

DESIGN OF ELECTRIC BIKE WITH SMART SENSORS AND GPS TRACKING SYSTEM

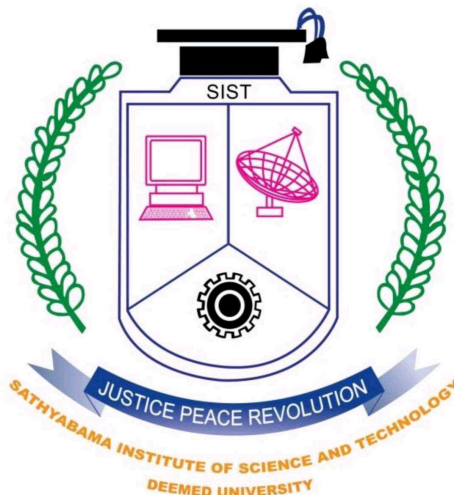
Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in
Electrical and Electronics Engineering

by

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A++" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

APRIL 2024



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **B. Reddy Chandra Sekhar (40140703)** and **S. Rakesh (40140030)** who carried out the project entitled "**DESIGN OF ELECTRIC BIKE WITH SMART SENSORS AND GPS TRACKING SYSTEM**" under our supervision from December 2023 to April 2024.

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DECLARATION

We **B. Reddy Chandra Sekhar (40140703)** and **S. Rakesh (40140030)** here by declare that the Project Report entitled "**DESIGN OF ELECTRIC BIKE WITH SMART SENSORS AND GPS TRACKING SYSTEM**" done by us under the guidance of **Dr. J. Barnabas Paul Gladys** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

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ABSTRACT

Electric vehicles are Nowadays replacing Conventional vehicles such that greenhouse gases reduced there by the effects of Greenhouse gases like Global warming, melting of ice, Air pollution, etc. can be reduced drastically. In an attempt to contribute to the above factors, in this project, we have developed an E-Bike by replacing the conventional bike- HERO HONDA Splendor bike with a Motor and Battery. A PMSM (Permanent Magnet Synchronous Motor) of 750 watts was used. The PMSM was powered by a 48V, 30mAh, Lithium Ion Battery. The PMSM motor powers the wheels of the bike by a Mechanical chain drive system. The developed E-Bike was tested and it was found that E-Bike can drive 40 Km in a single charge. The time taken for full charging is 5Hrs, and the battery takes nearly 120 minutes to discharge. The E-Bike was tested in different load conditions like Highways and rural roads and it found that the speed of the vehicle did not reduce with respect to the conventional vehicle and the performance was satisfactory.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Now a days, the Automobile markets are increasing rapidly, so the electric vehicles becoming with better improvements, Government also planning to bring the electric vehicles industries in India, to reduce the dependency on import energy sources, and reduce greenhouse gas emissions and mitigate adverse impacts of transportation including global warming. The main advantages of E-bike are their significantly reduced environmental impact compared to conventional gasoline-powered motorbikes. Additionally, E-bike offer operating costs due to their energy efficient nature and reduced reliance on fossil fuels and the electricity is generally cheaper than gasoline, resulting in lower fuel expenses for E-bike. And no need for regular oil changes, contributes to lower maintenance and servicing costs.

The E-bike can offer quick acceleration with high torque Manufactures in worldwide are actively addressing these challenges by investing in charging networks, and improving battery technology. E-bike utilize advanced battery technology, typically lithium - ion batteries, to store and deliver power source to the motor moreover continuous innovations in better technology are increasing the range and reducing charging times of the E-bike.

In conclusion, E-bike rapidly evolving segment of the transportation industry, and their environmental benefits with cost savings, E-bike significant role in the future of sustainable and efficient personal mobility.

1.2 ELECTRIC BIKE

E-Bike technology has evolved significantly, with focus on improving efficiency and user experience. PMSM motors have emerged as a promising choice due to their high efficiency, torque characteristics, and regenerative braking capabilities. LiFePO₄ batteries, known for safety and durability, have become a preferred energy storage option. The E-Bike is a bike which is driven with the help of battery which is coupled to electric motor.

TYPES OF MOTORS USED IN E-BIKE

1.2.1 Brushless DC (BLDC) motor:

BLDC motors convert a large portion of electrical energy into mechanical energy, resulting in longer range and less energy consumption.

1.2.2 Permanent Magnet Synchronous Motor (PMSM):

Compared to BLDC motors, PMSM's can achieve even greater efficiency, leading to potentially longer range and reduced energy consumption.

1.2.3 AC Induction motor:

While less common in electric -bike due to their lower efficiency compared to BLDC and PMSM motor.

1.3 ADVANTAGES OF E-BIKE:

- An E-bike is an environmentally friendly. It is the same as our regular Bike. It is powered by electricity rather than gasoline. No harmful emissions are emitted into the atmosphere. For the same reason, electric bikes don't produce any additional noise.
- E-bike, in general do not require any maintenance. Lubricate the drive system and inspect the chain and wheels on a regular basis to keep it clean.
- Riding an E-bike is fashionable and popular right now. It is also the most efficient approach to cut down on pollution.

1.4 AIM OF THE PROJECT

- The aim of an E-bike is to provide a sustainable and eco-friendly mode of transportation.
- E-bike aim to reduce dependence on fossil fuels, decrease air pollution, and promote a health their lifestyle.
- They offer an alternative to traditional bikes and cars, making commuting easier and more efficient.

1.5 SCOPE OF THE PROJECT

- The scope of E-bike, can vary depending on the specific goals and objectives.
- It can include aspects such as designing and manufacturing E-bikes, conducting research on battery technology and efficiency, exploring market demand and consumer preferences, and developing sustainable infrastructure for E-bike usage.
- The project can also involve analyzing the environmental impact and cost-effectiveness of E-bike compared to traditional modes of Transportation.

1.6 OBJECTIVE

- To Replace conventional Hero Honda splendor bike as E-Bike.
- To select a suitable motor that can drive Hero Honda splendor bike.
- To select a suitable lithium-ion battery to power the motor.
- To select a suitable controller for the motor.

1.7 LITERATURE SURVEY

The constant news concerning the demise of fossil fuels, according to Adithya Kumar et. al. (2016), has enhanced the importance of using electricity in the future. E-Bike will be used more frequently. The E-Bike will be beneficial to office workers and those who ride short distances. The E-Bike has a motor that assists the vehicle in moving ahead, and it is powered by a variety of sources. The batteries power the motor, which in turn drives the vehicle. Once the battery has been exhausted, it is recharged using a battery charger.

When one of the batteries runs, out, remaining batteries will step in to fill the void. During this period, the wheel revolves, rotating the shaft of the dc motor, which produces a voltage output. The voltages aids in the charging of the battery, improving the E-Bike range .IT is environmentally friendly and pollution-free because it produces no emissions. Furthermore, it is silent and can be recharged using an AC converter in the event of an emergency or gloomy weather. It is ideal for young elderly individuals, and it meets the needs of the economically disadvantaged. The most important feature of this E-Bike is that it does not consume valuable fossil fuels thereby saving the money.

Annette Metzen, et. al. (2008) suggests that more emphasis should be devoted to the deregulation to E-Bike. A common standard/guideline for E-Bike designers /manufactures will simulate growing popularity while also guaranteeing E-bike that are most efficient in a given operating cycle, such as city, hill, and distance. It might assist to offset the additional

cost and weight of larger components. more study into battery and drive technologies, as well as their use with electric E-bike, be advantage maturity of E-Bikes has increased in this regard. Even if the technological maturity of E-Bikes has increased and continues to improve, more effort is needed to make them competitive with other vehicles.

