Design and Implementation of Electric Assisted Bicycle by Self-Recharging Mechanism

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DECLARATION

We solemnly declare that this report is written by us and is not copied from any online or printed material.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

KWh: Kilowatt Hour

PM: Permanent Magnet

IGBT: Insulated Gate Bipolar Transistor

FYP: Final Year Project

E-Bicyle : Electric Bicycle

BMS: Battery Management System

DC: Direct current

BLDC: Brushless DC motor

ABSTRACT

During the revolution for environmentally-friendly technologies, bicycles emerged as the primary mode of transportation. Considering the increasing fuel prices and the need to address environmental concerns, it becomes necessary that bicycles should be used for short-distance travel compared to motor vehicles. With this vision in mind, we embarked on the development of our project, "The e-Bike."

Our project integrates bicycle with an electric power to provide assistance to riders throughout their journey. The system has been modified to allow riders to choose their preferred mode of transportation. They can opt for a fully electric motor-driven bicycle or manually operate it themselves. The decision to mount the motor cum alternator assembly onto bicycle was aimed at minimizing the additional effort required, considering the slight increase in weight that the rider would have to bear. A comprehensive analysis of the overall weight has been included in the report.[1]

The design ensures that individuals of all age groups can rely on it. Our implementation of the project was primarily focused on establishing an inter-college transportation system while reducing the dependence on automobiles within the campus. This initiative serves as a tribute to the principles of "GREEN ENERGY."

Keyword: Electric bicycle, BLDC,Boost converter, Generator

CHAPTER 1:

INTRODUCTION

The growing concerns of global warming and the increasing scarcity of traditional resources have prompted a shift towards sustainable and eco-friendly modes of transportation. As the automotive sector struggles with economic challenges, the Electric Bicycle market has emerged with significant growth potential. People are embracing the concept of "clean" energies, seeking alternatives that are environmentally responsible and energy-efficient.

In this context, the focus of this project is to design and implement an Electrically Assisted Bicycle with a Self-Recharging Mechanism. The integration of electric propulsion with traditional bicycle mechanics aims to provide riders with enhanced mobility.This project seeks to address the limitations of conventional bicycles and electric scooters[2] by incorporating a self-recharging mechanism that enhances convenience and improves the range of the electric-assisted bicycle.

In order to realize the full potential of electric bicycles, it is crucial to make them affordable and accessible to a wider range of individuals. Currently, the existing electric scooters in the market are often prohibitively expensive, making them out of reach for the middle-class population. Thus, a key objective of this project is to develop a cost-effective solution that caters to the needs and budgets of the common people, ensuring widespread adoption and maximizing the positive impact on society.

Additionally, the project will emphasize the importance of maintaining high-quality standards while ensuring low production costs. By employing efficient manufacturing processes and utilizing suitable materials, the goal is to create a product that is not only affordable but also durable and reliable. By achieving a balance between cost-effectiveness and quality, the project aims to position the Electrically Assisted Bicycle with Self-Recharging Mechanism as a competitive option in the market.

Overall, this project aims to contribute to the ongoing global efforts in promoting sustainable transportation solutions. Through the design and implementation of the Electrically Assisted Bicycle with Self-Recharging Mechanism, we aim to address the pressing challenges of global warming, resource shortage, and the need for affordable and environmentally friendly mobility options. By embracing clean energy technologies and innovative design approaches, we envision a future where electric bicycles play a pivotal role in creating a more sustainable world.

1.1 Overview:

The project titled "Design and Implementation of Electrically Assisted Bicycle with Self-Recharging Mechanism" aims to develop an innovative and sustainable solution for transportation. This project recognizes the severe global issues of global warming, resource scarcity, and the need for cleaner and more efficient modes of mobility. By making this project we seek to create an electric bicycle that offers enhanced convenience, extended range, and reduced environmental impact.

The primary objective of this project is to design and implement an Electrically Assisted Bicycle that can seamlessly integrate electric power with human muscular strength. By adding an electric motor to provide assistance to riders, the bicycle aims to address the physical limitations of traditional bicycles, particularly when it comes to climbing slopes or passing through rough terrains. This electric assistance not only makes cycling more accessible for most individuals but also promotes a healthful and more active lifestyle.[3]

In addition to the electric assistance, the project focuses to add a self-recharging mechanism into the electric bicycle.By enabling the bicycle to recharge itself, the project aims to extend the range of the electric bicycle, making it a more useful and reliable mode of transportation.

Ultimately, the project seeks to contribute to the global efforts in promoting sustainable transportation solutions. By developing this project we aim to offer a practical alternative to conventional modes of transportation which contribute significantly to pollute the environment and resource depletion. Through the adoption of clean energy technologies, the project proposes a future where electric bicycles play an important role in creating a greener, healthier, and more sustainable environment.

1.2 Statement of Problem:

The project "Design and Implementation of Electrically Assisted Bicycle with Self-Recharging Mechanism" addresses several key challenges and issues in the realm of urban transportation. The following problem statement highlights the specific concerns that this project aims to overcome:

In the current scenario, global warming and resource scarcity have become pressing issues, necessitating the adoption of sustainable and environmentally friendly transportation solutions. Traditional modes of transportation, particularly automobiles, contribute significantly to pollution and greenhouse gas emissions. Additionally, the rising cost of fuel and the limited availability of traditional resources further underscore the need for alternative modes of mobility.[4]

While electric bicycles offer a promising solution to these challenges, there are certain limitations that hinder their widespread adoption. Existing electric bicycles often have limited range and can be costly, making them inaccessible to a significant portion of the population. Furthermore,

recharging these bicycles typically relies on external power sources, which may not always be readily available or environmentally friendly.

To address these limitations, the project aims to develop an Electrically Assisted Bicycle with a Self-Recharging Mechanism. The specific problem areas this project seeks to tackle are as follows:

1. Limited Range: Traditional electric bicycles have a restricted range due to their reliance on battery power alone. This limitation hampers their usability and practicality, particularly for longer distances or hilly terrains. There is a need to extend the range of electric bicycles to ensure they can effectively replace conventional modes of transportation.
2. High Cost: The electric scooters and bicycles currently in the market are often expensive, making them inaccessible to a significant portion of the individuals, especially the middle-class. The project aims to develop an affordable electric bicycle without compromising on quality and performance, ensuring accessibility for a wider range of population.
3. Dependence on External Power Sources: Most electric bicycles rely on external power sources for recharging, which may not always be convenient. The project intends to add a self-recharging mechanism into the bicycle, using renewable energy sources such as regenerative braking. This will decrease dependence on traditional power grids and enhance the environmental sustainability.
4. User Experience and Acceptance: The success of any transportation solution depends on user experience and acceptance. The project counts the importance of understanding user preferences and requirements to design an electric bicycle that meets their needs. Conducting market research and user surveys will help identify potential barriers, gather feedback, and ensure the final product is according to the user expectations.

By addressing these problem areas, the project aims to overcome the limitations of existing electric bicycles and offer a sustainable and cost-effective solution for urban transportation.

1.3 Applications:

The main purpose of this project is to purpose a mode of transportation that is environment friendly and also accessible for most of people. We implemented technology to provide an extra boost to cover long distances with less effort. It not only improves physical fitness but also it is cost saving over other vehicles. In certain rules electric bicycles are taken as simple bicycles thus it avoids complicated processes like complex registration process, licenses, plates, and insurance that is only for motor vehicles.

1.4 Theoretical Bases and Organizations:

In the domain of transportation, significant advancements have been made in the development of high-tech vehicles. However, it is essential not to ignore the importance of bicycles. Bicycles have gained popularity across the globe due to their lightweight design, ease of handling, and cost-effective operation that eliminates the need for fuel. Particularly for short-distance travel, bicycles prove to be highly efficient. Moreover, bicycles possess several distinctive qualities that set them apart from other vehicles. They do not require registration fees, insurance, or a driving license,

making them a hassle-free mode of transportation. Additionally, bicycles are associated with lower risks of severe accidents, thus promoting safer commuting. Furthermore, riding a bicycle offers significant health benefits akin to engaging in physical exercise.

It is important to note that e-bikes belong to specific standards to differentiate them from motorbikes.While the use of e-bikes is a relatively new concept in Europe, it has gained significant resistance in countries like India and China. Notably, in China, e-bikes have experienced a substantial surge in popularity, outnumbering cars by a ratio of four to one.

