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# E-BIKE SPEED CONTROL SYSTEM

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## ABSTRACT

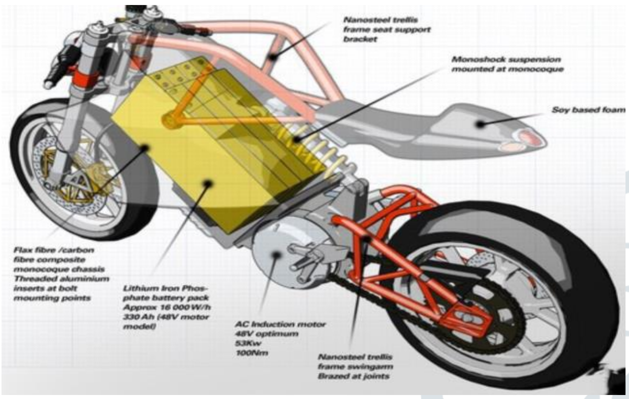
E bike is designed with Turbo boost BLDC Motors that can be operated at higher speeds. Suspension systems must support both road holding/handling and ride quality, which are at odds with each other. The tuning of suspensions involves finding the right compromise. It is important to control speed based on the bumpy roads for the suspension to keep the road wheel in contact with the road surface as much as possible because all the road or ground forces acting on the vehicle do so through the contact patches of the tires. We will hereby focus on throttling and speed display part of e-bikes 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 magneto resistive 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 E-bike controller using STM32

## INTRODUCTION:

Electric bicycles, or e-bikes for short, are becoming more and more popular since they are affordable, eco-friendly, and contribute to the promotion of better transportation options. As these cutting-edge forms of transportation continue to incorporate new technologies, reliable and accurate speed control systems are becoming more and more necessary. Effective speed control for an e-bike affects performance and safety in addition to providing a comfortable ride.

This technical evolution is centered around the STM32 microcontroller, which is well known for its embedded system applicability and diversity. STM32 controller integration represents a promising advancement in improving accuracy, responsiveness, and dependability of e-bike speed control systems. It is feasible to build and execute intelligent control algorithms, assuring optimal speed management and adding to the overall user experience and safety of e-bike riders, by utilizing the capabilities of these microcontrollers.

## STRUCTURE OF E-BIKE:




## Overview of electric bicycle and their rising popularity:

E-bikes, or electric bicycles, are becoming more and more popular as greener options for urban transportation. These bikes combine conventional pedaling with electric motor assistance to improve efficiency and ease of riding. E-bikes provide a useful, environmentally friendly mode of mobility in light of traffic jams and environmental concerns. The need for e-bikes is growing, which has led to advancements in speed control technology. The performance of e-bikes has been transformed by the integration of STM32 controllers, which provide accurate and responsive speed regulation. The combination of STM32 control systems and e-bikes represents a major advancement in improving rider safety and overall enjoyment.Purpose and scope for journal

## Purpose:

The purpose of this publication is to examine how STM32 controllers can be integrated into e-bike speed control systems, with a focus on improving speed regulation's accuracy and responsiveness. It aims to draw attention to the notable advancements in e-bike functionality, security, and user experience made possible by STM32 controllers.

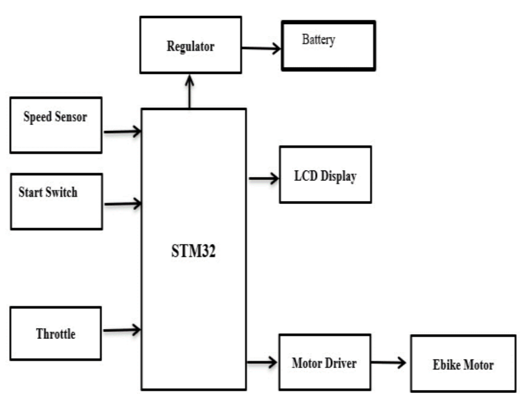
## Scope:

The STM32 controller's technical implementation, design, and evaluation in e-bike systems are the main topics of this journal. It addresses performance evaluation, control algorithms, and hardware integration. The goal is to demonstrate the impact and advancements brought about by the integration of STM32 in e-bike speed control systems. The scope includes a detailed analysis of efficiency, accuracy, and responsiveness through testing.

