Final Year Project Report On

PEDAL ASSIST SYSTEM FOR E-BIKE

In the partial fulfillment of the requirements for four years of Bachelor of Engineering in Electrical& Electronics Engineering

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CERTIFICATION

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ABSTRACT

The project investigates the integration of pedal assist technology within electric bicycles, aiming to enhance their efficiency, usability, and sustainability. The primary objective is to develop and evaluate a robust pedal assist system that seamlessly complements human pedaling efforts with electric propulsion. The study encompasses aspects such as system design, control algorithms, energy management, and user experience. Through a combination of theoretical analysis, computer simulations, and practical experimentation, this project seeks to provide insights into optimizing pedal assist functionality for electric bicycles, ultimately contributing to the advancement of eco- friendly urban transportation solutions.

ACKNOWLEDEMENT

We would like to express our special thanks for gratitude to the Electrical and Electronics department Kathmandu University for providing this opportunity to do this project. This project will help us in improving skills in group work, circuit design, working with electronics components, etc. We would like to express special respect and special thanks to our project supervisor Assistant Professor Dr. Bishal Silwal for his patience, guidance, enthusiasm and encouragement for this project. We would also like thanks our project coordinator Pramish Shrestha for providing necessary assistance and support.

LIST OF ABBRIVATION

SDG	: Sustainable Development Goal
EV	: Electric Vehicles
E-Bike	: Electric Bike
PMDC	: Permanent Magnet DC Motor
DC	: Direct Current
AC	: Alternative Current
IC	: Integrated Circuit
BLDC	: Brushless Direct Current motor
Li-ion	: Lithium-Ion

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CHAPTER I: BACKGROUND AND INTORDUCTON

1.1 Background

In the context of Nepal, where the expenditure on importing petroleum products has surpassed Rs 340 billion within the first 11 months of the current fiscal year, the reliance on petroleum-based transportation systems remains prominent. The fluctuations in petrol prices directly impact the cost of living, potentially leading to inflationary pressures. However, Nepal possesses significant potential within the hydroelectric energy sector. Shifting the nation's dependence from petroleum-fueled vehicles to electric vehicles (EVs) could contribute to greater energy self-sufficiency.

Despite this potential transition, there exists a certain degree of hesitancy among the population to adopt EVs, primarily due to specific challenges. One major concern is the range limitation presented by current battery technologies. Additionally, the high cost associated with battery replacements adds to this uncertainty. Notably, electric bicycles emerge as a more economical alternative compared to other modes of transportation. Nevertheless, achieving an extended range with an electric bicycle necessitates the use of larger battery packs. This introduces a trade-off, as a larger battery increases the weight of the bicycle, potentially compromising ride comfort and elevating the overall bike cost.

The concept behind pedal-assist electric bicycles revolves around harnessing both human effort and the power generated by the electric motor to attain an optimal range. Pedal-assist mode on an electric bike furnishes motor-generated power to facilitate smoother pedaling and increased speed. Once you activate the pedal assist and select your desired level of support, the motor delivers a specific power output to complement your pedaling effort, imparting a subtle sensation of propulsion while riding.

The pedal assist system is designed to offer various levels of assistance, representing varying power outputs from the motor. The different degrees of pedal assist establish the extent to which the rider depends on the motor versus their own pedaling for power. This innovative approach seeks to mitigate the challenges associated with range limitations and battery costs while providing users with an efficient and comfortable mode of transportation. Through this integration of human and electric power, the pedal-assist electric bicycle endeavors to enhance the viability of electric transportation in Nepal.

With the assistance of the electric motor, riders can cover longer distances without feeling as fatigued. This makes e-bikes a great option for commuters to commuters around the city without worrying about charging stations.

Pedal assist for electric bicycles aligns with several Sustainable Development Goals (SDGs) due to its potential to contribute to sustainable transportation, improved health and well-being, reduced environmental impact, and enhanced social equity.

SDG 2: Zero Hunger: Electric Bicycle can help people to get to and from work or school, which can improve their access to food.

SDG 3: Good Health and Well-being: Electric bicycle can make it easier for people to get around, even if they have difficulty walking or cycling long distances. This can help to improve their physical fitness and reduce their risk of chronic diseases.

SDG 7: Affordable and Clean Energy: Electric bicycle utilize electricity as a clean and sustainable energy source, aligning with the goal of promoting affordable and clean energy solutions. They contribute to reduced reliance on fossil fuels and can be charged using renewable energy sources, further supporting this SDG.

SDG 8: Decent Work and Economic Growth: Electric bicycle can help people to find jobs, as it can be a more affordable and efficient way to get around than public transportation or private cars.

SDG 9: Industry, Innovation, and Infrastructure: The development and adoption of pedal-assist electric bicycle require innovation in design, manufacturing, and infrastructure planning. Electric bicycle can also reduce the demand for traditional transportation infrastructure, easing the burden on road networks.

SDG 10: Reduced Inequalities: Electric bicycle can help to reduce inequalities in transportation, as it can be a more accessible way to get around for people with disabilities or limited mobility.

SDG 11: Sustainable Cities and Communities: Electric bicycle can help to reduce traffic congestion and air pollution in cities. This can improve the quality of life for everyone living in cities.

SDG 13: Climate Action: Electric bicycle can help reduce greenhouse gas emissions from transportation. This is because electric bicycles produce zero emissions when they are in use.

1.2 Problem Definition

According to the data published by National Population and Housing Census 2021, only about 3.1% of Nepali households own a four-wheeler (204,990 out of 6,660,841). The vast majority of Nepalese still own two-wheelers – about 27.3% own a motor-cycle (1,816,121 out of 6,660,841). Meanwhile, about 35.2% (2,347,433 out of 6,660,841) own a bicycle. In terms of the ecological belt, the percentage of two-wheeler is highest in the Terai belt (60.10%). This data clearly the interest for two wheelers. There are a lot of people who needs motor cycle for their daily work but they can't afford motor cycle. Farmer, Labor, Daily wages worker, students, watchman and many more people from different professions need a less effort taking and cheap means of transportation. Here comes pedal assist electric bicycle that costs very less than motor cycle and requires less effort than bicycle.

1.3 Objectives:

Primary Objective

The primary objective of our project is to design and develop a pedal-assist system for electric bicycles.

Secondary Objectives:

i. To investigate the effects of pedal assist on the performance of electric bicycles such as speed, range, and battery durability.
ii. To test the pedal assist system under a variety of conditions such as different terrains, loads, and weather conditions.

1.4 Methodology

- Literature review that showcases the groundwork done, summarizing the existing knowledge base and relevant studies about this project.
- Pedal speed has been observed using hall effect sensor.
- Controller has been designed using MATLAB Simulink for modelling then proteus for circuit simulation.
- Programming for speed control have been done on Arduino.
- Speed controlling system needs to be developed.
- Cadence sensor, gyroscope, Speedometer and speed control will be assembled then testing will be done.
- Assembling the whole system with bicycle and its testing will be done.

1.5 Significance of Study

The study on pedal assist for electric bicycles is significant because it can make cycling more sustainable, accessible, and practical. It can also help to reduce traffic congestion, noise pollution, and air pollution.

The study contributes to the promotion of sustainable transportation alternatives by making electric bicycles a more environmentally friendly option. Electric bicycles with pedal assist technology produce zero emissions and require less energy to operate than cars or motorbikes. This can help to reduce air pollution and climate change.