1.5 Summary:

The project "Design and Implementation of Electrically Assisted Bicycle with Self-Recharging Mechanism"[5] aims to tackle the limitations of traditional bicycles and existing electric bicycles while improving the urban transportation. By adding innovative features, the project provides an efficient, eco-friendly, and cost-effective mode of transportation.

Recognizing the popularity of bicycles due to their lightweight design and affordability, the project needs for improvements in terms of range and power assistance. The project focuses on developing an electrically assisted bicycle with a self-recharging mechanism to enhance the riding experience and tackle the limitations of traditional bikes.

The proposed design includes a motor system, a controller for power management, and a rechargeable battery. This setup allows riders to cover longer distances easily.The self-recharging mechanism utilizes renewable energy sources, reducing dependence on traditional power sources and minimizing environmental impact.

Aligned with sustainable city initiatives, the project contributes to reducing pollution and improving air quality. By promoting reducing carbon emissions, the electric bicycle offers a greener alternative to traditional motor vehicles.

In conclusion, the "Design and Implementation of Electrically Assisted Bicycle with Self-Recharging Mechanism" project aims to provide an efficient, eco-friendly, and affordable mode of transportation. Through innovative design and sustainable features, the project attempts to enhance the riding experience, promote physical exercise, and contribute to a greener environment.

CHAPTER 2:

LITERATURE REVIEW

The literature review provides an overview of subsisting research and knowledge relevant to the project.It explores various studies, advancements, and perceptions related to electric bicycles, self-recharging mechanisms, and their effects on viable non-rural transportation.

Electric bicycles, also known as e-bikes, have gotten high attention in recent years as a viable alternative to traditional bicycles and motor vehicles. Studies have shown that e-bikes offer several advantages, such as increased range, enhanced mobility, and reduced physical exertion during long-distance or uphill rides. Due to the additional electric assistance people get more attracted to bicycles that means it promotes more environmental friendly mode of transport as well as it reduces issues of traffic.

Self recharging mechanism is the most attentive thing in the field of electric bicycles. Research has explored different methods to use renewable energy sources to recharge batteries of these E-bikes. For instance, regenerative braking systems have been investigated, which convert kinetic energy generated during braking into electrical energy to replenish the battery.These advancements in self-recharging mechanisms contribute to the sustainability and efficiency of e-bikes, reducing their reliance on external power sources and minimizing their environmental impact.

Several studies have examined the impact of e-bikes on urban transportation and sustainability. Research findings indicate that e-bikes can effectively replace short car trips, reducing carbon emissions and traffic congestion in urban areas. By providing a flexible and efficient mode of transportation, e-bikes contribute to improving air quality, promoting physical activity, and enhancing overall urban mobility. Additionally, studies have highlighted the potential economic benefits of e-bikes, including reduced fuel consumption, savings on maintenance costs, and improved productivity due to reduced travel times.

Moreover studies have revealed that user have positive attitude to adopt electric bikes as a mode of transportation.Users like the addition of electric assistance and it also makes it more accessible even for those who have some physical limitations or have financial issues. The convenience, affordability, and health benefits associated with e-bikes have led to increased adoption rates in various cities around the world.[6]

In conclusion, the literature review demonstrates that electric bicycles, particularly those equipped with self-recharging mechanisms, have the potential to revolutionize non-rural transportation by

offering a sustainable, efficient, and accessible mode of mobility. The existing research highlights the advantages of e-bikes, including extended range, reduced physical struggle, and positive environmental impacts. Moreover, studies emphasize the importance of self-recharging mechanisms in enhancing the sustainability and efficiency of e-bikes. The literature supports the theory for the proposed project and provides a solid foundation for the design and implementation of an electrically assisted bike with a self-recharging mechanism.

2.1 Working of Proposed E-Bicycle:

Electrically-assisted bikes can be categorized into two main types: fully electric bikes and power-assisted bicycles. Fully electric bikes integrate an electric motor into the bicycle's frame or wheels, and they are propelled using a throttle that drives the motor force. While other type means we can add pedal assistance using human power to make it hybrid. These bikes provide assistance to the rider only when they are pedaling. The overall propulsion is determined by the combined forces of the electric motor and the rider's pedaling effort. Proper management of the electric assistance is important for achieving optimal performance in terms of driving, comfort, and battery liberty.[7]

Electric bicycle have three main components: a battery, an electric motor, and a controller. The battery provides the power source for the electric motor, which drives the bike's movement. The controller plays a vital role in managing the electric motor and regulating its assistance level.

Electric motors can be mounted on the bicycle in various ways. One common loom is to mount the motor straightly on one of the wheels, known as hub mounted motors. Another method involves using the motor to drive the tire or rim through friction, although this approach is less common. Motors can also be linked to the bike's transmission system, through pedals or the chain. This design allows the rider to benefit from the electric assistance while pedaling.

With recent technological advancements, e-bike systems have become more classy. Some systems even utilize smart phones to monitor the rider's pulse rate and adjust the level of assistance accordingly. These technologies enable cyclists to ride more efficiently on different routes based on their physical power and ability. According to the physical power and ability riders can drive on different routes because of these technologies.

Regarding control system mostly PI controllers are used to change the speed of electric vehicle by adjusting the control input to motor.

In conclusion, electrically-assisted bikes offer a range of options for riders seeking additional support during their cycling journeys. The components of an electric bike, including the battery, electric motor, and controller, work together to provide efficient and comfortable transportation. Advancements in technology have led to more sophisticated e-bike systems that tailor the level of assistance to the rider's needs. The PI controllers further enhances the performance and energy efficiency of electric bicycles.

2.2 Structure of Proposed E-Bicycle:

2.2.1 Proposed E-Bike Block Diagram and Information

A proposed diagram is shown below that outlines its components. It includes a battery, a controller for the BLDC (Brushless Direct Current) motor drive, a throttle valve, and various other parts. The shaft of the BLDC motor in the E-Bike is driven by lithium-ion battery.

Lithium-ion batteries are widely used in Electric Vehicles (EVs) due to their high charge power, excellent battery efficiency, and minimal maintenance requirements. In the case of the proposed E-Bike, it is powered by a 48V, 12AH lithium-ion battery. This battery provides the necessary electrical energy to drive the motor and propel the E-Bike forward.

The block diagram depicts the structure of bicycle and also shows the flow of power within the proposed E-Bike. The battery serves as the primary power source, supplying electricity to the controller. The controller then manages the power delivery to the BLDC motor depending upon input from the throttle valve. The throttle valve allows the rider to control the speed and acceleration of the E-Bike by adjusting the power output of the motor.

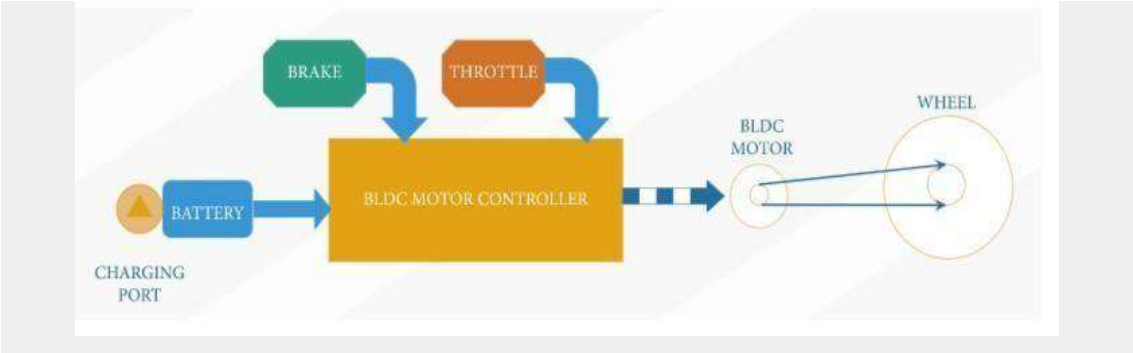


Fig 2.1: Representation of the Proposed E-Bicycle Prototype Model Blocks

2.3 Summary:

A study was conducted in 2018 in which about 1800 new ebike owners said that those individuals who have physical limitations use ebikes for fitness and enjoyment while young adults tend to use for moving from one place to other. The introduction of electric assist in bicycles has expanded the rider base and increased the frequency and duration of trips.