Carlos Tovar, et. al. (2009) proposes Novel the cities are living each day an accumulation of excessive traffic and noise. The air quality and health are two more components of city traffic that are badly damaged. Many sir contaminants, like as carbon monoxide and suspended particles, are primarily caused by transportation. It is a fantastic car that is both speedy and efficient while still being environmentally friendly. It is possible to enjoy a leisurely and enjoyable cruise while also arriving at locations using this vehicle. A E-Bike costs the same as a regular bike. This means that when you buy this vehicle, you have all of the features of standard bike plus the added power of battery, which allows you to go faster and for longer than you could on your own. The E-bike electricity is designed to help the rider maintain a steady, safe speed on or off the road. Furthermore, law considers these vehicles to be equivalent to a standard bike. That is to say, the user does not need license to ride an E-Bike.

Ravina More, et. al. (2011) proposes different models of calorie measurement need to be reviewed and tested to find which one is the most suitable to be adopted for range of bikes. For more information, to reduce the number of calibrations required for each particular cycles, researchers can look into developing a single model that fits all bikes incentive-based ways for E-Bikes can be tested, such as switching the bike from manual to electric mode once the calorie's burned goal has been met. It is necessary to consider a circuit that can accomplish the same. The anti-theft system is reliant. The features will be implemented using the bike's existing power supply. The end product will be cushioned, waterproof, and temperature insensitive for a specific temperature range to protect it from harsh environmental elements, A result, the project attempts to establish the bike, an attempt will be made to model a similar design

1.8 Existing System

As we are comparing with Ampere Reo Electric bike. In this survey we taking the specifications of Ampere Reo electric bike. This bike provides Range up to 55km/per charge with top speed 25km/hr and it will take charging time up to 8 to 10hours. And it is using Lead acid battery as a power source with 48 kwh and with hub motor 1200w with

16Nm @420 rpm.

In our project, we are taking hero splendor bike and converting into electric by replacing the engine of bike. Here are using the lithium-ion battery with 48volts and 30 Ampere Compare to lead acid battery it has Improved Energy Density, Enhanced Fast Charging. Extended Cycle Life.

And we are using the mid drive motor instead of BLDC, hub motor. PMSM means permanent magnet synchronous motor. It has High Energy Conversion Efficiency typically ranging from 85% to 98% and. It will Reduced Energy Consumption. It has Lower Operating Costs, Compare to the BLDC motor.

1.9 Proposed System

This electric bike gives range up to 40km per charge Top speed of this bike is 40km/hr Within 5hours it will charge the full battery pack. We are providing the safety innovations in this bike PMSM will give more torque than the BLDC hub motor.

CHAPTER 2

DESIGN OF ELECTRIC BIKE

2.1 BLOCK DIAGRAM

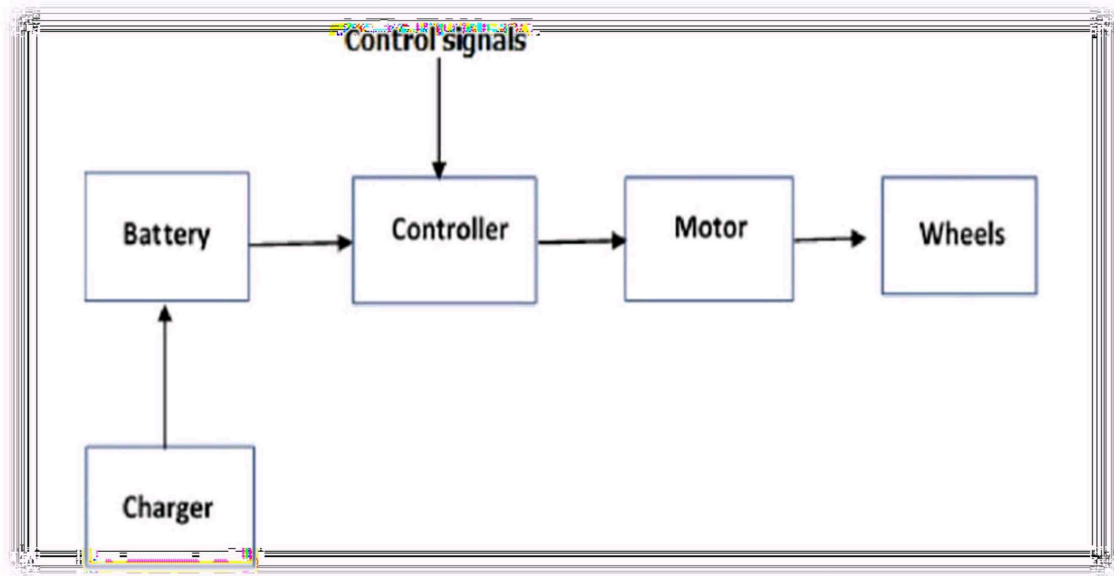


Fig: 2.1: Block diagram

- The main components of an E-bike from Fig no 2.1 are given below
 - Motor
 - Battery
 - Controller, and Throttle.
 - The motor is usually mounted on the frame of the bike and is powered by the battery.
 - The controller regulates the amount of power that is sent to the motor, and the throttle allows the rider to control the speed of the bike.
 - Other components may include a display screen, brakes, and gears.

- **ELECTRIC MOTOR:** Which converts Electrical energy from the battery into Mechanical power to drive the wheels.
- **CONTROLLER:** The controller is an electronic unit that manages the power flow between the battery and the electric motor.
- **BATTERY PACK:** The battery pack is where the electrical motor-bike store Electrical energy.

2.2 DESIGN OF ELECTRIC BIKE

Here the Fig No 2.2 the current from battery moves to controller where all the connections are made. When the power is given to motor, it rotates the wheel using chain and sprocket.

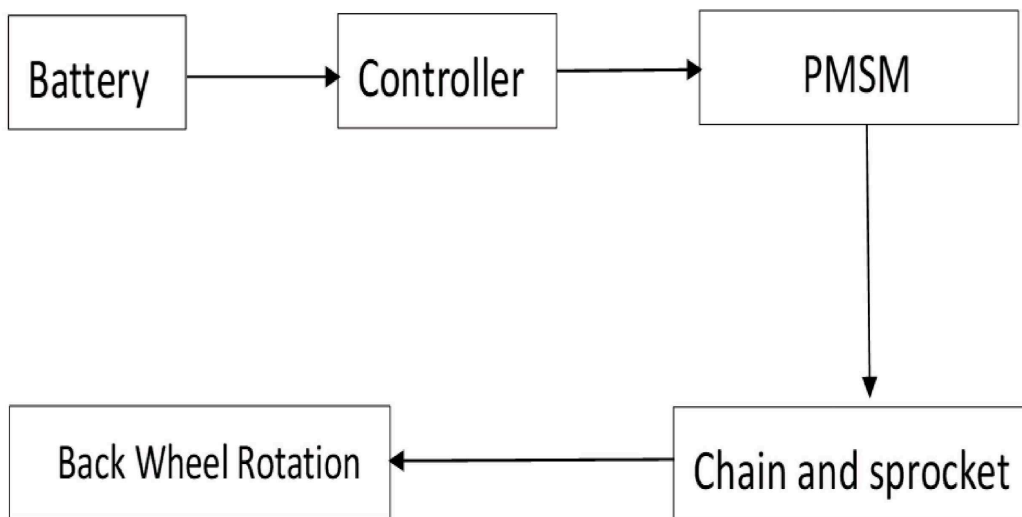


Fig: 2.2: Block diagram of E-Bike

2.3 HOW TO TURN ON E-BIKE

Insert the key and key and turn on the ignition. Long press the power button in the instrument console, then the power supply will be active.