The study also encourages a healthier lifestyle by making cycling more accessible to people who might not otherwise be able to ride a bicycle, such as those with physical limitations. Pedal assist can help people to get more exercise, which is beneficial for their physical health.

Finally, the study has the potential to make cycling more practical for daily commuting and leisure rides. Electric bicycles with pedal assist can travel longer distances and climb hills more easily than traditional bicycles. This can make them a more attractive option for people who need to travel long distances or who live in hilly areas.

Overall, the study on pedal assist for electric bicycles is a significant contribution to the field of sustainable transportation. It has the potential to make cycling more accessible, practical, and sustainable, and to improve the overall quality of life in cities.

CHAPTER 2: TECHNOLOGY & LITERATURE REVIEW

Pedal-assist e-bikes have been progressing since the 19th century. Thus, there have been many projects related to Pedal-assist e-bikes that had been completed and some are in the completion stage. So, in this section literature survey on various papers, books, articles, journals, and websites is mentioned. And the details of the components used and the technology involved are also mentioned.

2.1 Literature Survey

The evolution of pedal-assist e-bikes from basic bicycles has yielded a progressive fusion of electric propulsion technology and conventional cycling. Starting with the integration of electric motors in the early 20th century, subsequent strides in battery efficiency, pedal-assist systems, lightweight designs, smart features, regenerative braking, torque sensors, extended range batteries, electric gear systems, and off-road capabilities have ushered in a new era of versatile and eco-conscious transportation. These advancements have harmonized sustainable commuting with cutting-edge innovation, culminating in sleek, high-performance e-bikes with predictive power management, solar charging integration, and even foldable designs, marking a transformative journey from the humble bicycle.

In the paper [1] The PMDC motor had to be regulated by a mechanism that involved a DC motor driver. This driver had specifications able to withstand up to 20A. The driver is controlled by an Arduino Board which receives input signals via. a potentiometer. The Arduino board was programmed in such a way that varying the resistance in the potentiometer would result in an equivalent value of bytes which the program could comprehend and translate to proportional DC motor speeds. MC33887 Motor Driver is used in this project. This driver can control a single DC motor with maximum consumption of 2.5A and peaks of 5A and Motor voltage can range from 5- 28V in this system.

In the article [2] An Old Bicycle has converted into Hybrid Electric Bike. The components used in this article are Bicycle, Arduino mega, brushless hub motor, lithium-ion battery, Motor Driver I.C., and Accelerometer Gyroscope (MUP-6050 GY-521).

According to the [3] article the E-bike is converted into a Smart E-bike in the UK. Where a ‘smart’ monitoring system was developed (implemented on 30 e-bikes) that autonomously recorded and transmitted the bike’s position, route, and level of assistance (open source, open hardware) in real- time, feeding an online interface for both research analysis and participant review, turning singular e-bikes into a networked fleet.

Paper [4] details the Electric Bike which runs on the battery thereby providing voltage to the motor. This paper compromises with the design and fabrication of the Electric Bike which makes use of Electric energy as the primary source and solar energy, if possible, by attaching solar panels. It also highlights the design aspects of the bike. There is a provision for charging the battery by ejecting it from the main system. The electrical power generated which is used to run the bike can give better fuel economy compared to conventional vehicles, better performance, and also causes less pollution. Here they have used a permanent magnet self-generating motor with 250-watt power and 2100rpm. The motor runs on 48 volts and 7.5-amp power sources. This motor can reach a peak current starting equal to 15 amps.

A hybrid cycle has been made in [5] which has a hub motor, speed controller which also works on the dynamic brake, 12v 9A lead acid battery, and hall effect sensor used to sense the speed of the motor.

In the article [6] the normal cycle has been converted into a pedal-assist e-bike. There are two major components of the pedal that assist. First is the Disc in which magnets are placed, generally six to eight. Here, eight Neodymium Magnets are used. And the second is the magnetic switch which senses the magnet from the disc and completes the circuit. Here, the Reed switch is used by the team.

In the paper [7] throttle control e-bike has been made in which the throttle acts like an accelerator in the bike. But, works a little differently, it controls the current flowing to the motor, and when it rotates it provides more power to the motor, and thus motor will get more power and run faster. Another crucial component is the motor controller which detects the speed of the motor with the help of the hall effect sensor of stator.

2.2 Components survey

As the project of Electrical and Electronics department projects the main concern is about Electrical components rather than Mechanical. So, the major Electrical components that can be used in this project are.

2.2.1 Frame

The bicycle frame provides the structure and support for all other components. It is usually made from materials like aluminum, steel, carbon fiber, or alloy, designed to accommodate both the mechanical and electrical components. And in this project, our personal frame will use.

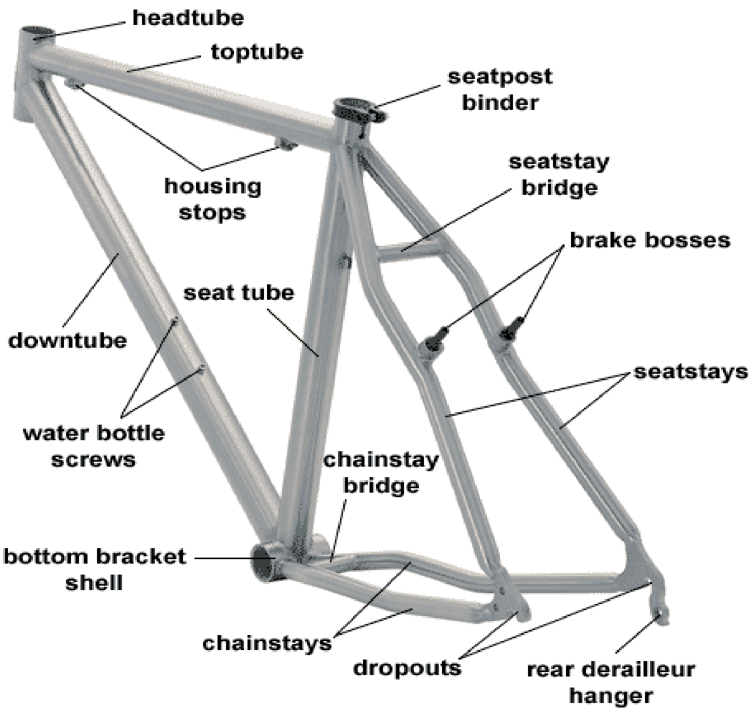


Figure 1: Frame

2.2.2 Battery

The battery is a crucial component that powers the electric motor. Here, lithium-ion is mounted on the frame or within the frame's downtube. Battery voltage is 36v and current rating is according to load i.e. motor.

Figure 2: Battery

2.2.3 Electric Motor

The electric motor assists the rider's pedaling efforts, making cycling easier. It's often located in the hub of the front or rear wheel, or in the bike's mid-drive system (located near the pedals). Motor power is measured in watts and influences the level of assistance provided.

Figure 3: Electric Motor

2.2.4 Controller

The controller manages the interaction between the rider, the motor, and the battery. It enables the rider to control the level of assistance, typically through a display unit or control panel on the handlebars.

Figure 4: Controller

2.2.5 Display Control Unit

This component provides the rider with information about speed, battery level, assist level, and other relevant data. Riders can adjust settings and monitor their ride through this interface.

Figure 5: Display Control Unit

2.2.6 Cadence Sensor

Also known as a torque sensor or cadence sensor, this device detects the rider's pedaling and adjusts the level of motor assistance accordingly. Torque sensors measure the force applied to the pedals, while cadence sensors measure pedaling speed.