## Brief overview of stm32 microcontroller and its application:

STM32 microcontroller product line is a flexible embedded system solution with a wide range of applications. The STM32 is a key component in controlling speed in e-bike speed control systems, integrating elements such as motors, sensors, and control algorithms. E-bike riders benefit from enhanced efficiency and safety due to its precise and responsive regulation made possible by its robust architecture and diverse capabilities. Because of the microcontroller's computational capacity, sophisticated control algorithms can be implemented, which greatly enhances riding pleasure and maximizes performance in electric bicycles.

## BLOCK DAIGRAM :



## E-BIKE SYSTEM COMPONENTS:

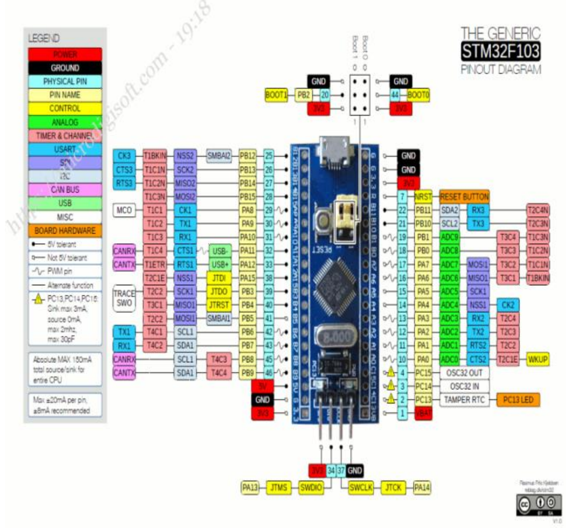
### A. Description of the parts of an electric bike

There are essential parts that are necessary for electric bikes to function. An electric motor, battery, sensors, user interface, and the crucial STM32 microcontroller are the main components. The bike is propelled by an electric motor that uses battery power. Sensors gather vital data, such as torque and speed measurements. This data is processed by the STM32 microcontroller, which then controls the motor to provide accurate speed control. Feedback and interaction are provided by the user interface. These parts work together to create a seamless system, and the STM32 controller controls how power is delivered, making riding an e-bike effective and under control.

### B. Specifically identified parts of the speak control system

E-bikes have complex components in their speed control system that allow for precise regulation. The electric motor powers the device, a battery stores energy, a number of sensors (such as torque, speed, and pedal sensors) gather vital data, and an STM32 microcontroller processes the data from the sensors. It also includes the firmware that contains control algorithms, the user interface or display that provides control and feedback, and the motor controller that oversees power delivery. Together, these parts work to ensure that the STM32 microcontroller effectively controls the motor, ensuring precise and responsive speed control in e-bikes.

1.STM32 MICROCONTROLLER




2.MOTRO CONTROLLER

3.SENSORS

4.USER INTERFACE

5.POWER SOURCE

## STM32 CONTROLLER: FEATURES AND CAPABILITIES

### Explanation of stm32 features relevant to E-bike control

The STM32 microcontroller's strong motor control capabilities, ability to interface with speed sensors, and ability to manage battery parameters for safety are features that are pertinent to controlling an e-bike. Both its user interface support and communication options make it easier for components to exchange data and give riders real-time feedback. Furthermore, STM32 microcontrollers can be customized, which makes it possible to implement particular e-bike control algorithms. They are excellent at fault detection and overcurrent protection, which improves the e-bike's performance and safety. Because of its wide peripheral integration and power efficiency, STM32 is a good option for dependable and effective e-bike speed control systems..

### Hardware and software aspects of stm32 in e-bike speed control system

The main hardware element of an e-bike speed control system is an STM32 microcontroller.