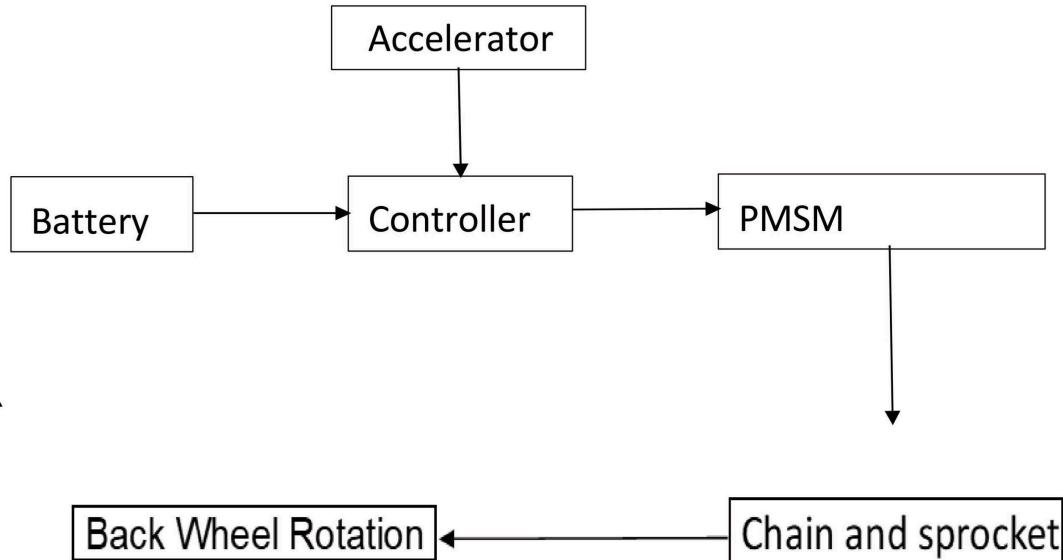


Fig: 2.3: Block diagram of converting E-Bike

Here the Fig No 2.3 When we rotate the accelerator to our desired amount, the controller takes the input and give the limited power to the motor and runs accordingly.

2.4 WORKING OF INSTRUMENT CLUSTER

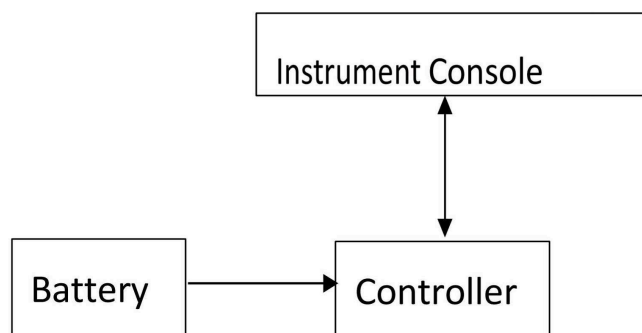


Fig: 2.4: Block diagram for instrument cluster

Here the Fig No 2.4 the instrument console displays speed, battery level, odometer. It has three buttons (power button, motor power up button and motor power down button). Power button has two function, long press- for turning on ignition. Short press-for toggling between voltage level, trip meter and odometer.

2.5 WORKING OF LIGHT AND HORN

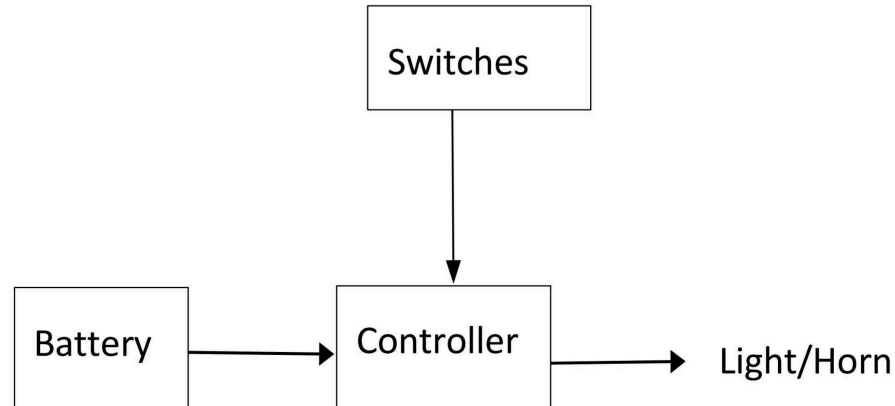


Fig: 2.5: Block diagram for lights and horn

Here the Fig No 2.5 there are two switches in handle bar one is for light and another is for horn. when the switches are pressed the controller reads it and sends the output to light/horn.

2.6 DESIGN CALCULATIONS

2.6.1 Mass Range Calculations

Person Weight	=	150kg
Battery Pack	=	8kg
Motor & controller	=	12kg
Bike weight	=	80KG

TOTAL	=	250KG
-------	---	-------

So, Battery and Motor are required to propel the bike with the weight of **250kg**.

2.6.2 Motor Load calculation

$$\begin{aligned}F_p &= \text{Propulsion Force} \\F_{wf} &= \text{Windage \& Friction Drag} \\F_d &= \text{Down force from Gravity}\end{aligned}$$

Consider the Grad @3.14%

$$\begin{aligned}\alpha &= \tan^{-1}(\text{slope}) \\&= \tan^{-1}(3.14/100) \\&= \tan^{-1}(0.0314) \\\alpha &= 1.8 \text{ degree}\end{aligned}$$

2.6.3 To Finding F_d (Gradient Resistance)

$$\begin{aligned}F_d &= m * a * \sin \alpha \\&= 250 * 9.81 * \sin 1.8 \\&= 77.03 \text{ N}\end{aligned}$$

2.6.4 To Finding F_{wf} (Aero Resistance)

$$\begin{aligned}C_d &\Rightarrow \text{Aerodynamic Area Co-efficient} = 0.74 \\ \rho &= \text{Density} = 1.225 \text{ kg/m}^3 \\ A &= \text{Frontal Area of Bike} = 0.37 \text{ m}^2 \\ V &= \text{Velocity of ke} = 25 \text{ km/h} \Rightarrow 6.94 \text{ m/s} \\ F_{wf} &= \frac{1}{2} (\rho * v^2 * C_d * A) \\ &= \frac{1}{2} * 1.225 * (6.94)^2 * 0.74 * 0.37 \\ F_{wf} &= 14.85 \text{ N}\end{aligned}$$

2.6.5 To Finding F_r (Rolling Resistance)

$$\begin{aligned}C_R &= \text{Rolling CO-efficient} \Rightarrow 0.004 (\text{for bike}) \\ F_R &= C_R * mg * \cos \alpha \\ &= 0.004 * 250 * 9.81 * \cos 1.8 \\ &= 9.80 \text{ N}\end{aligned}$$

2.6.6 Total Propulsion Force, F_p

$$\begin{aligned}F_p &= F_d + F_{wf} + F_R \\ &= 77.03 + 14.85 + 9.80\end{aligned}$$

$$= 101.68 \text{ N}$$

$$\text{Propulsion Power} = \text{FP} * \text{Velocity}$$

$$= 101.68 \text{ N} * 6.94 \text{ m/s}$$

$$= 705.65 \text{ W}$$

Thus, The Motor is to be **750 W**

2.7 DESIGN OF BATTERY

$$\text{Voltage(V)} = 48\text{Volts}$$

$$\text{Current(I)} = 30\text{Amps}$$

$$\text{Power(W)} = 1440\text{Watts}$$

$$V = \text{Battery voltage (complete pack)}$$

$$V = 48\text{V}/3.2\text{V}$$

$$V = 15\text{S}$$

$$I = \text{Battery current /cell current}$$

$$I = 30/6$$

$$I = 5 \text{ P}$$

$$\text{Total cells} = \text{S} * \text{P}$$

$$\text{Total cells} = 75$$

$$\text{Cell} = 6 \text{ Amp}$$

$$I = 5 \text{ P}$$

$$\text{Total Amp} = 5 * 6$$

$$= 30 \text{ Amps}$$

BMS required for S = 15s, V = 48V, I = 30Amps

2.8 SELECTION OF BATTERY PACK:

How many series? How many parallels?

$$\text{Single cell has} = 3.2\text{V Normal Voltage}$$

$$= 6\text{Ah capacity}$$

$$5 \text{ cells in Parallel} = 5 * 6\text{Ah}$$

$$= 30\text{Ah}$$

$$15 \text{ cell group in Series} = 15 * 3.2\text{V}$$

$$= 48\text{V}$$

15S, 5P configuration will be 48V, 30Ah.