Figure 6: Cadence Sensor

2.2.7 Gyroscope

Gyroscope sensor is a device that can measure and maintain the orientation and angular velocity of an object. These are more advanced than accelerometers. These can measure the tilt and lateral orientation of the object whereas accelerometer can only measure the linear motion. Gyroscope sensors are also called as Angular Rate Sensor or Angular Velocity Sensors. These sensors are installed in the applications where the orientation of the object is difficult to sense by humans. Measured in degrees per second, angular velocity is the change in the rotational angle of the object per unit of time.

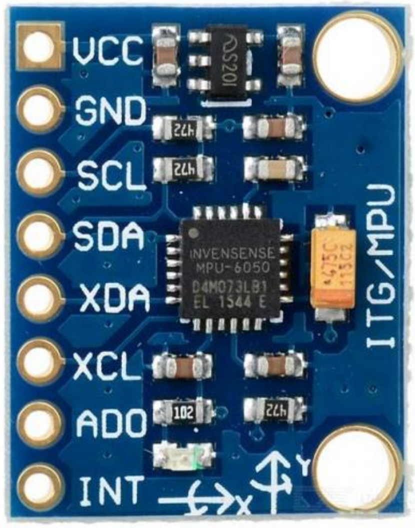


Figure 7: Gyroscope

2.2.8 Speedometer

The provided Arduino program is a comprehensive system for monitoring and displaying various metrics using sensors and peripherals. It begins by initializing an LCD and configuring interrupt handling for a speed sensor. Within the loop function, it continually reads voltage from a sensor and computes the corresponding root mean square (RMS) current and wattage based on these readings. Additionally, it acquires analog input from a temperature sensor and displays it on the LCD. The speedCalc function determines the speed of a rotating wheel by measuring the time taken for a complete rotation using interrupts. The getVPP function reads a voltage sensor over a specific duration to ascertain the peak-to-peak voltage. The LCD is continuously updated with readings of speed, voltage, and current. Although the speed calculation is based on the wheel's circumference rather than its diameter, knowing the diameter allows for the calculation of the circumference, which indirectly influences the speed computation. Alternatively, the program could directly utilize the wheel diameter for more precise speed calculations.

CHAPTER 3: METHODOLOGY

3.1 Flow Chart

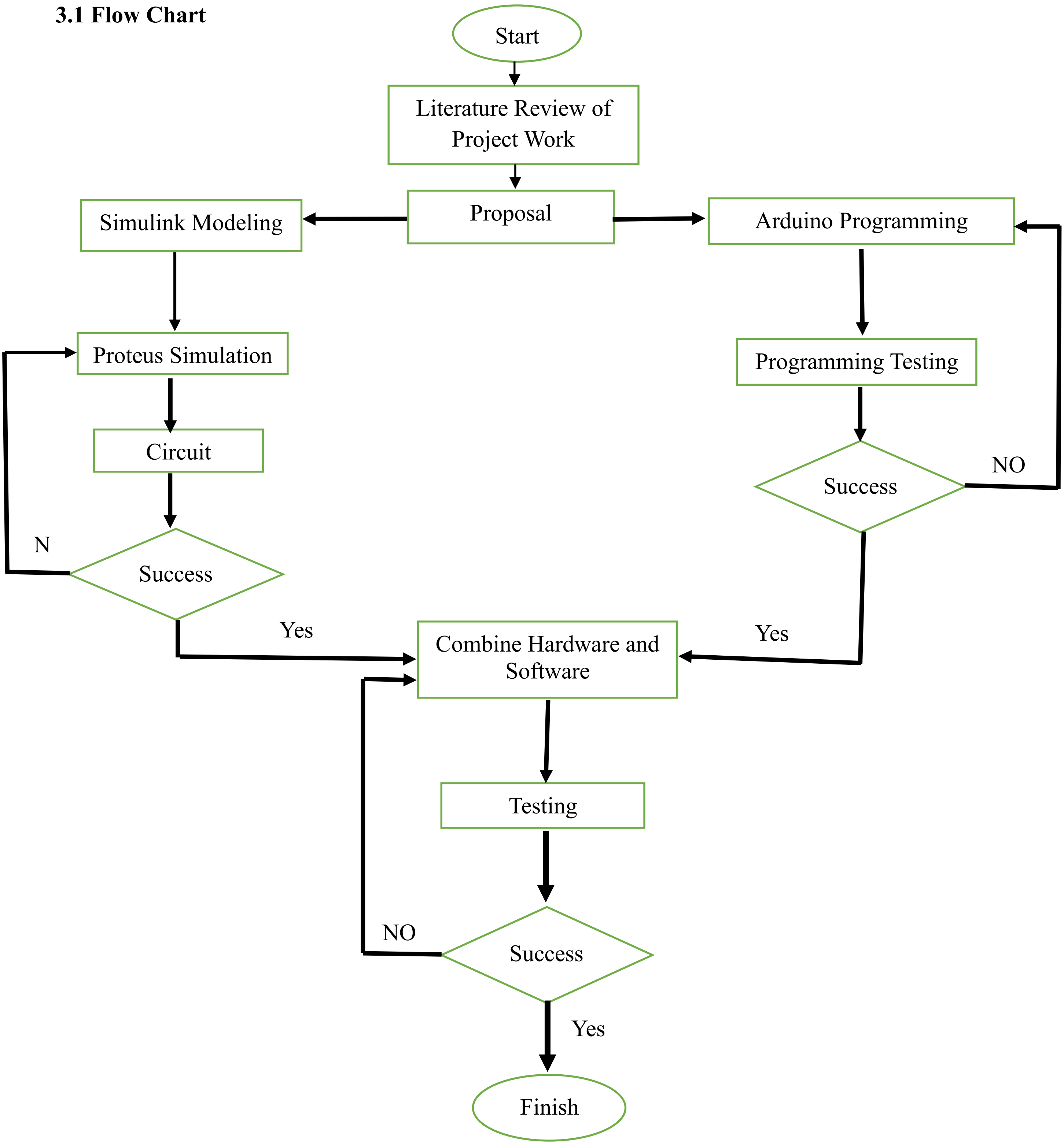


Figure 8: Flow Chart

Firstly, literature review was done for the component selection and proposal. After that Simulink modelling and Arduino program was done parallelly. Simulink modeling was done on proteus and MATLAB then circuit will be made. After that both hardware and software will be assembled together for testing.

