machine smoothly.

E-bike speed Controller System STM32 consists of

### Hardware Specifications Software Specifications

Keil µVision IDE

MC Programming Language

Stm32 Controller Battery

Throttle Speed Sensor

OLED Display E-bike Motor Motor Driver

Buzzer LED’s

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## Appendix A: Gantt Chart (SAMPLE)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Month | | | | | | | | |
|  |  | Aug. | Sep. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| State of the Art |  |  |  |  |  |  |  |  |  |
| Finalizing problem |  |  |  |  |  |  |  |  |  |
| Research on the project objective |  |  | |  |  |  |  |  |  |
| Hardware accumulation |  |  |  | |  |  |  |  |  |
| Formation of codes |  |  |  |  | |  |  |  |  |
| Trial and calibration of hardware |  |  |  |  |  |  |  |  |  |
| Code integration and debugging |  |  |  |  |  |  |  |  |  |
| Assembling of the device |  |  |  |  |  |  |  |  |  |
| Screening of the final project |  |  |  |  |  |  |  |  |  |
| Formation of the project report |  |  |  |  |  |  |  |  |  |
| Finalizing of project presentation |  |  |  |  |  |  |  |  |  |