CHAPTER 3

SELECTION OF COMPONENTS

3.1 Introduction of PMSM Motor

Introducing the Permanent Magnet Synchronous Motor (PMSM) in electric bikes brings several advantages. PMSM motors offer higher power density, improved efficiency, and smoother operation compared to other motor types. With their compact size and high torque capabilities, PMSM motors enhance the overall performance and range of electric bikes. This technology contributes to more enjoyable and efficient riding experience.

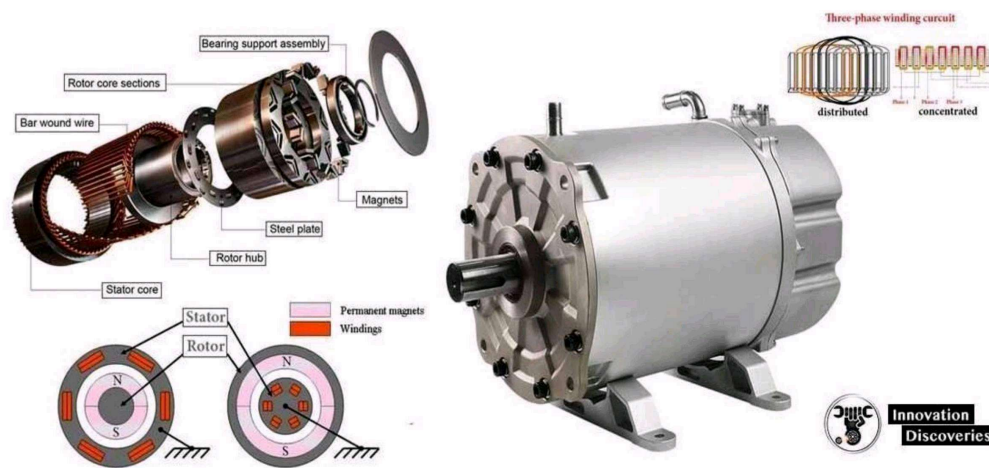


Fig: 3.1 PMSM construction

3.1.1 Highlights of Fig 3.1 PMSM Motor

- 48VDC,750W (OUTPUT) ,3000RPM OF PMSM
- In -runner with shaft output and keyway
- External Control
- Built in Hall Sensor with Hall Effect Angle of 120degrees
- Operating temperature up to +80c

3.2 WORKING PRINCIPLE OF PMSM MOTOR

The working principle of a Permanent Magnet Synchronous Motor (PMSM) is based on the interaction between a rotor equipped with permanent magnets and a stator with three-phase windings. PMSMs are also known as Brushless DC Motors (BLDC), as their operation is similar to that of a brushless DC motor. Here's a simplified explanation of the working principle of a PMSM:

- **Permanent Magnets:** The rotor of a PMSM contains permanent magnets, typically made of materials like neodymium-iron-boron (NdFeB). These magnets generate a constant magnetic field with a fixed north and south pole.
- **Stator Windings:** The stator, which surrounds the rotor, has three sets of windings that are usually connected in a star (Y) or delta (Δ) configuration. These windings are typically designed for three-phase AC power input.
- **Power Supply:** When three-phase AC power is supplied to the stator windings, it creates a rotating magnetic field within the stator. The frequency and phase of the AC power supply determines the speed of this rotating magnetic field.

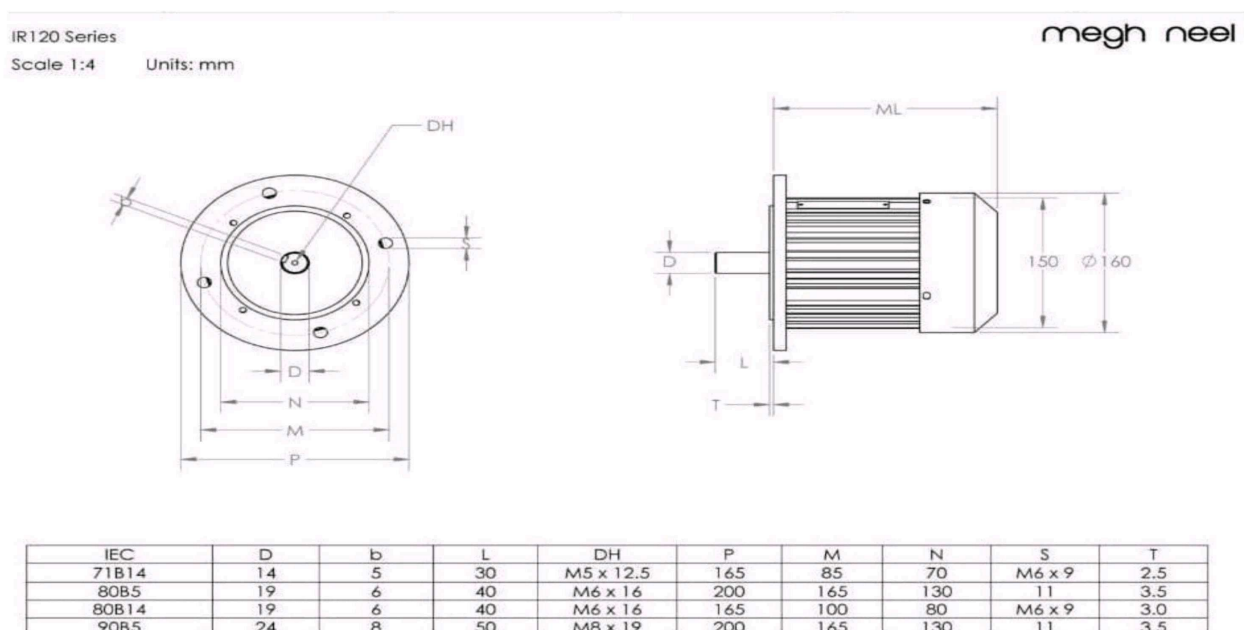


Fig: 3.2: Motor Construction

3.3 SIGNIFICANCE OF PMSM:

PMSM stands for **Permanent Magnet Synchronous Motor**, and it is a type of electric motor that has gained significant importance and popularity in various industries due to its unique characteristics and advantages. Here are some key significances of PMSMs:

- **High Efficiency:** PMSMs are known for their high efficiency, which means they convert a large percentage of electrical energy into mechanical energy. This efficiency is crucial in applications where energy conservation is a priority, such as electric vehicles and industrial machinery.
- **Precise Control:** PMSMs offer precise control over speed and torque. This makes them ideal for applications that require accurate and stable performance, such as robotics, CNC machines, and high-precision manufacturing equipment.
- **High Power Density:** PMSMs have a high power-to-weight ratio, making them suitable for applications where space and weight constraints are important factors. This is particularly beneficial in electric vehicles and aerospace applications.

3.4 TORQUE CHARACTERISTICS PMSM

The torque characteristics of a Permanent Magnet Synchronous Motor (PMSM) are an essential aspect of its performance. Understanding these characteristics is crucial for designing and using PMSMs in various applications. Here are the key torque characteristics of a PMSM:

- **Torque-Speed Curve:** The torque-speed curve, also known as the torque-speed characteristic, is a fundamental representation of a PMSM's behavior. It shows how the motor's generated torque changes with its rotational speed (angular velocity).

- **High Starting Torque:** PMSMs are known for their ability to provide high starting torque, which makes them suitable for applications that require a motor to start under a load or at low speeds, such as industrial machines and electric vehicles.
- **Linear Torque Response:** PMSMs typically exhibit a linear relationship between torque and current up to their rated torque. This means that by varying the current supplied to the motor, you can control the torque output precisely.