There is more sense of safety for riders according to them while driving electric bicycles, as they feel more confident in navigating wider intersections and challenging terrains. This increased confidence contributes to a positive impact on accessibility and inclusivity, leading to the acceptance of e-bikes as "other power-driven mobility devices" (OPDMDs) in accordance with ADA regulations.[8]

Moreover it has also be seen that ebikers also like to cover long distances frequently, which has demonstrated numerous health benefits associated with regular physical activity. The appeal of e-

bikes is particularly strong among the baby generation, who are aging and find electric bikes to be an smart option for maintaining an active standard of living.

While concerns about e-bikes exist, they are typically more focused on issues related to safety, speed, and crowding as compared to traditional bicycles.

Overall, the utilization of e-bikes has shown positive impacts on various aspects, including rider stats, safety perceptions, convenience, health benefits, and the encouragement of an active standard of living.

Chapter 3:

Motors

A DC motor is that type of motor that utilizes direct current and then it gives us mechanical output.

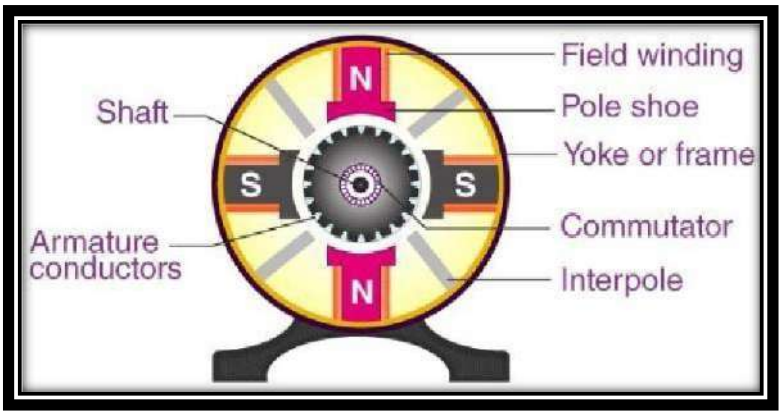


Fig. 3.1 Internal Structure of DC motor

3.1 Parts of a DC Motor

A DC motor comprises of the following main parts that are explained below:

3.1.1 Armature/Rotor:

It is just like a cylinder having magnetic laminations separated from one another. It is rotating part that is totally separated from field coil using an air gap.

3.1.2 Field coil/Stator:

It is that part of motor that not moves, remains stationary and winding is wounded on it. This winding produces magnetic field. A cylindrical cavity is present between its poles.

3.2 Working of DC motor

This motor works on the principle of Lorentz Law which can be defined as "A current carrying conductor is when placed in a magnetic field or electric field experiences a force".

When field coil gets energized, magnetic field is produced in the air gap that is in the direction of the radii of armature. This magnetic field enters from North Pole of armature and then it exits from South Pole of field coil.

3.2.1 Types of DC Motor:

DC motors exist in different types because of different applications like electric shavers or automobiles. According to this we can explain these types:

- Self Excited
- Separately Exited

3.2.2 Self Excited DC Motor:

In this type of motor armature winding and field winding are connected in series or parallel. It can be further divided into Shunt wound,Series wound and Compound wound DC motor.

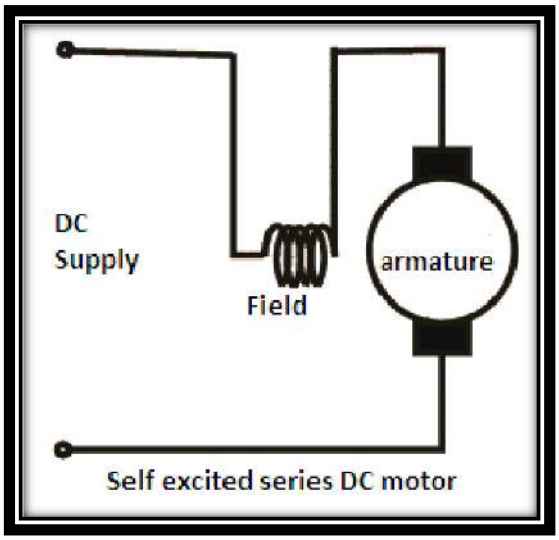


Fig. 3.2 Self Excited DC Motor

3.2.3 Separately Excited DC Motor:

This type of motor needs a separate constant voltage supply for its field circuit. That's why it is known as separately excited motor.

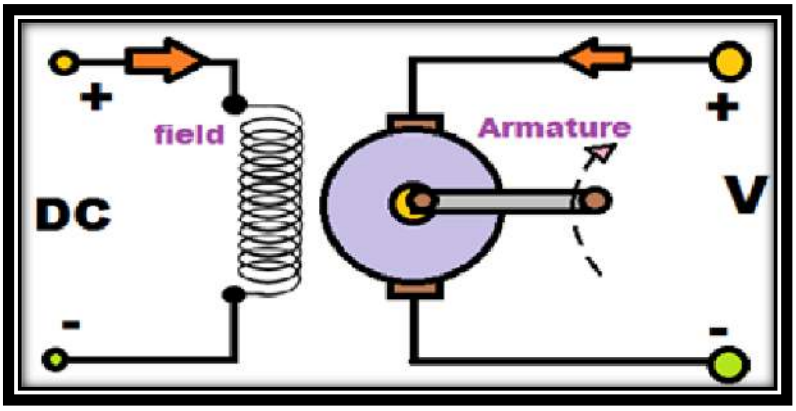


Fig. 3.3 Separately Excited Dc Motor

3.3 Brush Less DC Motor & Controller:

3.3.1 Working Principle

The controller of this motor controls the speed and torque of it. It is able to stop, reverse as well as control the speed of motor.[9]

3.3.1 Construction:

Its main components are:

- Rotor made up of permanent magnets or Neodymium magnets.
- Stator that creates magnetic field when gets energized have windings.

Motor rotates because of rotor magnets and stators winding. They are attracted due to opposite poles and repelled because of same poles. In brushed motor also similar process takes place.[10]

Current switching method that is applied to wire windings creates a difference between these motors. Its controller detects the position of rotor with the help of sensors or senselessly sensor can be Hall sensor. After receiving information[11] controller enables transistors and switches the current to energize the winding of stator at correct time.

3.3.2 Types of BLDC motor

On the basis of rotor placement BLDC motor can be divided into 2 types:

In runner:

In this case rotor is on inner side and stator on outer side.

Out runner:

And for this motor rotor is on outer side and stator on inner side

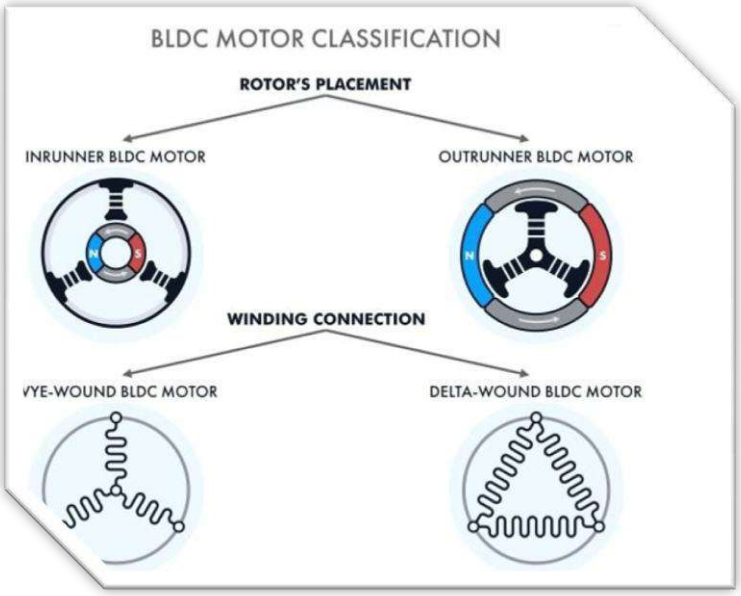


Fig. 3.4 BLDC Motor Classification

3.4 Simulation:

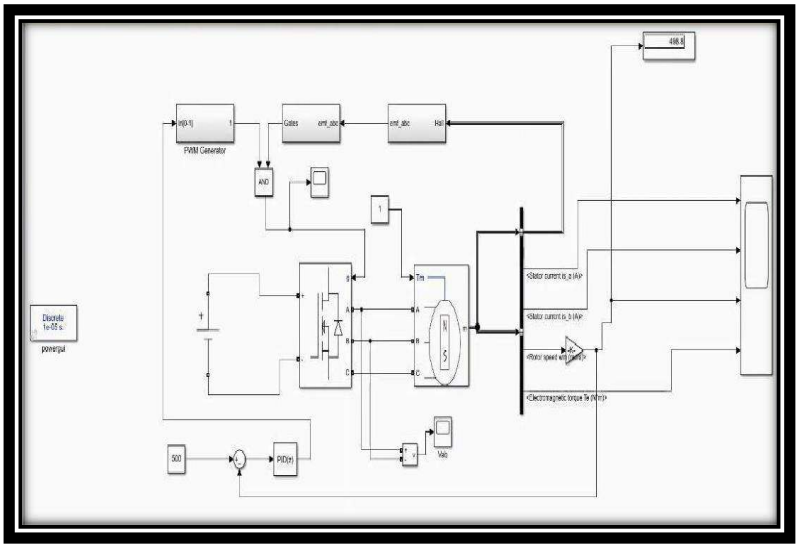


Fig. 3.5 MATLAB Simulation

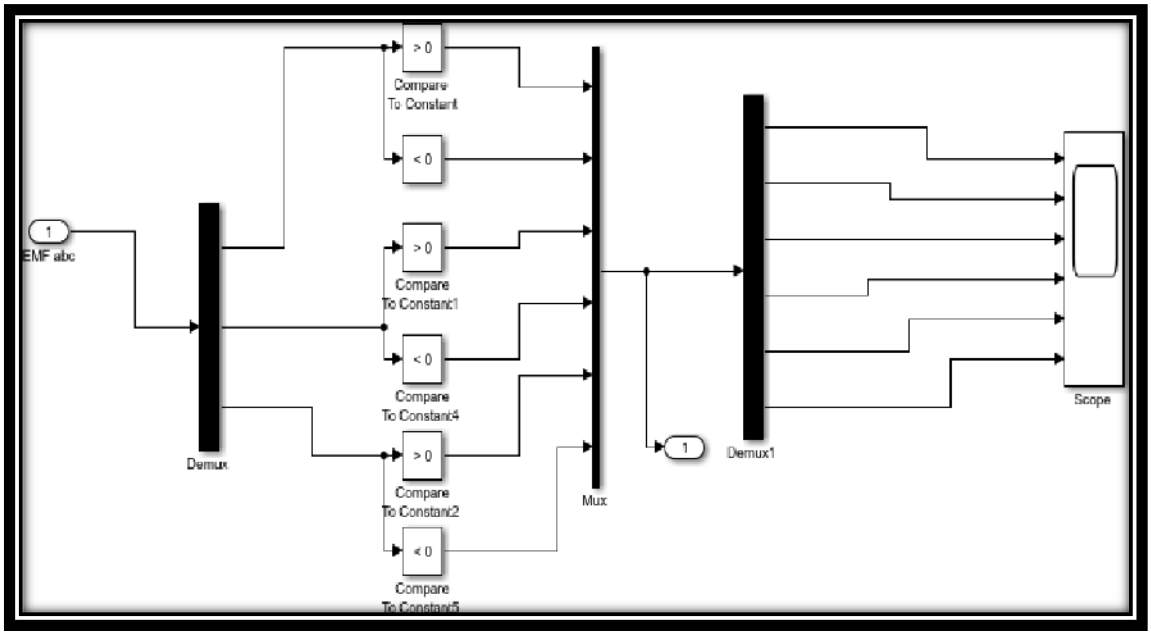


Fig. 3.6 Logic Gates

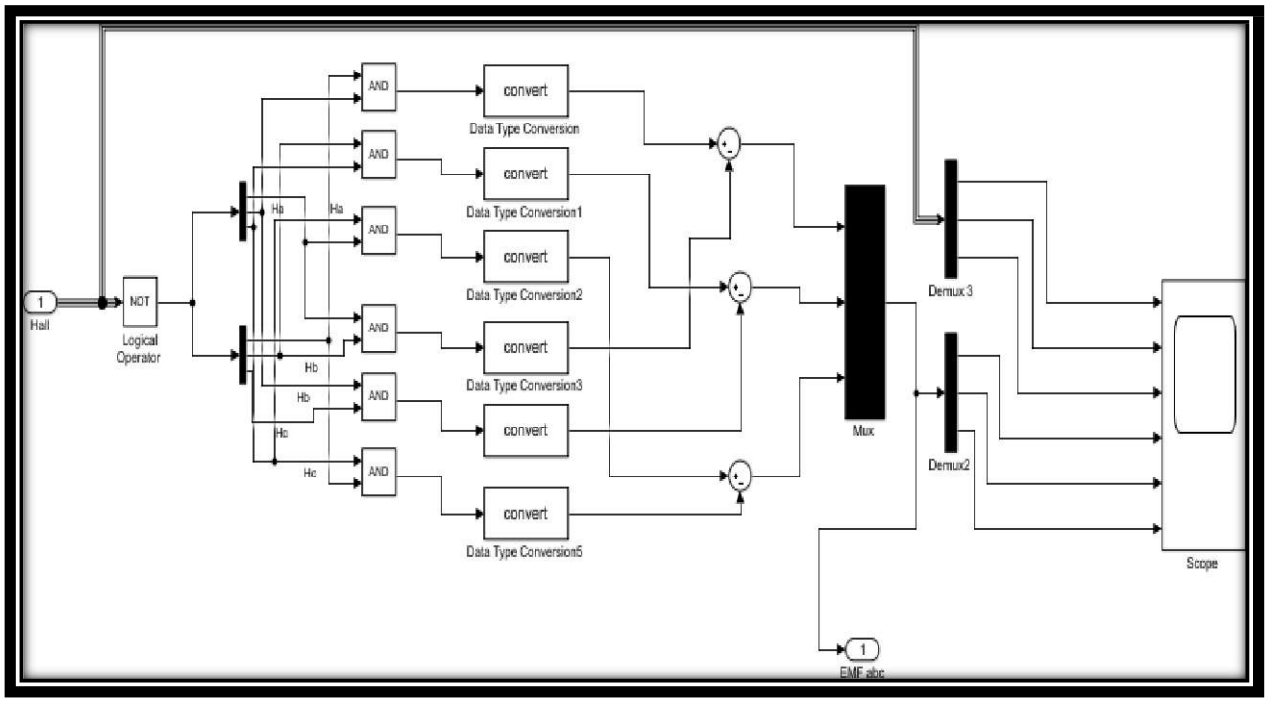


Fig.3.7 Decoder Model

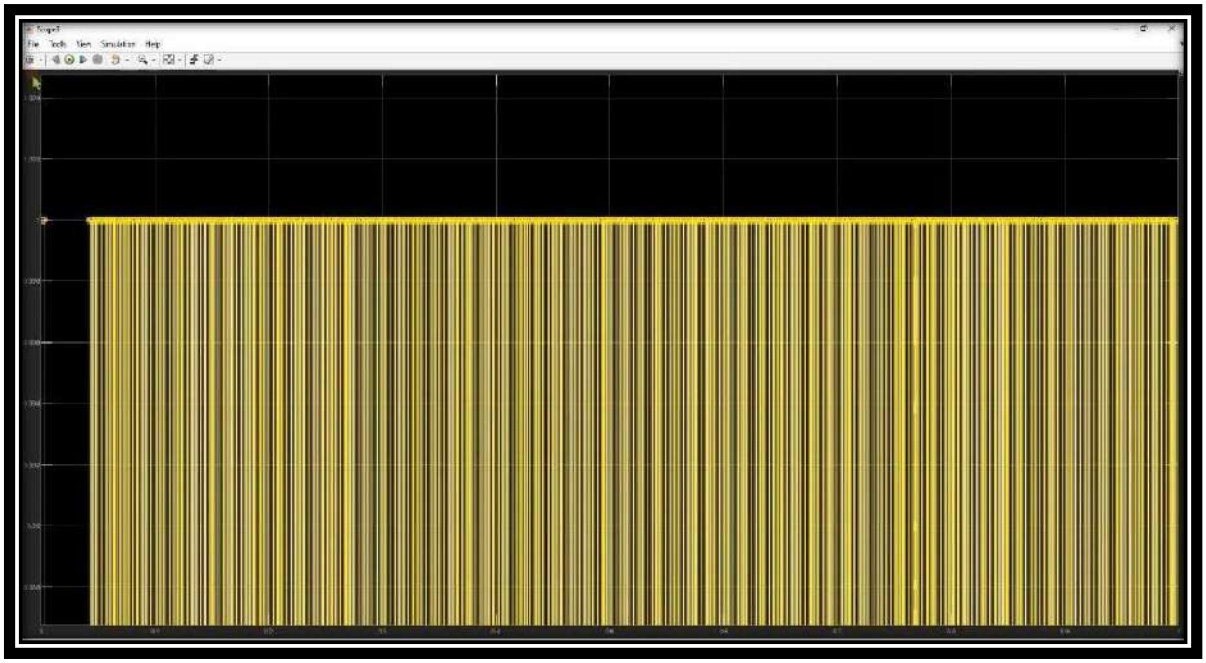


Fig. 3.8 Pulse Width Modulation

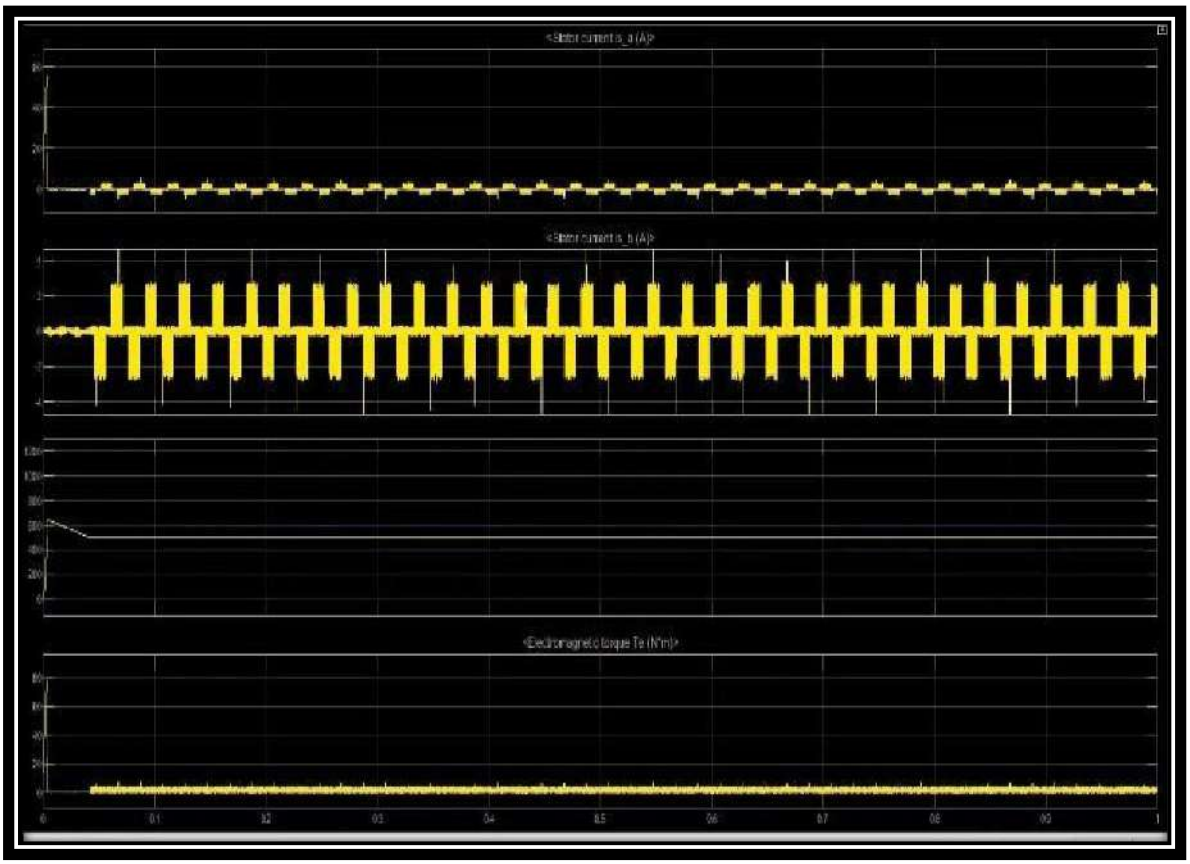


Fig. 3.9 Speed Graph of Output

3.5 Summary:

These BLDC motors are in use since a long time like about 50 years. Its application area is from a small size device to large complicated automation related industrial projects. All electronic control systems improve torque, increase speed regulation and also enhance the other characteristics of the motors. Thus for such cases BLDC[12] motor remains the only option to use. For some cases we can also use brushed DC motor in ways like using a suitable sensing device or by measuring the back EMF of stator windings.

Chapter 4:

BATTERY MANAGEMENT SYSTEM AND BATTERY

4.1 BMS

Battery management system , maintain the voltage ,current and temperature. Sometimes more current flow in any of the cell. Because of BMS, current flow equally in all the cell.

4.2 What is Battery Management System?

Battery internal parameter, like temperature, voltage, and current are controlled by BMS, also charging and discharging. BMS also prevent the battery from over- charging and discharging. It prevent the battery from burn.