3.2 Block Diagram

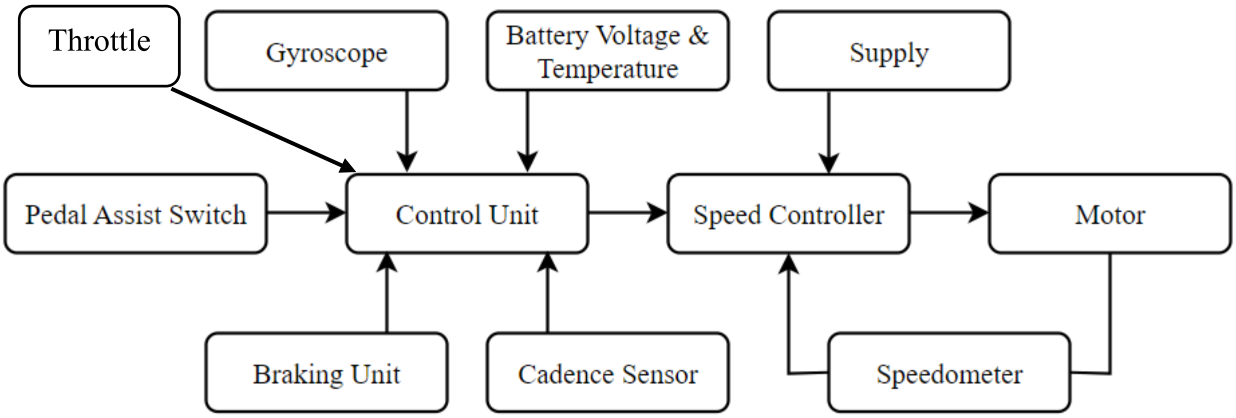


Figure 9: Block Diagram

The functioning of this pedal assist system is facilitated by a central main controller, which processes inputs from the pedal assist switches to determine the appropriate power delivery. Additionally, the main controller integrates data from various sources, such as the battery temperature sensor, brake switches, gyroscope and cadence sensor. These inputs collectively enable the main controller to generate a control signal that regulates the speed controller's operation. The pedal assist system features five distinct levels of assistance:

Level 0: This stage offers no motor assistance, relying solely on the rider's pedaling for propulsion.

Level 1: The motor contributes 30% of the total power required, supplementing the rider's efforts.

Level 2: Stepping up the assistance, the motor provides 60% of the power output, substantially aiding the rider's pedaling action.

Level 3: At this level, the motor takes on a more significant role, contributing 90% of the necessary power, considerably reducing the rider's exertion.

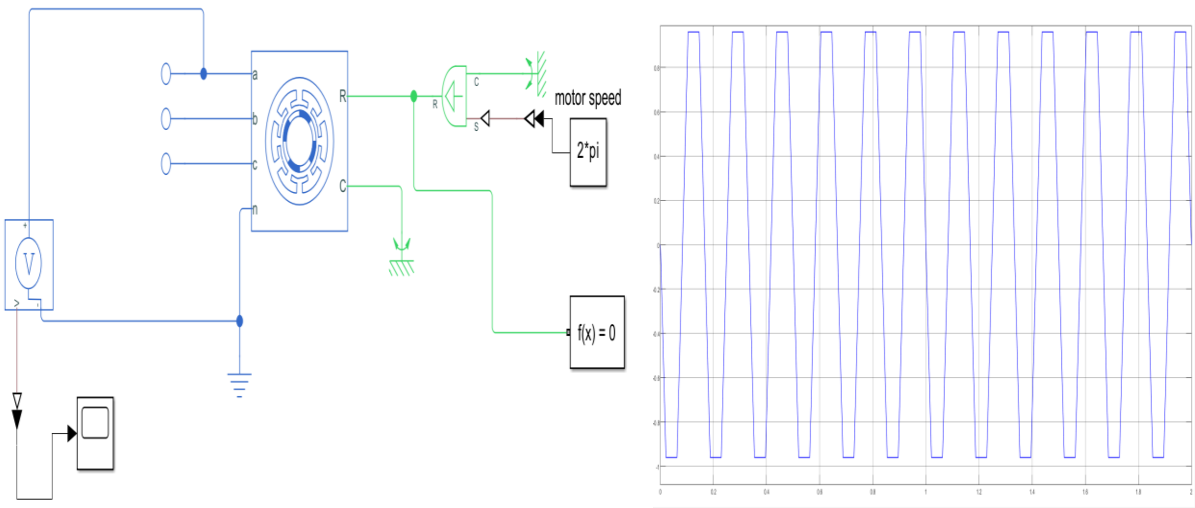
CHAPTER 4: RESULT AND ANALYSIS

4.1 Interfacing cadence sensor with microcontroller

The cadence sensor is composed of a magnet ring and a Hall effect sensor. When the magnet ring passes by, the Hall effect sensor generates an interrupt signal, initiating the microcontroller's counter to tally the number of times the magnet crosses the sensor. Recognizing the limitations of sequential loop execution in delivering precise results, we have implemented interrupt handling and port manipulation in the microcontroller to enhance the accuracy of real-time operations.

4.2 Simulation of BLDC

Simulation of the Speed controller is done on MATLAB and circuit diagram is constructed on EasyEDA.



(a) (b)

Figure 10: (a)Simulink model of BLDC, (b) Input waveform of BLDC

Firstly, we give reference speed to the rotor with the help of 2*pie as shown in above simulation. After that we examine the state or waveform of the voltage. The waveform obtained from the above simulation is trapezoidal wave so we need to prove trapezoidal waveform as input. For this we use three phase inverters, locate the position of rotor with help of positioning sensor and mosfet is used to create changes to get maximum output torque.

4.3 Simulation of BLDC Speed controller

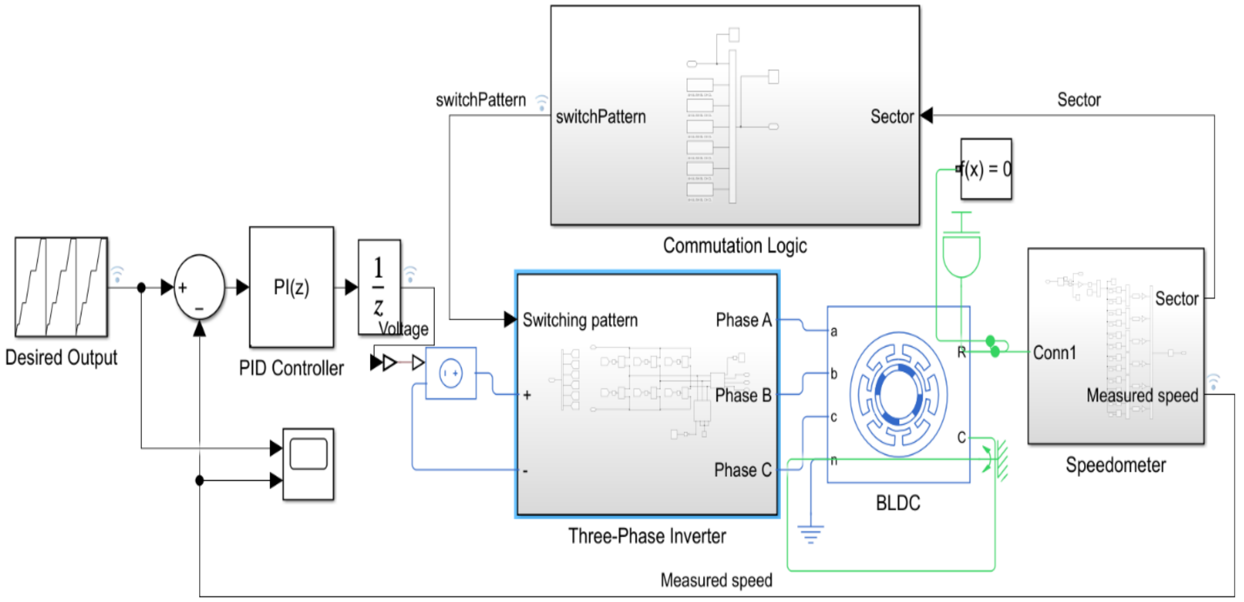


Figure 11: Speed control of BLDC

In the above simulation of speed control of BLDC, three phase inverter provides trapezoidal waveform. Then we have hall effect positioning sensor that detects the position of the rotor. After knowing the position of the rotor, mosfet switches to get maximum torque.