3.5 CHALLENGE ASSOCIATED WITH PMSM

While Permanent Magnet Synchronous Motors (PMSMs) offer numerous advantages, they also come with several challenges and considerations that need to be addressed in various applications. Here are some common challenges associated with PMSMs:

- **Temperature Management:** PMSMs can generate heat during operation, and excessive heat can reduce motor efficiency and lifespan. Efficient cooling and thermal management systems are essential to prevent overheating, especially in high-power applications.
- **Sensor Integration:** Many PMSM control systems rely on position sensors (e.g., encoders or resolvers) for accurate feedback and control. Sensor integration can add complexity and cost to the motor system, and sensor failures can lead to operational issues.
- **Complex Control Algorithms:** Achieving precise control and high efficiency with PMSMs often requires complex control algorithms. Implementing these algorithms and tuning them for specific applications can be challenging, particularly for those without expertise in motor control.

3.6 Specifications OF PMSM MOTOR

Parameter	Value
➤ Rated Voltage	48VDC
➤ Rated Current	21A
➤ Rated Power (Input)	1000 Watts
➤ Rated Speed (RPM)	3000 RPM
➤ Rated Torque (Nm)	2.71 Nm
➤ No Load Current (A)	< 3 A
➤ No Load RPM	3800 RPM
➤ Current Density (A/square mm)	4.2 A/square mm
➤ Back EMF constant, k_E	0.151 V-s/rad
➤ Motor Mounting	Flange
➤ Frame Size	IEC 90B5 (See below)
➤ Motor Diameter	160 mm
➤ Motor Length (ML)	119 mm (Without cooling fan)
➤ Shaft Diameter	24 mm
➤ Shaft Length	52 mm
➤ Finish	Powder Coated

3.61 Stator

Parameter	Value
➤ Outer Diameter	122 mm
➤ Inner Diameter	80 mm
➤ Number of Slots	12
➤ Axial Length	50 mm
➤ Number of Turns	6 Turns
➤ SWG	21
➤ Number of parallel wires	10
➤ Winding Resistance (1 Phase)	0.0128 Ohms

3.62 Rotor

Parameter	Value
➤ Outer Diameter	78 mm
➤ Number of Poles	10
➤ Type & Grade of Magnet	Arc, N40
➤ Magnet Thickness	3 mm
➤ Axial Length	50 mm
➤ Lamination / Electrical Steel Grade	M47
➤ Shaft Material	EN8
➤ Rotor moment of inertia	0.00132 kg·m ²
➤ Magnet Dimensions	R39.25xR36xW20xL50

3.7 BATTERY

Battery is the heart of the electric bike. It supplies the energy to motor. Battery acts as a condenser by storing the electric energy produced by generator due to electrochemical transformation and supplying it on demand. It is also known as accumulator of electric charge. This generally occurs while starting the system. It can deliver high electrical current for starting an engine. Lead-acid, Nickel-Cadmium, Nickel Metal Hybrid and Lithium-ion batteries are currently used for electric bike. For electric bike, 2-3 battery are used and connected in series to produce larger input supply to motor which is equal to 24-36V and it can be extended depends upon the rating of motor. Batteries used for electric bike.

Compared to other high-quality rechargeable battery technologies, Li-ion batteries provide a number of benefits (nickel-cadmium or nickel-metal hydride). They have one of the highest energy densities of any battery technology available today (100-265 Wh/kg or 250-670 Wh/L). Li-ion battery cells can also deliver 3.6 volts, which is three times higher than Ni-Cd or Ni-MH technology. This means they can supply a lot of current for high-power applications, which is a good thing. Li-ion batteries are also low-maintenance, as they don't need to be cycled on a regular basis to keep their life. Li-ion batteries have no

memory effect, which is a harmful phenomenon in which a battery can remember a decreased capacity after repeated partial discharge/charge cycles. This is an advantage over Ni-Cd and Ni-MH batteries, which also exhibit this behavior. In addition, Li-ion batteries have a low self-discharge rate of 1.5-2 percent each month. They don't contain the hazardous cadmium found in Ni-Cd batteries, making them easier to dispose of.

Li-ion batteries have supplanted Ni-Cd batteries as the market leader in portable electronic gadgets as a result of these benefits (such as smartphones and laptops). Lithium-ion batteries are also utilized to power electrical equipment in some aerospace applications, such as the new and more ecologically friendly Boeing 787, where weight is a major cost consideration. Much of the promise of Li-ion technology in terms of renewable energy derives from its prospective uses in battery-powered cars. The Nissan Leaf and the Tesla Model S, which are now the most popular electric automobiles, both employ Li-ion batteries as their primary fuel source.

Li-ion batteries, while their technological potential, have a number of flaws, particularly in terms of safety. Li-ion batteries have a proclivity for overheating and are susceptible to damage at high voltages. This can result in thermal runaway and combustion in some situations. This has resulted in severe issues, including the grounding of the Boeing 787 aircraft following reports of onboard battery fires. A number of shipping companies refuse to send batteries in bulk by plane due to the risks connected with these batteries. Safety systems for lithium-ion batteries are required to regulate voltage and internal pressures, which can increase weight and performance in some circumstances.

3.7.1 LiFePO₄

The below Fig 3.7 is the Lithium Iron Phosphate (LiFePO₄) batteries offer several advantages for electric bikes (e-bikes) that make them a popular choice among riders and manufacturers. Here are some key advantages, including high energy density, long cycle life, and safety features, specific to LiFePO₄ batteries for e-bikes.



Fig: 3.7: LiFePO₄ Battery

3.7.2 SIGNIFICANCE OF LiFePO₄ BATTERIES IN E-BIKE TECHNOLOGY:

- **Safety:** LiFePO₄ batteries are known for their excellent thermal stability and safety features. They are less prone to overheating and thermal runaway, reducing the risk of fire or explosion
- **Long Cycle Life:** LiFePO₄ batteries offer a longer cycle life compared to some other lithium-ion battery chemistries. They can withstand a higher number of charge and discharge cycles.
- **High Energy Density:** LiFePO₄ batteries have a relatively high energy density, allowing them to store a significant amount of energy in a compact space.
- **Fast Charging Capability:** LiFePO₄ batteries can support fast charging, reducing the time it takes to charge an E-Bike.

3.7.3 INTEGRATION OF PMSM AND LiFePO₄ BATTERIES IN E-BIKE:

- **Performance and Efficiency:** Several studies have shown that e-bikes equipped with PMSM motors exhibit superior performance in terms of acceleration and hill-climbing ability compared to other motor types. LiFePO₄ batteries contribute to longer riding ranges and reduced charging times, enhancing overall e-bike efficiency.
- **Safety and Durability:** The safety of e-bikes with LiFePO₄ batteries is well-documented. Their stable chemistry and resistance to thermal runaway reduce the risk of accidents and fires. PMSM motors have also demonstrated reliability and durability in various e-bike applications.
- **Environmental Impact:** E-bikes powered by LiFePO₄ batteries contribute to reducing greenhouse gas emissions and air pollution in urban areas, aligning with sustainable transportation goals.

3.8 CHARGER

The below given Fig No 3.8 is the charger diagram which we used in our project.

Voltage Output: 54.6V - This is the output voltage provided by the charger. It should match the voltage requirements of the electric vehicle's battery.

Current Output: 6A - This indicates the maximum current (in amperes) that the charger can deliver to the electric vehicle's battery. It's important to ensure that the charging current is suitable for the vehicle's battery specifications.

Power Output: The power output can be calculated by multiplying the voltage and current values.

In this case, it would be $54.6V \times 6A = 327.6 \text{ watts (W)}$. Charging Connector Type: 3Pin, Input Voltage:AC170V-300V, Input Frequency:47-63Hz

Protection Features: Safety features such as overvoltage protection, overcurrent protection, short circuit protection, and overheating protection to ensure safe charging.

Charging Time:6Ah Battery in 1 Hour Compatibility: **48v lithium battery**.



Fig: 3.8: Charger

3.9 CONTROLLER

The below Fig 3.9 is the controller of we used in our project and its the One of the most crucial components of an electric bike is the electric bike controller; it is the e-brain that controls the motor's speed, start, and stop. It's connected to everything else in the car, including the battery, motor, throttle (accelerator), display (speedometer), PAS, and any other speed sensors.