4.3 Working of Battery Management System

Check the operation for using typical battery management system of this component for the better performance. Current and voltage is measured by BMS controller. Battery management system is used single handedly for charging and discharging. BMS controller hints the input voltage and it trigger the charging MOSFET, which is charging the battery.

Cells used in BMS for balancing.

- Passive cell balancing
- Active cell balancing

We use passive cell balancing for use in balancing for the bypass resistor to unleash extra voltage and take other cell into balance.

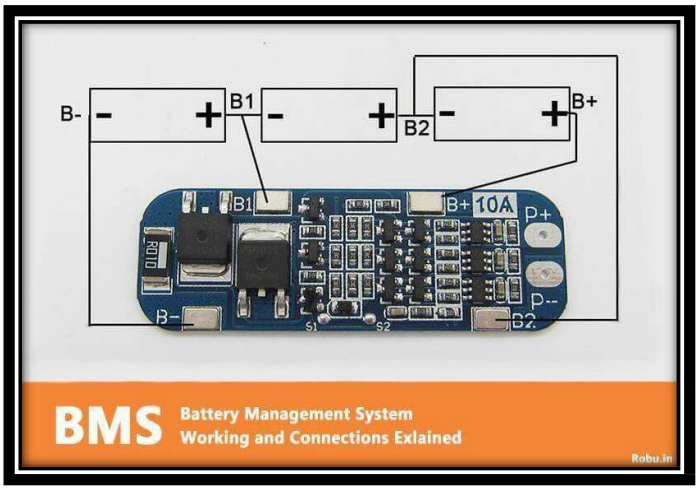


Fig. 4.1 BMS

- Not full charge voltage – 3.7V
- Full charge voltage -- 4.2V

4.4 Function of BMS

4.4.1 Safety

Lithium-ion battery plugs have high density, which increase the possibility of fire. As a result, it was already signified, working of rated value is essential. To enhance the battery life, it saves the battery plugs from overcharge or discharge. Latest BMS have Bluetooth and UART communication ability. The function of battery is between the maximum and minimum qualified value, current, voltage, and temperature. BMS helps battery for working within these essential qualified values, as we know. In case of battery plugs, it helps and guarantee equal cell of charging and discharging. BMS is helping to increase the life of battery plugs for performance.

4.4.2 BMS Configuration

Fig show the block of battery management system and how it can be used to save the battery failures.