Block Parameters

Time Values	Output Values
0	0
0.1	100
0.2	100
0.4	300
0.7	300
1	600
1.3	600
1.7	900
2	900

4.3.1 Three Phase Inverter

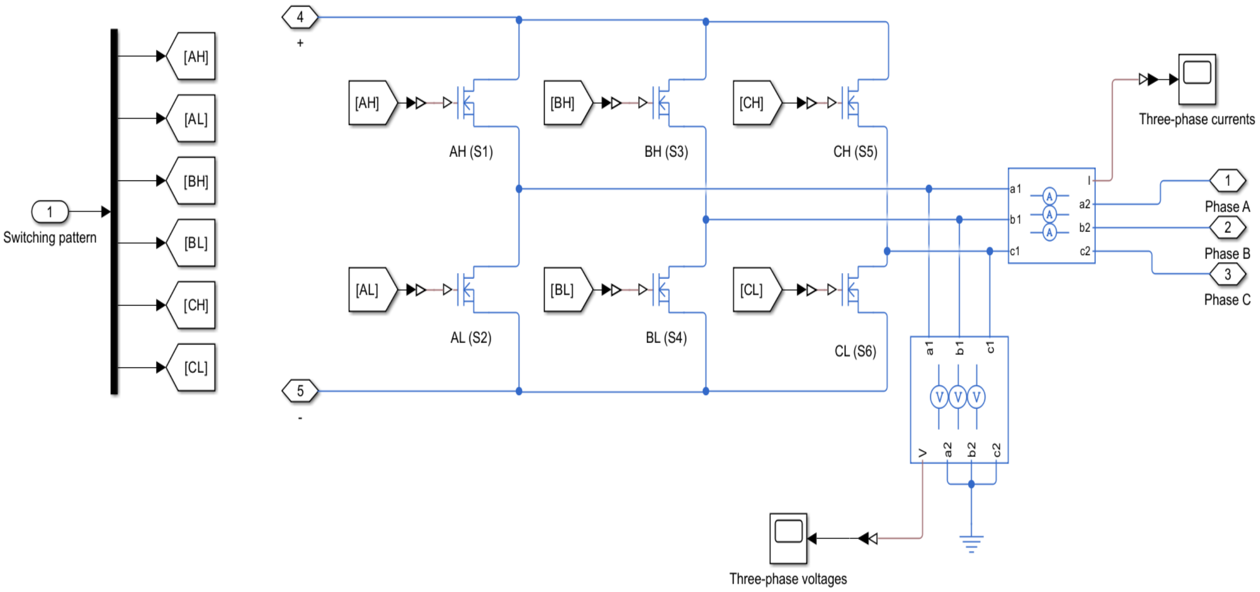


Figure 12:Three Phase Inverter of Controller

To run BLDC motor sequential excitation of the stator must require. So, three leg mosfet are configured so that A, B and C phase are excite subsequently and the time of switching is calculated and set in the simulation as shown above.

4.3.2 Commutation Logic

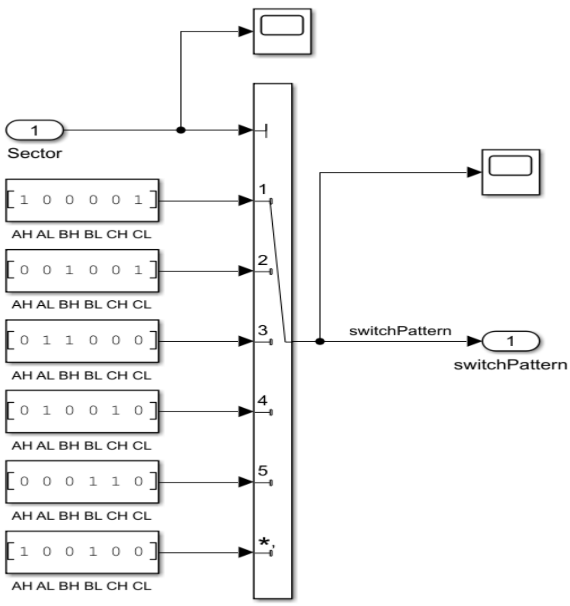


Figure 13:Commutation Logic of BLDC motor.

This is the switching pattern of MOSFET of to switch the stator of BLDC motor. Here, six MOSFET are switching by six switching patterns.

4.3.3 Speedometer

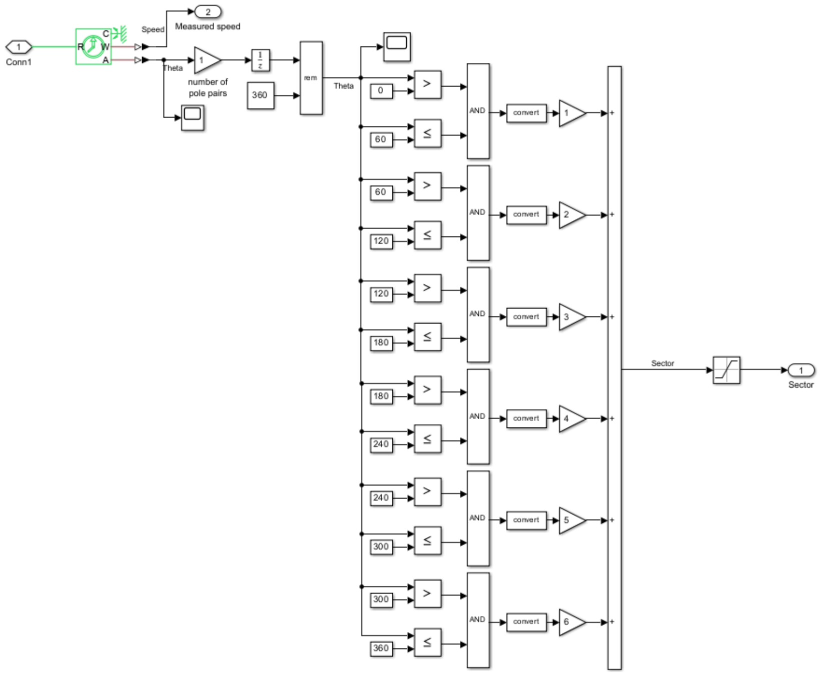


Figure 14:Speedometer sensor of BLDC motor.

This is the method to measure the speed of the motor using Simulink. Here, different angle of the poles of the motor is measured and the speed is detected.

4.4 Installation of speed controller

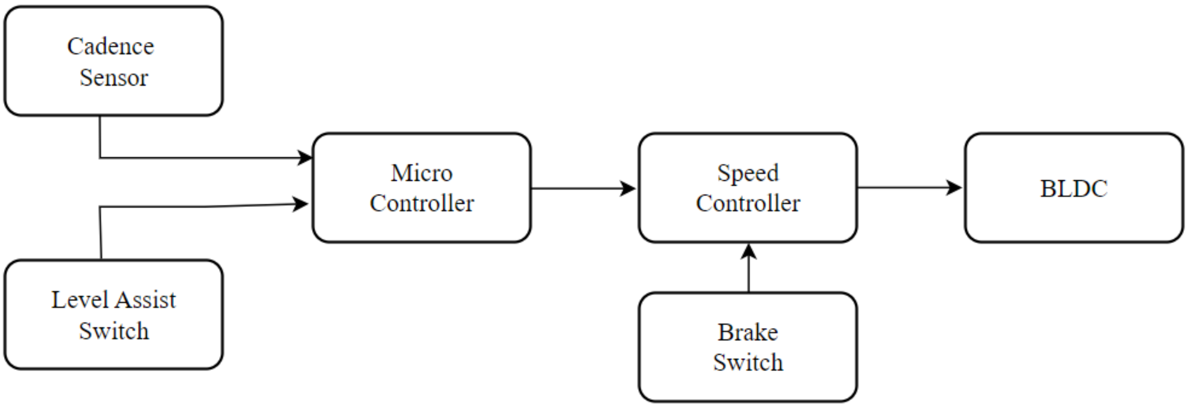


Figure 15: Block diagram of speed controller

Based on the motor specifications (250W, 36V), we've opted for a brushless sensored speed controller with a matching power rating of 250W and a voltage compatibility of 36V. Notably, this controller is equipped with low voltage protection, triggered at 31V. The controller interfaces seamlessly with a microcontroller that accepts variable voltage as a throttle input, ranging from 1V to 5V.