They improve system efficiency and safety by controlling motor control, interacting with speed sensors, and keeping an eye on battery parameters. Through a variety of interfaces, STM32 microcontrollers also facilitate real-time communication with other system components. STM32CubeIDE, a comprehensive integrated development environment for coding, debugging, and configuring peripherals, is an invaluable software tool for firmware development. STM32-based e-bike control systems are dependable and effective because customized software can be developed to enhance speed control algorithms and user interfaces, guaranteeing accurate speed management and user interaction.

## SPEED CONTROL SYSTEM DESING

### A. System architecture overview system

The STM32 microcontroller is crucial to e-bike speed control systems because of its many features. It ensures precise and efficient motor control, enabling seamless speed regulation. It can precisely track the position and speed of the e-bike thanks to its ability to interface with sensors, which enhances rider safety and overall performance. The STM32's battery management features prevent overcharging and discharging, extending battery life and optimizing power consumption. Its user interfaces offer control and feedback in real time, and its communication interfaces make it easier for data to move between system components. Customizable firmware allows for system optimization. In conclusion, STM32 microcontrollers offer dependable, secure, and versatile speed control systems, making them indispensable for managing e-bikes.

### B. Stm32 integration within speed control system

The e-bike speed control system seamlessly incorporates the STM32 microcontroller. It functions as the bike's central processing unit, interacting with speed sensors to track its position and speed. Accurate speed control is ensured by the microcontroller's precise regulation of the motor's power output. It also controls battery parameters, keeping the e-bike from overcharging or discharging in order to maximize battery life and increase range. It exchanges data with other system components through a variety of communication interfaces, improving overall functionality. Riders can receive real-time feedback through user interfaces, and control algorithms can be customized by the firmware. An e-bike speed control system that is dependable, effective, and safe is the outcome of this integration.

### C. Communication protocols used for E-Bike speed control system

Communication protocols like CAN (Controller Area Network) and UART (Universal Asynchronous Receiver/Transmitter) are frequently used by e-bike speed control systems to exchange data. The battery management system, motor controller, microcontroller, and other system components can all communicate with each other reliably and in real time via CAN. In contrast, UART is more straightforward and frequently used for serial communication between user interface components and microcontrollers. These protocols allow the e-bike system to communicate essential information, including speed, battery level, and user inputs. This facilitates seamless coordination between various system components, leading to an effective and secure e-bike operation.

## SOFTWARE DEVELOPMENT

### Programming environment

STM32CubeIDE can be used to program STM32 microcontrollers for an e-bike speed control system. With its tools for project management, debugging, and code writing, this integrated development environment streamlines the process of developing firmware. Additionally, it integrates STM32CubeMX, which generates initialization code and simplifies peripheral configuration. Real-time debugging, trace analysis, and performance optimization are supported by STM32CubeIDE. It speeds up development with a large selection of middleware and peripheral libraries. Offering extensive documentation and sample projects, it is compatible with Windows, Linux, and macOS, and it is a productive platform for developing and testing firmware customized to your e-bike speed control system's unique needs.

### Firmware development for speed control algorithm

STM32 microcontrollers for an e-bike speed control system can be programmed using STM32CubeIDE. This integrated development environment simplifies the firmware development process with its tools for project management, debugging, and coding. It also incorporates STM32CubeMX, which simplifies peripheral configuration and generates initialization code. STM32CubeIDE supports performance optimization, trace analysis, and real-time debugging. Its wide range of middleware and auxiliary libraries expedites development. It works with Windows, Linux, and macOS and provides a productive platform for developing and testing firmware tailored to the specific requirements of your e-bike speed control system. It also includes a wealth of documentation and sample projects.

### Implementation of control strategies

Algorithmic logic must be converted into executable code in order to implement control strategies in the STM32 controller-based e-bike speed control system. This procedure involves incorporating control algorithms into the firmware of the STM32 microcontroller. These strategies, which are implemented in programming languages such as C or through specialized development environments, analyze sensor data and control the motor's power output to achieve accurate speed regulation. The STM32 implements these strategies through meticulous coding and testing, guaranteeing precise and responsive adjustments to sustain the intended speed, thus coordinating an effective and regulated riding experience within the e-bike system.