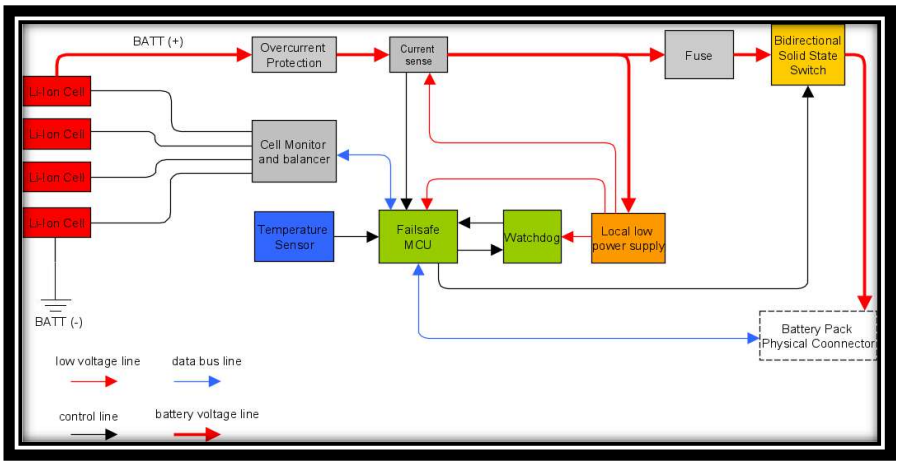
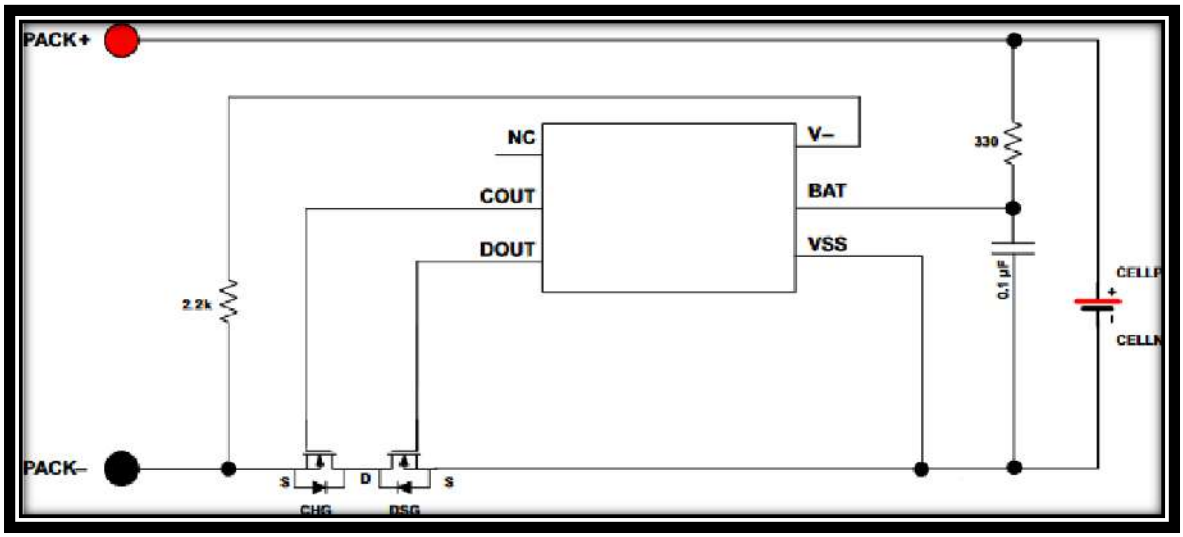


Fig. 4.2 BMS block diagram

The four lithium-ion cell in series controlled by BMS. cell entering also called balancing, reading all the voltages and balance the voltage into them. MCU which is manipulate elementary data. Market offer every type of choices for simple designs, like single handedly cell without balance or MCUs.



These type of simple systems have the cracks that is without modify or alter. Designer is restricted to what the supplier part (such as high or low side switch).

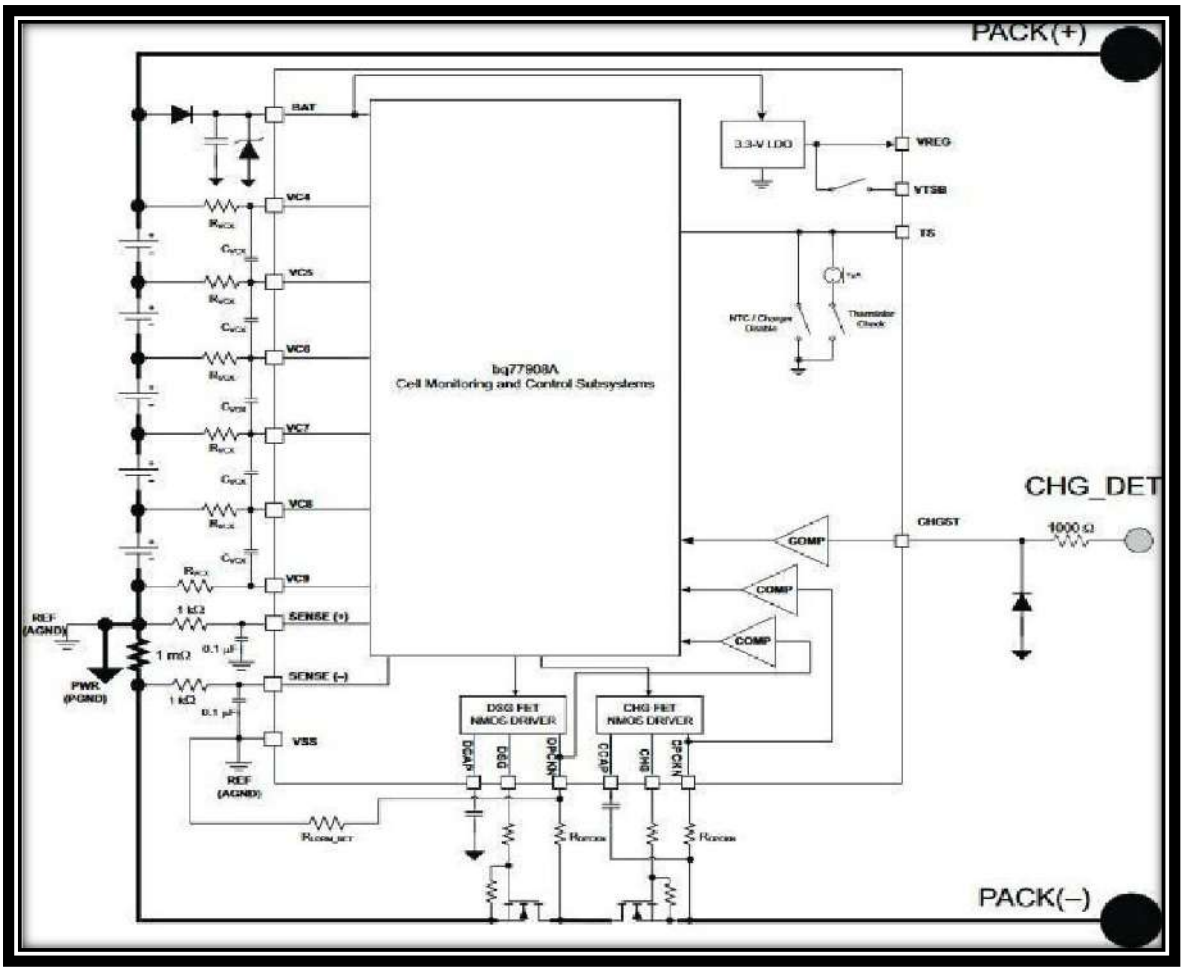


Fig. 4.3 BMS & MCU-independent Cell balancer

4.5 Battery

4.5.1 Lithium-Ion battery

Average voltage of battery in market is 3.7 volts, but mostly the functioning voltage is little extensive range and so, voltage issue. Flexible battery are used in market to increase the voltage of battery, 42 volt lithium-ion battery used in high voltage battery. Lithium-ion battery is better than lead-acid battery, and has low weight, high current, charging and discharging efficiency is high, saving energy and used for the protection of environment.[13]

4.5.2 Lithium Ion battery price

If we use single cell battery of 42 volts of lithium ion battery, for this efficiency is not good for the saving of battery. So we used lots of cell combine in series and parallel. Top lithium ion battery manufacture company, like LOOM SOLOR, for plant powering manufacture is TN company, Electrolyte market demand of lithium ion battery, lithium ion battery for market size and forecasting is Electrolyte Additives.

4.5.3 Battery protection board

Lithium ion battery of 42 volt is used for protection board. Made of electrical circuit which the current circuit on and off in no time, and the charging and discharging range of temperature is between -38 degree centigrade to + 82 degree centigrade.

Protection of lithium ion battery is used as charging and discharging of protection of battery used in series-parallel. The over-voltage, current, temperature, under voltage is find by this board and increase the battery power, and save the battery from damaging. Protection board is necessary part of battery.[14]

4.6 Lithium-Ion battery vs. Lead-Acid battery

- **By weight**

Energy density of lead acid battery is range up to 50-69wh/g, and the lithium ion battery range is from 200-250wh/g. Since the weight of lithium ion battery is more than the lead acid battery, and capacity of lithium ion is also greater. So, lithium ion battery has advantages over lead acid battery.