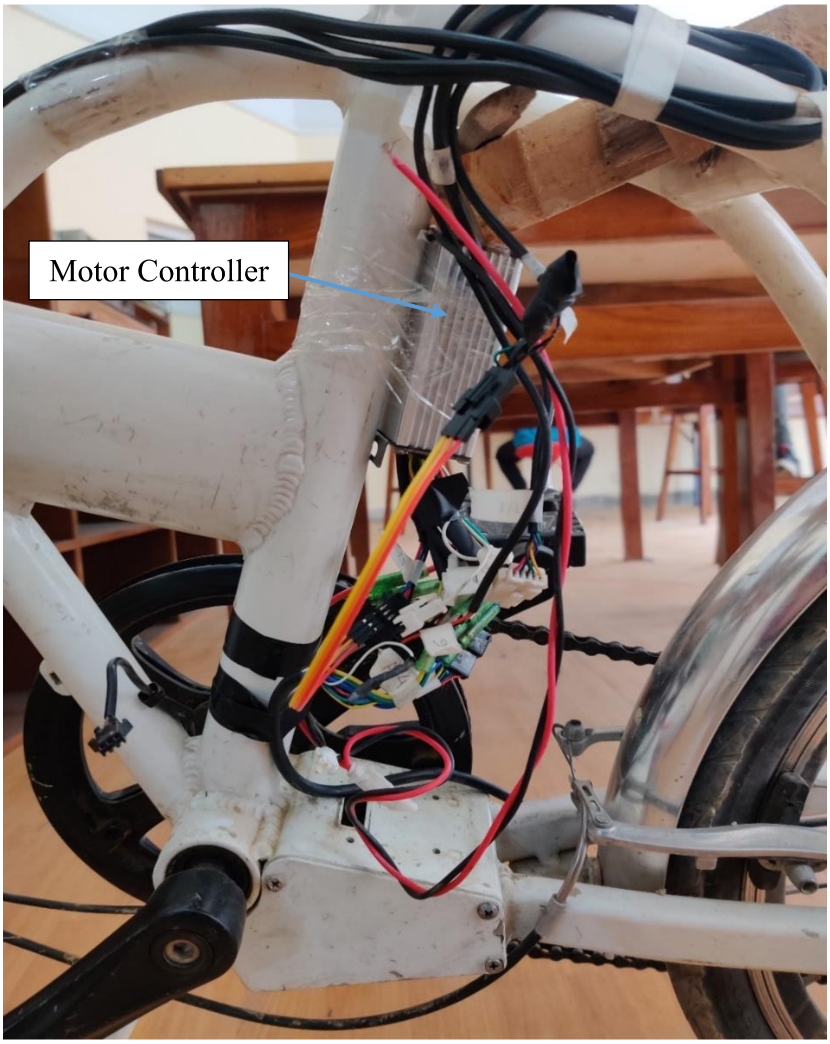


Figure 16: Controller Interfacing

In our setup, we utilize the analog output of the microcontroller, specifically an Arduino, as the throttle input for the speed controller. The interconnection of inputs and outputs for the speed controller is illustrated in the diagram below.

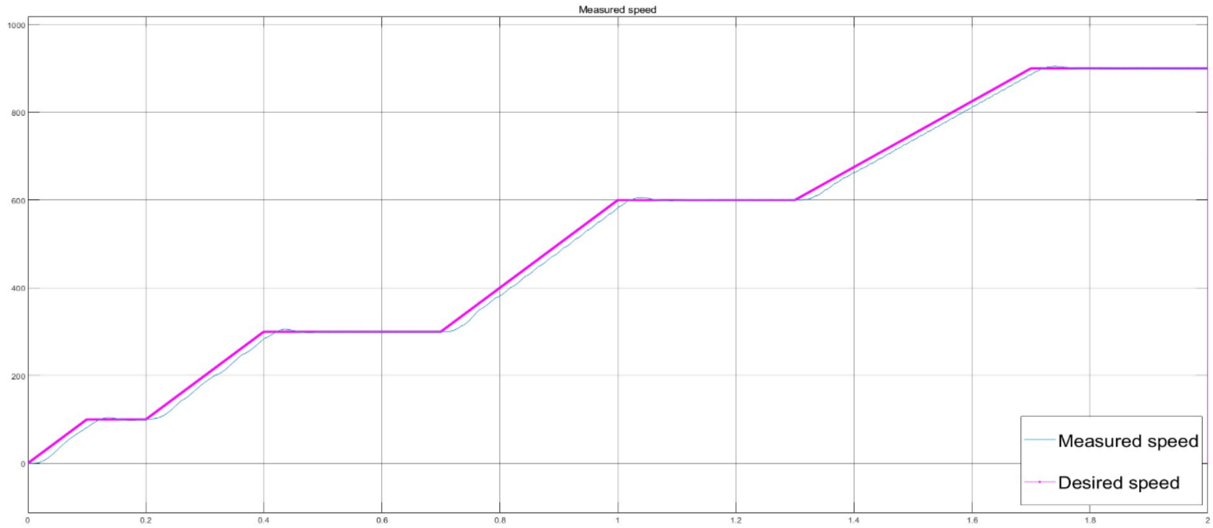


Figure 17: Signal of Reference signal

4.5 Battery pack sizing calculation

For a lithium-ion battery, the formula for the battery capacity is:

$$T = \frac{ditance\ travelled}{speed} = \frac{50\ km}{25\ km/hr} = 2\ \text{hr}$$

$$B_{li} = \frac{100*Il*t}{100-Q} = \frac{100*6*2}{100-10} = 13.33\ \text{Ah} = 15\text{Ah (with 12.5\% safety)}$$

Where,

B_{li} = Battery Capacity

I_L = Load current

t= Duration for which the electrical power is supplied to the load

Q = Percentage of charge that should remain after the battery is used.

We employ a 250W 36V motor, requiring a battery with a voltage matching the motor's specifications. Our choice is a li-ion battery with a nominal voltage of 3.7V and a maximum of 4.2V. By connecting 10 batteries in series, we achieve a total voltage of 37V and 42V when fully charged. Opting for 5000mAh 18650 li-ion batteries is an optimal decision. Through the series connection of 3 sets of 10 batteries, we create a total of 60 batteries, resulting in a combined battery capacity of 15000mAh.