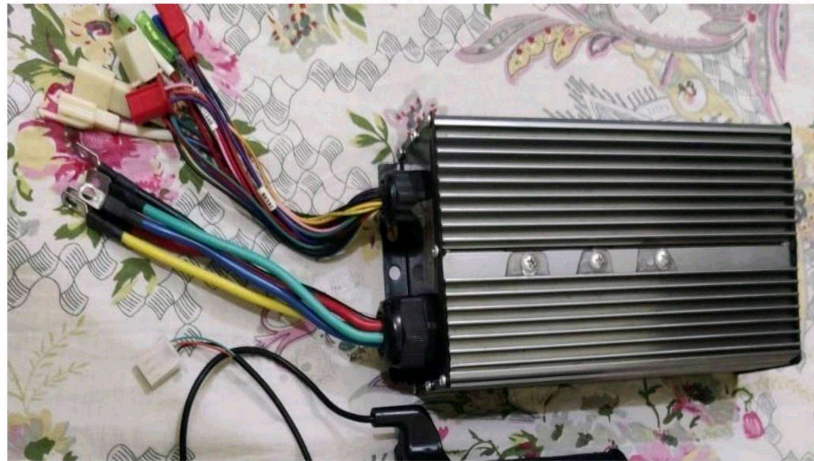


Fig: 3.9: Controller

The TA controller is made up to main chips (microcontroller) and peripheral components (resistors, sensors, MOSFET, etc.) Inside the controller, you'll find a PWM generating circuit, an AD circuit, a power circuit, a power device driver circuit, a signal acquisition and processing circuit, an over-current and undervoltage protection circuit, and a single acquisition and processing circuit.

The controller supplies the working voltage to the external device, such as the switch +5V, headlamp +5V, and so on, after attaching the battery. Based on the input from the throttle or PAS, the PWM generates an appropriate pulse pattern for the MOSFET driving circuit. To control the motor speed, the MOSFET driving circuit manages the MOSFET circuit's turn-on and turn-off.

When the voltage is lower than the controller set value, the under-voltage circuit protects the battery from discharge, and the PWM circuit stops the output. The controller, battery, and motor cannot operate at greater currents because of the over-current protection circuit. The basic job of an electric bike controller is to collect all inputs from all

electric components (throttle, speed sensor, display, battery, motor, and so on) and determine which signal should be returned to them (motor, battery, display).

The controller's many protection functions will differ from the controller's design. Some basic security functions are listed below. Protection against overvoltage. When the battery voltage becomes too high, the controller checks it and shuts down the motor. This prevents overcharging of the battery. Protection against low voltage.

When the battery voltage drops too low, the controller checks it and shuts down the motor. This prevents the battery from becoming overcharged. Protection against overheating. The temperature of the FET (field-effect transistor) is monitored by the controller, which shuts down the motor if it gets too hot. The FET power transistors are therefore protected. Protection against overcurrent. If the motor is receiving too much current, reduce the current supplied to it.

This safeguards the motor as well as the FET power transistors. Protection from braking. Even though the controller was receiving other signals at the same time, the motor shut down while braking. When a user simultaneously presses the brake and throttle, the brake function takes precedence.

3.10 WIRING DIAGRAM OF CONTROLLER

The given Fig 3.5 is the connecting wires of the controller, from the connector through only we will give supply to the motor.

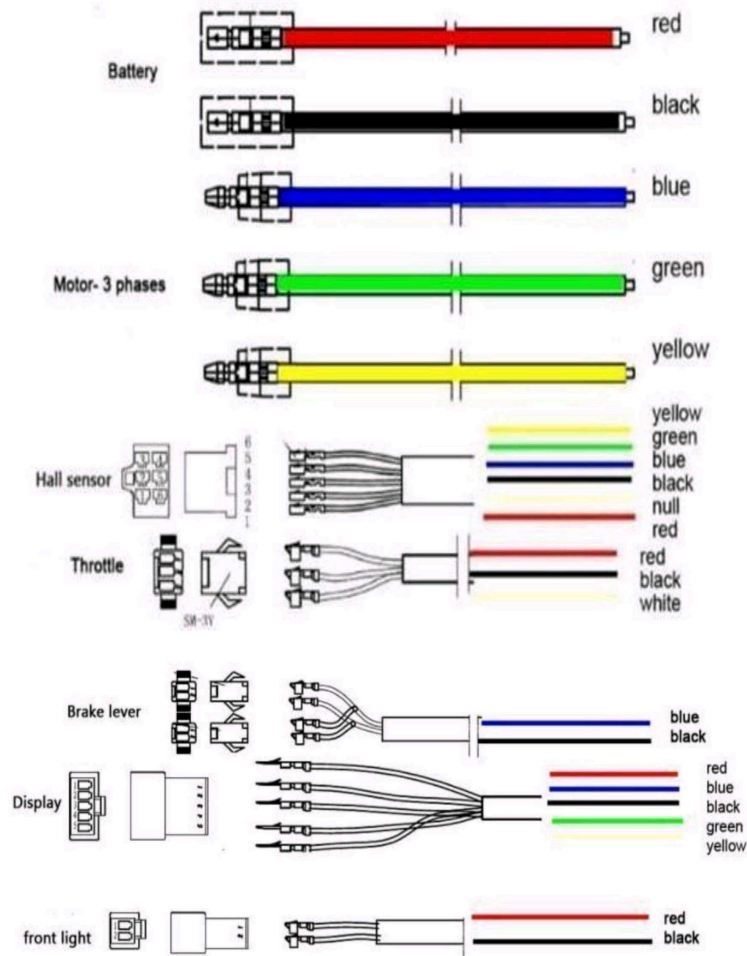


Fig: 3.10: Controller Connecting wires

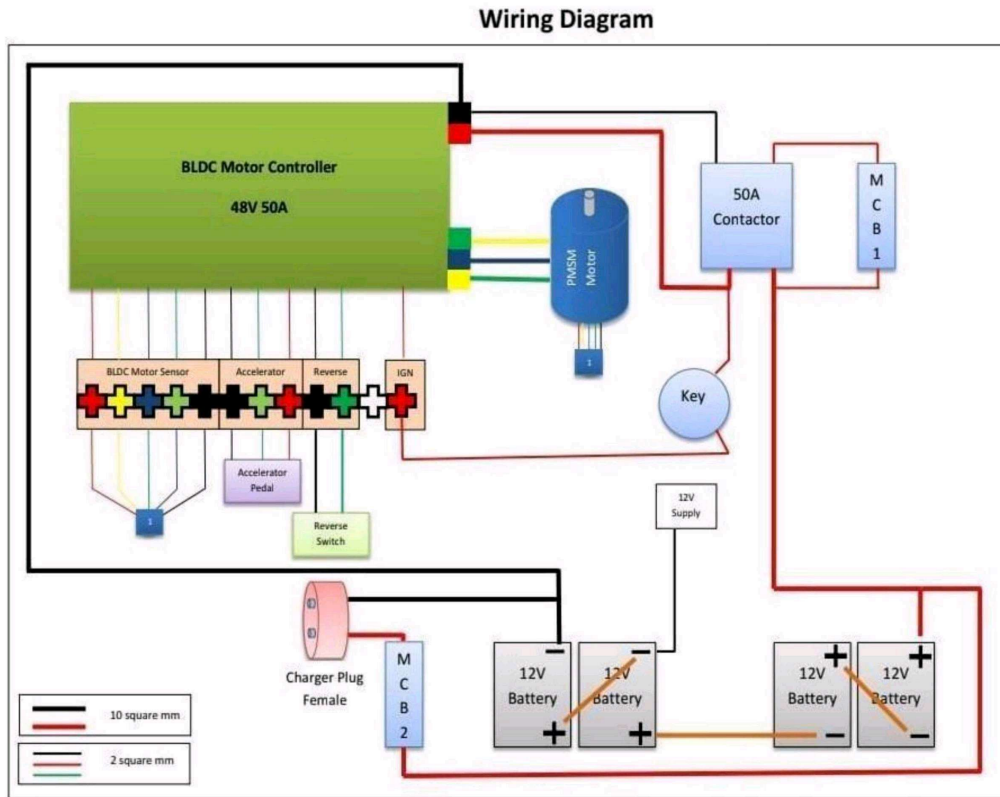


Fig: 3.11: Wiring Diagram of Motor and Controller

3.11 Controller-Motor Connections Fig No 3.11

Ignition: Connect the 24/48V Battery Positive to the Controller Red Wire Bullet Connector via a key switch.