- **Service life**

Two types of lithium ion battery is used, one has more than 2000 cycles and others has 1000 cycle, while lead acid battery may have 300 to 350 cycles. Therefore, the life of lithium ion battery is 3 to 6 times more than lead acid battery.

- **Price**

Lead acid battery have low price than lithium ion battery and access for every one cause of cheaply, while on the other hand lithium ion battery is too much expensive than lead acid battery. If we see the price is same for both battery, than lithium-ion is better option.

- **For protection**

For the protection of battery, lithium-ion is friendly than the lead acid battery and also lithium ion is recycling too.

4.7 Summary

For BMS, battery management system simulation is the helpful method for the design, and design issues in hardware progress, protecting, testing. When a reliable lithium ion cell is used, the simulation of battery management system framework is implement and distinguish as the seeming specimen. Simulation is best way to question of various battery management system administrative job under the battery environmental situation. Firstly tested the performances, before the implementation on hardware setup to escape from the difficulties. It faster the process of progress and firstly, guarantee the reliability of hardware sample.

Chapter 5

RECHARGING MECHANISM SYSTEM

5.1 What is a DC Generator?

When armature of dc generator rotates in magnetic field an emf produce and convert mechanical energy into electrical energy. An EMF will generated based on the principle of Faraday's Laws. EMF tends to flow a current when the circuit is closed.

5.2 Parts of a DC Generator.

It is used as a Dc motor without changing its construction. DC generator also called DC machine. The following diagram shown below

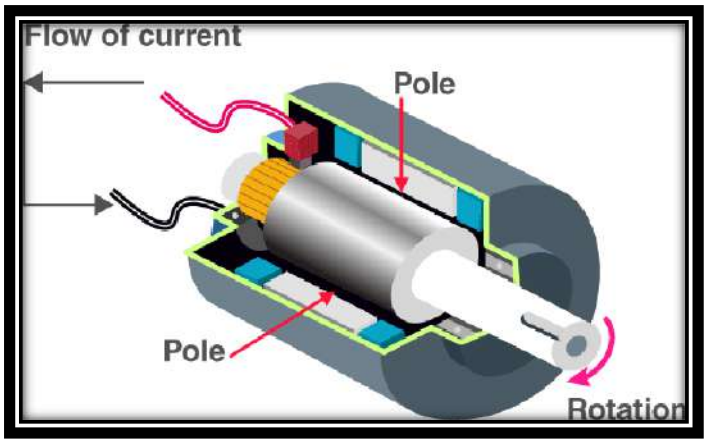


Fig. 5.1 Parts of a DC Generator

5.2.1 Stator

The main role of the stator is provide magnetic field when coil spin.it has two pole with opposite polarity. These magnet present in rotor region.

5.2.2 Rotor

Rotor is DC machine with slotted iron lamination with slots that are stacked to shape a cylindrical armature core. The role of the lamination is to decrease the loss due to eddy current.

5.2.3 Armature Winding

Armature windings are closed circuit and are connect in series to parallel to enhance the produced current.

5.3 How does a DC Generator Work?

According to law of faraday electromagnetic induction. As we know that when a current- carrying conductor is place in a varying magnetic field, an Electromagnetics force is induce in the conductor. Follow Fleming's right-hand rule, the direction of the induced current changes when the motion direction of the conductor changes. Let say armature rotates clockwise and a conductor move left upwards. When the armature completes a half rotation, the direction of conductor moves will be reverse downward. Hence, the current direction in every armature will be alternating. Nevertheless, with a

commutator split ring, connections of the armature conductors are reverse when a current reversal occurs. Therefore, we get a unidirectional current at the terminals.

5.4 Circuit theory working and application:

The boost converter is dc to dc converter. The output voltage of the dc to dc converter is greater than the input voltage. The output voltages depends on duty cycle. It is also produce the step up and step down transformers and the names comes from the analogous step up and step down transformer. The input voltages are step-up the level of input voltage. According to law of conversion energy, the input power equal to the output power.

5.5 Basic:

It is DC-to-DC converter and it has a magnitude of voltage at output terminal. It might be greater than or equal to the input voltage magnitude. The boost converter is equal to circuit(fly back) and one inductor is used in the place of the transformer. And the other one is boost converter. These converters has ability to produce the range of output voltage than the input voltage. The diagram shows the basic boost converter.

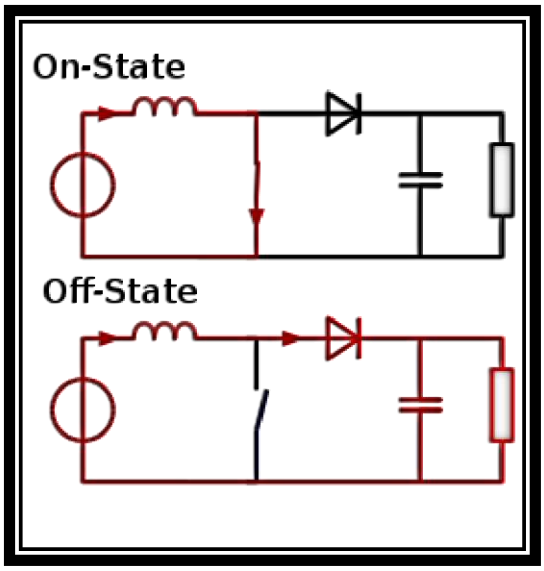


Fig. 5.2 Boost Converter

5.6 Boost Converter

The first transistor is ON continually in Boost converter and when we use second transistor, then at the gate terminal high frequency is applied. When input current flow from the inductor L, then the second transistor is remain in its own state. The magnetic field produce across the inductor and negative terminal of the transistor is charging up. The anode is potentially ground the second transistor is conducting and then, second diode cannot conduct.[15]

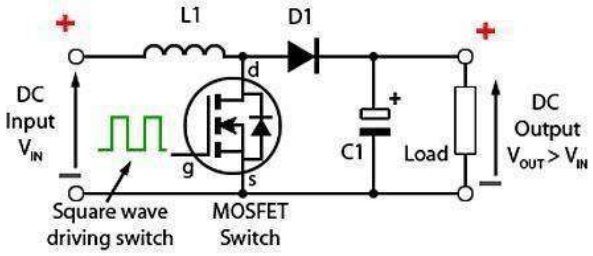


Fig.5.3 Boost converter working

When capacitor C charged, the load is apply to the circuit that is in the ON State and it can construct earlier oscillator cycles. At the ON period, the capacitor C can discharge regularly and it cause to produce high amount of ripple frequency on the output voltage. The approximate PD are given by the equation below.

VS + VL

5.6.1 Application of boost converter:

- It is use in the self-regulating power supplies.
- It has electronics that consume power.
- It is use in the power systems like battery.

5.6.2 Advantages of boost converter:

- higher output voltage is produced
- operating cycle has low duct
- MOSFETs voltage is low

Chapter 6

IMPLEMENTATION AND TESTING

The project implementation has following steps for accomplishment

- Fabrication of BLDC Hub motor in rear wheel using Bike rim and tyre.
- Fitting of battery at rear wheel carrier.
- Fitting of Generator at the frame of bicycle.
- Fitting of buck-Boost and connection with generator
- Fitting of accessories on bicycle

Here's how it's done:

1. **Getting Ready:** First, you need a bike rim (the circular part of the wheel) and a tire. These are the parts of your bike's back wheel that touch the ground.
2. **Adding the Motor:** Inside the rim, a special motor called a BLDC Hub Motor is placed. This motor has magnets and coils that work together to create movement when electricity flows through them.
3. **Power Source:** The motor needs electricity to run. So, you'll need a battery attached to your bike. This battery provides the energy that makes the motor spin.
4. **Putting It Together:** The motor is placed in a way that its center fits where the axle of your wheel used to be. The axle is what holds your wheel in place. Now, the motor becomes the newiaxle, and it's connected to the rest of your bike.
5. **Control and Direction:** To make the motor go, you'll use a controller. It's like a switch that tells the motor when to start and stop. When you want to move, you use this controller.
6. **Enjoy the Ride:** Now, when you twist the bike's handle or use pedals, the motor gets the message to start spinning. It works with your own effort to make the bike go faster and smoother.