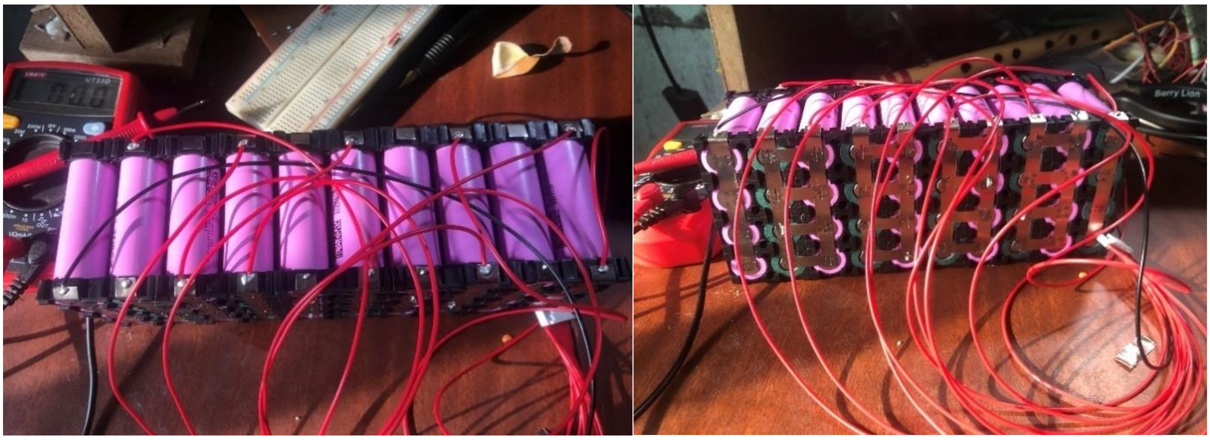


Figure 18: Battery Pack

4.6 Motor Size Selection

Wheel Diameter(D) = 0.66m (26 inches)

Radius(R)=0.33m

Total weight = Cycle weight + Battery & Controller Pack + Rider weight

= 15+5+70

=90 kg

Required speed = 25 kmph = 25000/3600 = 6.94 m/s

F_P = Propulsion Force

F_D = Down force from Gravity

F_{WF} = Windage & Friction Drag

F_R = Rolling Resistance

Consider the road Grade = 2.7%

$\alpha = \tan^{-1}(\text{slope})$

$= \tan^{-1}(2.7/100)$

$= \tan^{-1}(0.027)$

$\alpha = 1.56$ degree

<u>To Finding F_D (Gradient Resistance)</u>

$F_D = m * \sin\alpha$

$= 90 * 9.8 * \sin 1.56$

$= 24.01$ N

To Find F_{WF} (Aero Resistance)

Cd = Coefficient of air drag = 0.7

ρ = Density = 1.225 kg/m^3

A = Frontal Area of Bicycle = 0.37 m^2

V = Velocity of Bicycle = 25 km/h = 6.94 m/s

$F_{WF} = 0.5 * Cd * \rho * A * V^2$

$F_{WF} = 0.5 * 0.7 * 1.225 * 0.37 * (6.94)^2$

$F_{WF} = 7.64$ N

To Find F_R (Rolling Resistance)

C_R = Rolling CO-efficient = 0.004(for cycle)

$F_R = C_R * mg \cos\alpha$

$= 0.004 * 90 * 9.8 * \cos(1.56)$

$= 3.52$ N

Total Propulsion Force, F_P

$F_P = F_D + F_{WF} + F_R$

$F_P = 24.01+7.64+3.52$

$F_P = 35.17$ N

Propulsion Power = FP * Velocity

= 35.17 N * 6.94 m/s

= 244.08 W

Thus, 250W motor is selected.

4.6 Display, Gyroscope And CT

(a) (b)

Figure 19: (a) Display and CT (b) Gyroscope

Here, 20*4 LCD display is used to display speed, voltage, Battery Temperature and the current of the motor. Where, CT sense the current from the motor and the speed is measured using Speedometer as shown above, voltage is measured using potentiometer and battery temperature is measured using lm35 temperature sensor. Gyroscope is implemented in the system which sense the inclination of the road and power will supply accordingly.

4.7 Speedometer

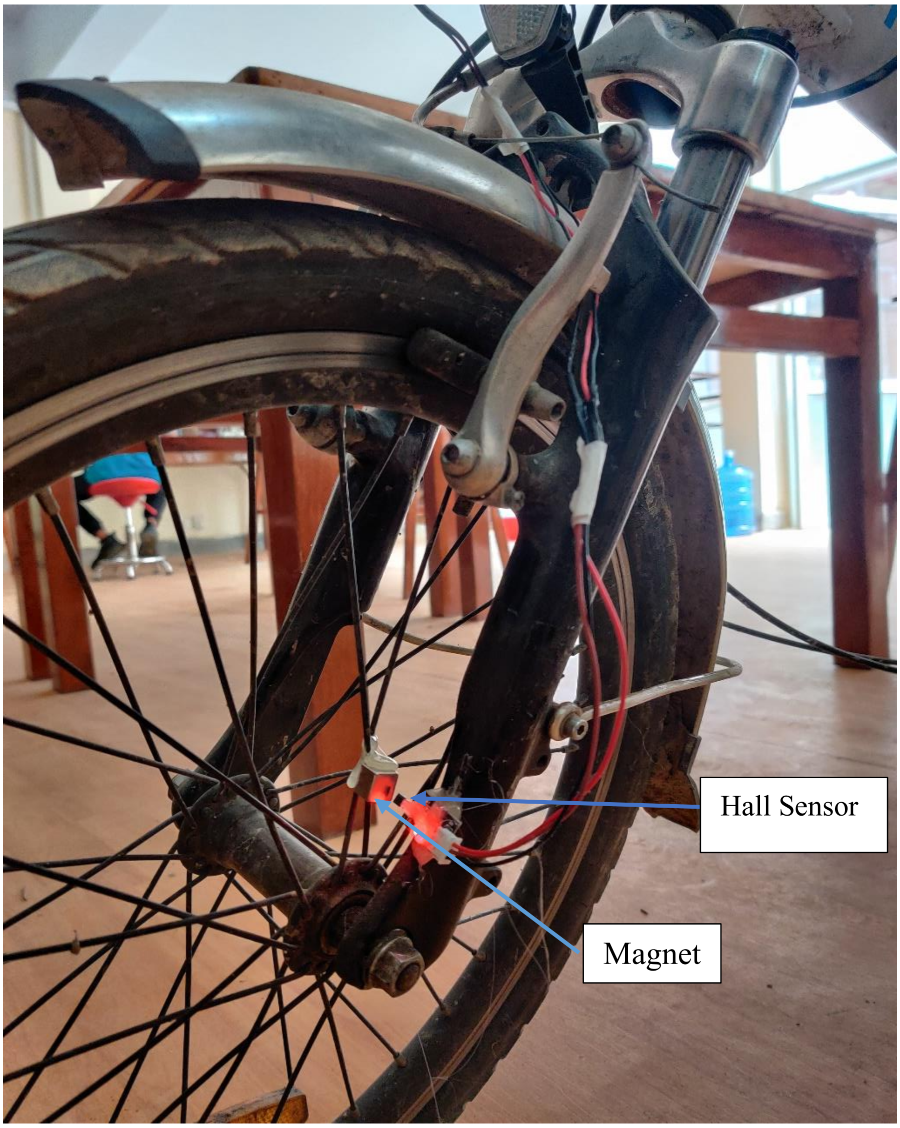


Figure 20: Speedometer implementation

The provided Arduino program is a comprehensive system for monitoring and displaying various metrics using sensors and peripherals. It begins by initializing an LCD and configuring interrupt handling for a speed sensor. Within the loop function, it continually reads voltage from a sensor and computes the corresponding root mean square (RMS) current and wattage based on these readings. Additionally, it acquires analog input from a temperature sensor and displays it on the LCD. The speedCalc function determines the speed of a rotating wheel by measuring the time taken for a complete rotation using interrupts. The getVPP function reads a voltage sensor over a specific duration to ascertain the peak-to-peak voltage. The LCD is continuously updated with readings of speed, voltage, and current. Although the speed calculation is based on the wheel's circumference rather than its diameter, knowing the diameter allows for the calculation of the circumference, which indirectly influences the speed computation. Alternatively, the program could directly utilize the wheel diameter for more precise speed calculations.