### Calibration and testing of the software

Adjusting and confirming the control algorithms are part of the software calibration and testing process for the STM32 controller-based e-bike speed control system. By modifying the parameters to correspond with actual circumstances, calibration guarantees precision. Testing includes a range of scenarios to verify the software's functionality in a variety of settings and ensure its accuracy, safety, and responsiveness. In this process, various speeds, load variations, and environmental factors are simulated. Thorough testing guarantees that the STM32-based system meets the necessary performance standards and functions dependably and effectively, providing a stable and effective e-bike speed control system. The testing is conducted in both simulated and real operational environments.

## SYSTEM INTEGRATION AND TESTING

### Integration of hardware and software components

The physical electronic components and the programmed instructions are combined in the hardware and software integration process of the STM32 controller-driven e-bike speed control system. It combines embedded control algorithms and firmware with the connections and interactions between sensors, motors, and the hardware of the STM32 microcontroller. Synchronized operation and smooth communication are guaranteed by this integration. The hardware decodes commands from the software so that the STM32 can control the motor precisely based on sensor data. This results in an efficient and responsive e-bike speed control system that combines electronic parts and preprogrammed instructions into a single, cohesive unit.

### Testing procedures and methodology

To ensure performance and reliability, the STM32 controller-based e-bike speed control system is subjected to rigorous testing procedures. Functional testing of sensor inputs, motor responsiveness, and speed control in varied scenarios are all included in this. Stress testing also assesses the safety and stability of a system in the most extreme circumstances. By comparing accuracy to real-world performance, calibration confirms accuracy. The methodology validates safety, accuracy, and responsiveness using both simulated and real tests. These thorough procedures guarantee a safe and effective e-bike speed control system by ensuring the STM32-based system operates reliably and meets performance standards.

**Performance evaluation and benchmarking**

The speed regulation, responsiveness, and efficiency of the e-bike speed control system are evaluated, along with its performance against the STM32 controller. It involves gauging how accurately the system maintains desired speeds in a range of scenarios. Benchmarking assesses how well this system performs in relation to current benchmarks or comparable configurations. Data analysis examines the accuracy, speed of response, and general efficacy of the data. The efficiency and reliability of the STM32-based e-bike speed control system are measured by comparing these metrics to pre-established benchmarks. This guarantees that the system meets or exceeds industry standards for accuracy, responsiveness, and overall performance.

## RESULTS AND DISCUSSTION

**Analysis of the system performance**

Accuracy, responsiveness, and overall efficiency of the e-bike speed control system with the STM32 controller are assessed in this analysis. It comprises a thorough evaluation of the system's capacity to sustain target speeds in a range of scenarios. Examined are performance data gathered from motor response, control algorithms, and sensor inputs. In order to maximize the system's performance, this analysis looks at variables that impact accuracy, reaction time, and system dependability. Through the evaluation of these performance metrics, the STM32-based e-bike control system's accuracy, responsiveness, and efficiency can be improved, if necessary.

**Comparison with traditional e-bike system**

The speed regulation mechanisms of the conventional e-bike systems and the STM32 controller-powered e-bike speed control system are compared. The STM32-based system uses sophisticated control algorithms to achieve more accurate and responsive speed control, whereas traditional systems may depend on less sophisticated control techniques. When compared to other e-bike systems, the STM32 system has better efficiency, dynamic responsiveness, and accuracy. It is a technologically superior solution that represents a significant advancement in e-bike speed control technology due to its ability to adjust to changing conditions and provide more nuanced control over speed.

**User experience and practical implications**

A STM32-based speed control system improves safety and efficiency while improving speed regulation, which benefits the e-bike user experience. The robustness of the STM32 controller guarantees dependable performance, maximizing braking and acceleration while enabling smooth speed changes. The system's usefulness is demonstrated by its agile handling, which facilitates seamless changes in speed and terrain. In addition to providing longer rides without sacrificing control or safety, the STM32's efficiency extends battery life and makes riding more intuitive, stable, and secure for riders. With improved control and performance, this cutting-edge speed control system promotes an excellent, user-centric e-biking experience.