In simple words, turning your bike into an electric bike with a BLDC Hub Motor means putting a special motor inside the back wheel. This motor uses electricity from a battery to help you move your bike with less effort. It's like having an extra push when you pedal, making your ride more enjoyable and efficient.

Table 6.1: Electric Bicycle running with BLDC motor

Test Case No.	**1**	
Test Case Name	**Driving BLDC Hub Motor**	
Pre-Condition	**Batter should be able to deliver required power (Charged)**	
Action	**System Response**	**Result**
Rider twist the throttle to make torque torotate wheel	**System turns ON and Motor runs**	**PASS**

Elaboration:

This test case aims to verify the functionality of the electrically assisted bicycle's motor system when the rider twists the throttle to generate torque and initiate the rotation of the wheel. The pre-condition ensures that the battery is sufficiently charged to provide the necessary power for motor operation.

When the rider twists the throttle, it sends a signal to the system to activate the motor. In response, the system turns ON, and the BLDC hub motor, which is integrated into the bicycle's wheel hub, starts running. The motor's operation generates the required torque, leading to the rotation of the wheel.

The "PASS" result indicates that the system performs as expected and the motor responds appropriately to the rider's action. This successful outcome demonstrates that the electric motor, throttle control, and power delivery mechanisms are working harmoniously, ensuring a seamless driving experience for the user.

This test is crucial as it confirms the core functionality of the e-bike's propulsion system, which is a fundamental feature of electrically assisted bicycles. By passing this test case, the e-bike's ability to deliver power and initiate wheel rotation under rider control is validated, contributing to the overall reliability and usability of the vehicle.

Table 6.2: Power Generation by generator

Test Case No.	**2**	
Test Case Name	**Power Generation**	
Pre-Condition	**Battery is not charging via any means**	
Action	**System Response**	**Result**
Rider changeover the pedal torotate generator	**Generator is working to provide Power to Buck-boost converter**	**PASS**

Elaboration:

This test case aims to validate the power generation functionality of the electrically assisted bicycle's generator system. The pre-condition ensures that the battery is not charging and is not receiving external power, focusing solely on power generation through the generator.

When the rider changes the way they pedal, activating the generator, the generator system becomes operational. As a result, the generator converts mechanical energy from the rider's pedaling option into electrical power. This generated power is then directed to the Buck-Boost converter, which regulates the voltage to an appropriate level for the battery's charging requirements.

The "PASS" result confirms that the generator effectively generates electrical power and that the subsequent processes, such as directing power to the Buck-Boost converter, are functioning as expected. This outcome ensures that the e-bike's ability to convert human pedaling energy into electrical power for battery charging or other purposes is successfully demonstrated.

In summary, this test case emphasizes the e-bike's capacity to harness rider-generated mechanical energy and convert it into usable electrical power. By validating this functionality, the test case contributes to the overall understanding of the e-bike's power generation capabilities and its integration with the vehicle's electrical system.

Table 6.3: Working of boost converter

Test Case No.	**3**	
Test Case Name	**Working of boost converter**	
Pre-Condition	**Battery is charging via Dc generator**	
Action	**System Response**	**Result**
Supply power from generator to makebuck-boost converter	**Generator is working to provide Power to Boost converter**	**PASS**

Elaboration:

This test case focuses on verifying the functionality of the boost converter within the electrically assisted bicycle's electrical system. The pre-condition states that the battery is actively being charged by the DC generator.

When power is supplied from the generator, it triggers the boost converter into operation. The boost converter is an electronic circuit that takes in the incoming electrical power and increases the voltage level before delivering it to the desired destination, such as the battery or another component of the system.

The system response confirms that the generator functions as expected, providing the necessary electrical power to the boost converter. This action showcases the boost converter's ability to amplify the voltage level of the incoming power, a key process in efficient power management within the e-bike's electrical system.

The "PASS" result signifies that the test case is successful, indicating that the boost converter operates properly when receiving power from the generator. This positive outcome demonstrates the boost converter's role in maintaining the appropriate voltage levels within the electrical system and supporting effective battery charging.

In summary, this test case ensures the proper operation of the boost converter, highlighting its function in elevating voltage levels to enhance the efficiency of power delivery and utilization within the electrically assisted bicycle's system.

Fig. 6.1. BLDC Hub Motor installed in wheel

Fig. 6.2. Pedal drive system

Fig. 6.3 Final output complete cycle

Conclusion:

Electric bicycle has a lot of benefits in daily life, when recharging mechanism is integrate, then cycle is more suitable, proficient, and good. First of all, Self recharging mechanism store energy produced by peddle wheel and reducing the battery dependant source. Secondly, the problem of reducing of battery with time is improved with self recharging mechanism. Due to this feature riders don't need to worry that their battery will become low and they also don't need to find charging stations. This feature enables bicycle to be a most reliable and convenient mode of transportation because it can store energy even while moving on the roads. Moreover this self recharging feature also enables it to increase the efficiency of electrically assisted bicycle. Thus it reduces energy wastage and improves range. In conclusion, this project is a sustainable, convenient, efficient transportation solution. This innovative design enhances user experience and also contributes to green environment.

References:

[1] Nielsen, T., Palmatier, S.M. and Proffitt, A., 2019. Recreation conflicts focused on emerging e-bike technology. *Parks & Open Space, Boulder County*.

[2] Emadi, A. Nasiri, and S. B. Bekiarov, "Electric Bicycles and Electric Bikes", Boca Rat on, FL: *CRC Press, Oct. 2004.*

[3] Nasiri, Z. Nie, S. B. Bekiarov, And A. Emadi, "Electric Bikes worlewide", Ieee Transa ctions on Industrial Electronics, *Vol. 55, No. 2, February 2008*

[4] Bieliński T, Ważna A. Electric scooter sharing and bike sharing user behaviour and characteristics. Sustainability. 2020 Nov 19;12(22):9640.

[5] F. Kamran, and T. Habetler, "Battery power Electric bicycles", IEEE Transactions on Power Electronics, 13 (2), *366–371, 1998.*

[6] Martinez, S., Castro, M., Antoranz, R. and Aldana, F., "Development of an Improve El ectrically assisted bicycle", IEEE Transactions on IndustrialElectronics, *36 (3), 629–635, 1989.*

[7] Abagnale C, Cardone M, Iodice P, Marialto R, Strano S, Terzo M, Vorraro G. Design and development of an innovative e-bike. Energy Procedia. 2016 Nov 1;101:774-81.

[8] Zhou, Jibiao, Tao Zheng, Sheng Dong, Xinhua Mao, and Changxi Ma. "Impact of helmet-wearing policy on e-bike safety riding behavior: a bivariate ordered probit analysis in Ningbo, China." *International journal of environmental research and public health* 19, no. 5 (2022): 2830.

[9] MT. Sai and C. Liu, "BLDC motor Primer", IEEE Trans. Power Electron., *vol. 18, no. 4, pp. 1002–1011, Jul2003.*

[10] S. B. Bekiarov and A. Emadi, "Brushless DC motor using soft magnetic composites as a direct drive in electric bicycles", in Proc. 17th Annu. IEEE Appl.Power Electron. Con f., Dallas, *TX, Mar. 2002, pp. 597–604.*

[11] Ho, W.J., Lio, J.B. and Feng, W.S., "Alternative designs of Brushless DC motorusing s oft magnetic composite", IEE Proceedings of Electric Power Applications,*144 (4), 221–226, 1997.*

[12] S. H. Bukhari, T. A. Lippo, B. Kwon, "Brushless DC motor made easy", IEEE Transa ctions on Industry Applications, *vol. pp, no. 99, 2016.*

[13] Krishnan, R. and Srinivasan, S., "Energy efficiency of Li-ion battery packs re-used in stationary battery packs" Hungary, *June 1993, pp. 122–127.*

[14] M. Aamir, S. Mekhilef, "An Online Transformer-less Uninterruptible Power Supply (UPS) System with a Smaller Battery Bank for Low-Power Applications" IEEE Transactions on Power Electronics, *vol. 32, no. 1,2017*

[15] J. Choi, J. Kwon, J. Jung, and B. Kwon, "High-performance online UPS using three leg type converters", IEEE Trans. Ind. Electron., *v ol. 52, no. 3, pp. 889897,Jun. 2005.*