Motor Direction: Connect the Controller Phase Wires and the Hall Sensor wires to the respective wires from the motor as given below to achieve the desired direction.

Direction – Clockwise (From the Shaft Side)

Motor Phase Connection	Yellow	Blue	Green		
Controller Phase Connection	Green	Blue	Yellow		
Motor Hall Sensor Connection	Yellow	Blue	Green	Red	Black
Controller Hall Sensor Connection	Yellow	Green	Blue	Red	Black

Direction – Anti-Clockwise (From the Shaft Side)

Motor Phase Connection	Yellow	Blue	Green		
Controller Phase Connection	Yellow	Blue	Green		
Motor Hall Sensor Connection	Yellow	Blue	Green	Red	Black
Controller Hall Sensor Connection	Blue	Green	Yellow	Red	Black

Throttle / Accelerator Connect the 3pin male connector (Pink, Black, Green) to the throttle/accelerator plug. Ensure that the color codes match while connecting. Pink: +5 VDC, Black: Ground, Green: 0-3.4 VDC

Reverse

Option 1: From the Motor Controller, use the 2-pin female connector (Yellow/Green, Black) wires. Short the two wires using a switch or Joystick to achieve reverse direction. In this option, the motor run only at half the rated RPM of the motor.

Three Speed Option

Use the 3 pin Blue Female Plug (Red/White, Black, Yellow/Red) to achieve three speed options. Connect the Black to Yellow/Red to achieve maximum speed.

Speed 1 - Default

Speed 2 - Connect or short the Black wire to Red/White wire to achieve speed 2

Speed 3 - Connect or short the Black wire to Yellow/Red wire to achieve maximum speed

High Brake

Use the single pin male bullet connector (purple wire) to achieve motor braking. Connect the purple wire to +12V / +48VDC to break the motor.

Meter/Display

Use the single pin female bullet connector (purple wire) as input to the display unit.

3.12 THROTTLE

The below Fig 3.12 is the throttle of Regular electric bikes typically have a throttle that works just like a motorbike or scooter - twist it to go forward, and it doesn't have a reverse gear. However, there are some e-bike throttles that are specifically designed to include a reverse function.

Here's how these throttles with forward and reverse gear work:

Functionality: These throttles function similarly to a regular throttle for forward motion. You twist the grip to control the speed of the electric motor. However, they also have a separate button or switch for engaging reverse gear. When activated, the motor spins in the opposite direction, allowing the bike to move backward at a slow speed.

Benefits: There can be a few advantages to having a throttle with reverse gear on an e-bike:

Maneuvering in tight spaces: Reverse gear can be very helpful when maneuvering your e-bike in tight spaces like parking lots or garages. It allows you to easily back up without needing to get off the bike and push.

Safety: In some situations, being able to reverse slowly can be a safety benefit. For example, if you accidentally go down a short dead-end path, you can use reverse to back out instead of having to turn the bike around.

Availability: E-bikes with throttles that include reverse gear aren't as common as those without. They are typically seen on custom-built e-bikes or some higher-end models. However, you can also find these throttles available for purchase separately if you want to upgrade your existing e-bike. These aftermarket throttles usually come with the necessary wires and connectors for easy installation on most e-bikes.

Things to Consider:

Legality: In some regions, there may be regulations regarding the use of e-bikes with reverse gear. It's always a good idea to check your local laws before using a reverse function on your e-bike.

Safety: While reverse gear can be helpful, it's important to use it cautiously. Be aware of your surroundings when reversing and make sure the path behind you is clear.

Overall, throttles with forward and reverse gear offer some added convenience and functionality for e-bikes. If you frequently ride in situations where tight maneuvering or occasional need to reverse might be helpful, then this could be a worthwhile upgrade for your e-bike.



Fig: 3.12: Throttle

3.13 LIGHTS AND HORN:

The below Figures 3.13 is the Head Light and Indicator and Horn all this we used in our project.

Increased Visibility:

Lights: Having a bright front light allows you to see the road ahead at night and in low-light conditions. Even during the day, a front light helps you be more visible to motorists and pedestrians. A rear light makes you visible to traffic following behind you.

Daylight Running Lights: Some e-bikes even have daytime running lights (DRL) which are low-powered lights that stay on constantly, similar to car headlights. This can significantly improve your visibility during the day.

Most e-bikes are equipped with battery-powered LED lights, which are bright, energy-efficient, and last a long time on a single charge. Some high-end models may come with integrated lights powered by the bike's main battery.

A horn is a crucial tool to alert pedestrians and other cyclists of your presence, especially when riding on shared paths or in situations where they might not see you coming.

By equipping your e-bike with proper lights and a horn, you'll be significantly enhancing your safety and visibility on the road, making your rides more enjoyable and ensuring everyone around you is aware of your presence.



Head Light



Indicators



Horn

3.14 Chain Type:

We are using the standard roller chain type for this E-Bike, because this most common type of motorcycle chain and are a good option for most riders. They are relatively inexpensive and easy to maintain.

A motorcycle chain is a continuous loop made up too many interlocking metal links. These links connect to two sprockets: a smaller one on the engine's output shaft and a larger one on the rear wheel. Here's a breakdown of how the chain connects

Chain links:

The given Fig No 3.14 is the Chain drive Each link consists of several parts:

Inner plates: Two inner plates that hold everything together.

Outer plates: Two outer plates that connect to the sprocket teeth.

Pins: These solid or hollow pins run through the inner plates and connect them, allowing for rotation.

Bushings: These surround the pins and reduce friction between moving parts.

Rollers: These rollers (on the outer plates) ride on the sprocket teeth, enabling smooth transmission of power

Connecting the Chain:

Not all the links are identical. A special type of link called a master link allows the chain to be opened and closed for installation or removal.

The master link typically has a clip or a plate mechanism that secures it to a standard link. When installing the chain, the master link is positioned strategically, often with the closed end facing the front of the bike for additional security.

Sprocket Engagement:

The chain connects to the sprockets by its rollers fitting snugly between the sprocket teeth. As the engine powers the motorcycle, the smaller sprocket on the engine shaft rotates. This rotation pulls the chain links along, causing the rollers to engage with the teeth of the larger rear sprocket.

This chain-sprocket interaction transfers power from the engine to the rear wheel, ultimately propelling the motorcycle forward.

Overall, the motorcycle chain acts as a flexible yet robust link between the engine and the rear wheel, transmitting power through a series of interlocking links and precisely shaped sprockets.