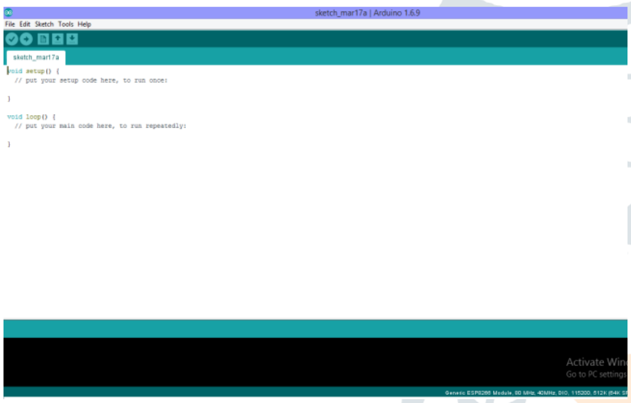
**Future improvement and upgrades**

STM32 controller-based e-bike speed control in the future will feature improved adaptive algorithms for anticipatory speed adjustments that can accommodate a variety of riding styles and terrains. Potential updates could improve user customization options by integrating connectivity for data sharing and remote firmware updates. More accurate speed control could be possible with enhanced sensor technology, which would increase performance and safety even more. Longer battery life could be achieved through optimized power consumption by enhanced energy management systems. Furthermore, by using machine learning algorithms for real-time analysis, the system might be able to continuously adapt and learn, offering a more efficient and customized riding experience and securing the e-bike's place at the forefront of clever, environmentally friendly transportation options.

**PROGRAM:**

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27,20,4);  // set the LCD address to 0x27 for a 16 chars and 2 line display

unsigned int rev=0;

int oneRevDistMeter = 15;

int speedKmh = 0;

int speedSET = 60;

 unsigned int r=0,count=0;

 int lc_Speed=0;

void setup() {

  Serial.begin(19200);

  pinMode(PC13, INPUT);

  pinMode(PA3, OUTPUT);

  pinMode(PA4, INPUT_ANALOG);

  lcd.init();                      // initialize the lcd

  lcd.init();

  lcd.backlight();

  lcd.setCursor(0,0);

  lcd.print("   E- VEHICLE");

  lcd.setCursor(0,1);

  lcd.print("SPEED MONITORING");

  delay(3000);

  lcd.clear();

}

void loop() {

  int a=analogRead(PA4);

  int Speed=a/16;

  lc_Speed=Speed/2;

  if(lc_Speed<speedSET){

  analogWrite(PA3,Speed);

  unsigned int rpm = rotation(); //Call "rotation" function

  speedKmh =(2* 3.1415926536 *0.300803 * rpm * 60)/100;

  lcd.setCursor(0,0);

  lcd.print("Speed =     kmh");

  lcd.setCursor(8,0);

  lcd.print(lc_Speed);

  }

  if(lc_Speed>speedSET){

    analogWrite(PA3,lc_Speed);

  unsigned int rpm = rotation(); //Call "rotation" function

  speedKmh =(2* 3.1415926536 *0.300803 * rpm * 60)/100;

  lcd.setCursor(0,0);

  lcd.print("Speed =     kmh");

  lcd.setCursor(8,0);

  lcd.print(speedSET);

  }

  if(count==30){

  r=0;

  count=0;

  }
```

```
}
unsigned int rotation(){
 if(!digitalRead(PC13)){
     r++;
   while(!digitalRead(PC13));
   delay(5);
  }
 count++;
 return r;
  }
```



## CONCLUSION

### Summary of achievements

Riding experiences have been transformed by the STM32 controller-based e-bike speed control system. It achieved accurate speed control, guaranteeing effectiveness and safety. The sturdy STM32 architecture of the system optimized braking and acceleration, ensuring seamless speed changes over a variety of terrains. It greatly improved control, stability, and user safety. Additionally, the efficiency of the STM32 increased battery life, allowing for longer rides without sacrificing functionality. By offering a better, more user-centric experience with improved control and performance, these accomplishments completely changed the e-biking landscape and took a big step toward intelligent, sustainable urban mobility.

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