4.8 Kalman Approximation

Error correction using a Kalman filter approximation in a gyroscope involves continuously updating the estimated orientation based on gyroscope measurements while also correcting for errors that may arise over time. Here's how this process generally works:

1. Initialization: The Kalman filter is initialized with an initial estimate of the orientation and its covariance matrix. This estimate could come from any available information or could be set to a default value if no prior information is available.

2. Prediction Step: At each time step, the filter predicts the current state of the system (orientation) using the gyroscope measurements. This prediction incorporates the system dynamics and any known noise characteristics. The predicted orientation is then updated based on the integration of gyroscope measurements over time.

3. Error Correction: In addition to using gyroscope measurements for prediction, the Kalman filter also utilizes other sensor data, such as accelerometers and magnetometers, to correct for errors that accumulate over time. These sensors provide information about the orientation of gravity and magnetic fields, which can be used to correct drift and bias in the gyroscope measurements. The Kalman filter adjusts the predicted orientation based on the difference between the predicted orientation and the orientation estimated from accelerometer and magnetometer readings.

4. Update Step: After incorporating the error correction, the Kalman filter updates the estimated orientation by combining the predicted orientation with the corrected orientation obtained from accelerometer and magnetometer data. This update is performed using a weighted average, where the weights are determined by the uncertainties associated with the prediction and the correction.

5. Iterative Process: The prediction, error correction, and update steps are repeated iteratively as new measurements become available. Each iteration refines the estimated orientation based on the current sensor readings and the previous estimates.

By continuously integrating gyroscope measurements for prediction and correcting for errors using accelerometer and magnetometer data, the Kalman filter approximation enables accurate estimation of the orientation of an object, even in the presence of noise, drift, and bias in the gyroscope measurements. This approach provides robustness and stability to orientation estimation systems, making them suitable for various applications such as navigation, motion tracking, and robotics.

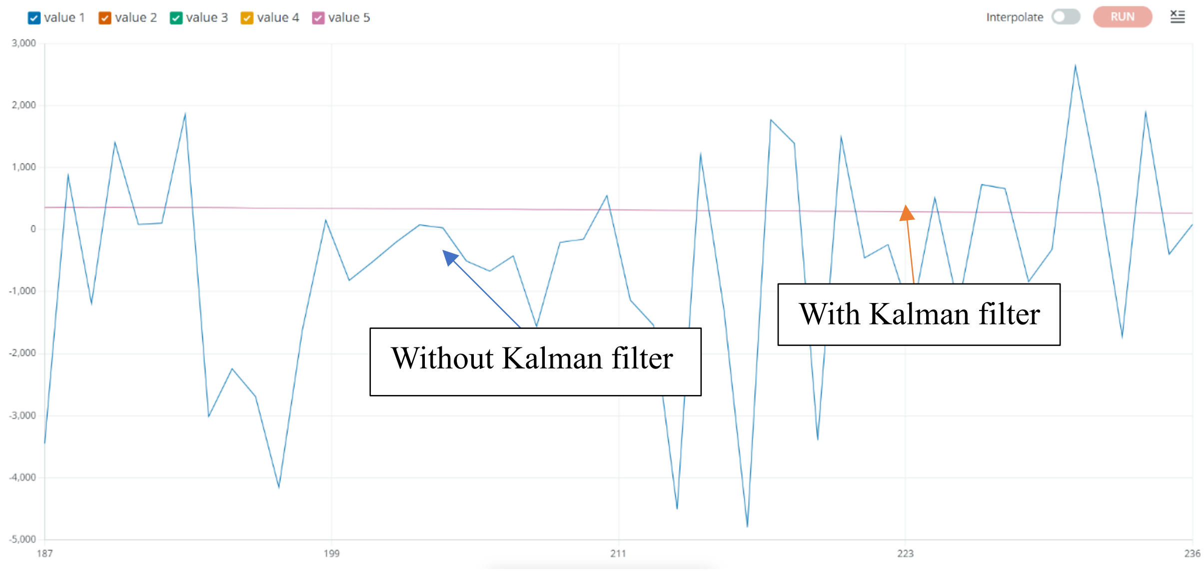


Figure 21: Angle Variation with and without Kalman Filter

4.9 Implementation of Multi-threading on Ebike.

Using FreeRTOS on ESP (Espressif) microcontrollers offers several advantages:

Multitasking: FreeRTOS allows you to create multiple tasks that can run concurrently. This is particularly useful in scenarios where you need to perform several tasks simultaneously, such as handling sensor data while maintaining a responsive user interface.

Task Scheduling: FreeRTOS provides task scheduling mechanisms that allow you to prioritize tasks based on their importance and execution requirements. This ensures that critical tasks get executed promptly, improving overall system efficiency.

Resource Management: With FreeRTOS, you can efficiently manage system resources such as CPU time, memory, and peripherals. This helps in preventing resource conflicts and ensures optimal utilization of available resources.

Interrupt Handling: FreeRTOS provides mechanisms for handling interrupts within tasks. This is essential for real-time applications where timely response to external events is crucial.

4.10 Implementation Self optimization system

Our system utilizes pedal RPM data from the cadence sensor. However, given the variability in riders' styles, our system autonomously tracks riding behavior by logging maximum, average, and minimum pedaling speeds. It then adjusts power delivery accordingly for optimized performance.

CHAPTER 5: CONCLUSION

This project focused on the development of a pedal assist system for e-bikes, with particular emphasis on the simulation of the speed controller and the implementation of the cadence sensor. The simulation of the speed controller proved to be successful, demonstrating its efficacy in regulating the e-bike's speed based on the rider's pedal input.

Furthermore, the integration of the cadence sensor into the system has been completed, providing a crucial element for accurate pedal assistance. The cadence sensor ensures a responsive and intuitive experience for the rider, aligning the electric assistance with their pedaling rhythm effectively.

Gantt Chart

S. N	Month	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1.	Project Selection								
2.	Literature Review								
3.	Component Selection								
4.	Proposal Submission								
5.	Proposal Defense								
6.	Simulation								
7.	Testing								
8.	Midterm Presentation								
9.	Assemble & Testing								
10.	Complete Project								
11.	Final Presentation								

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	Task Completed
	Task Remaining

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APPENDIX

Arduino Program for speed of the padel

```
const byte interruptPin = 2;
volatile unsigned long last;
volatile unsigned int count;
#define DEBOUNCE TIME 100
void isr()
{
if((millis() - last) >= DEBOUNCE_TIME ) {
count ++;
}
}
void setup()
{
Serial.begin(9600);
attachInterrupt(digitalPinToInterrupt(interruptPin), isr, HIGH);
}
void loop()
{
Serial.println(count);
count=0;
delay(100);
}
```