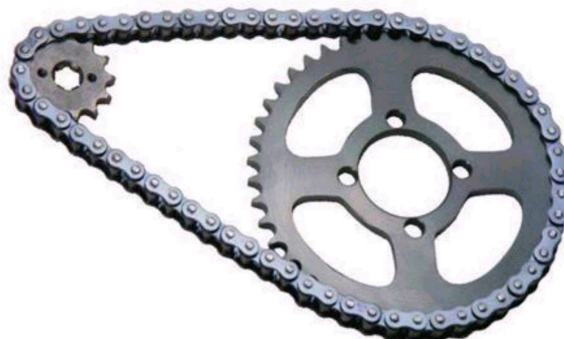


Fig:3.14: Chain Drive

CHAPTER 4

DEVELOPING AND TESTING OF ELECTRIC BIKE

4.1 WIRING DIAGRAM OF E-BIKE

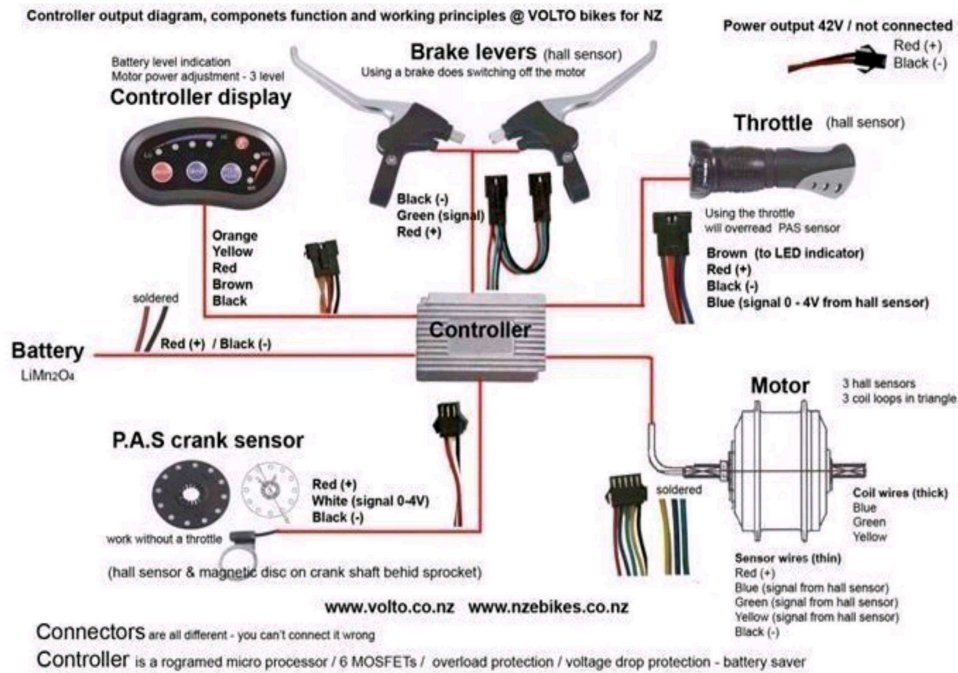


Fig. 4.1: Wiring diagram of E-Bike

The above Fig No 4.1 is the Electric bike wiring diagrams can vary depending on the specific components used, but here's a general explanation of how the main parts is connected through a controller:

Components:

Battery: The power source of the bike, typically Lithium-ion (Li-ion) in various voltages (e.g., 24V, 36V, 48V).

Motor: Provides electric power to assist pedaling. Common types are hub motors (in the wheel) and mid-drive motors (connected to the crankset).

Controller: The brain of the system, regulating power flow between battery, motor, and other components. It receives signals from throttle and display.

Throttle: Controls the motor's assist level, typically a twist grip or thumb lever.

Display: Shows information like battery level, speed, and pedal assist mode.

Connections:

Battery to Controller: The battery's positive and negative terminals connect to the designated power input terminals on the controller.

Motor to Controller: The motor's phase wires (usually 3) connect to the motor output terminals on the controller.

Throttle to Controller: The throttle wires connect to the throttle input terminals on the controller, often including wires for positive voltage, ground, and signal wire.

Display to Controller: The display connects to the controller through a communication port, often using a cable with multiple wires depending on the system.

4.2 BOARD CONDITION

We were searching for a second-hand or third-hand bike to purchase, Given Fig No 4.2 that bike we purchase but we ended up finding a bike in poor condition and decided to buy it, and this bike is in good conditions, but few parts rusted so we removed those parts. and front and rear tire are shaking so we changed the both tier, new tubes are fixed in the tires and head light, side light are not there. And brakes are not working. Handling of the bike is normal. seat cover also damaged.

Research Work

Overall bike weight is 112 kg, and it has a 92cc engine, seat height is 785mm and length*width*height is 2000*720*1052mm³, height is 1052mm, ground clearance 165mm, wheel size for Front 457.2mm, Rear is 457.2mm, Brakes of front and Rear is Drum and it is Integrated Braking system.

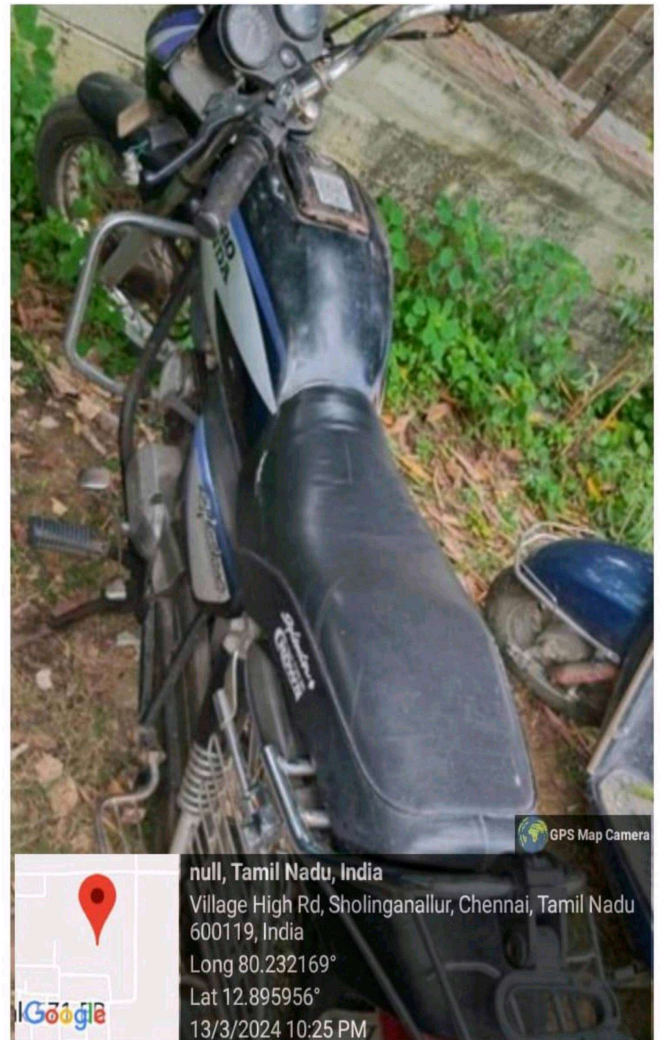


Fig: 4.2: Board condition

Firstly, we decided to remove the parts of the bike such as engine, fuel system, exhauster, some parts which are not wanted, then we went to the mechanical shop to Remove parts of the bike. A mechanical person removed the engine, Fuel system, exhaust.

4.3 REMOVED PARTS

All these parts were removed by a Mechanical person. like Engine, fuel system, and exhauster, then we calculate the engine weight as 25 kgs. fuel system and exhauster are 2kg, mechanical person taken these parts as a charge of removing these parts. we did not remove the chain drive system because we are using the chain drive system for this bike.



Engine



Fuel System



Exhaust

"After removing the parts of the bike, the Fig No 4.3 such as the engine, fuel system, and exhaust the now the bike weight comes to around 80kgs .it has some space to place components like motor, battery, and controller. Inside the petrol tank, we can place some small components so we do not remove the petrol tank. We have to place the motor, battery, controller so, firstly we tested these components with our guide.



Fig: 4.3: Removed parts

4.4 TESTING OF COMPONENT:

The below Fig No 4.4 shows the Testing of the components was completed successfully by our project Guide and lab in charge, for this testing we needed a motor, battery, controller, and throttle, so firstly we gave a power supply to the controller from the battery with red and black wires and then from to controller to motor same color wires are connected such as blue, Yellow, Green. One plug wire is connected from the controller to the motor and the throttle is connected to the controller. An electric clock wire is connected to the battery supply. When the connection is done the throttle rises slowly the motor starts rotating.



Fig: 4.4: Testing of Components

4.5 SOFTWARE DESIGN OF BIKE

Before starting this project, we design the bike with the help of mechanical student. according to these dimensions we design this bike below given Fig No 4.5.

length*width*height is 2000*720*1052mm³, height is 1052mm, ground clearance 165mm, wheel size for Front 457.2mm, Rear is 457.2mm.

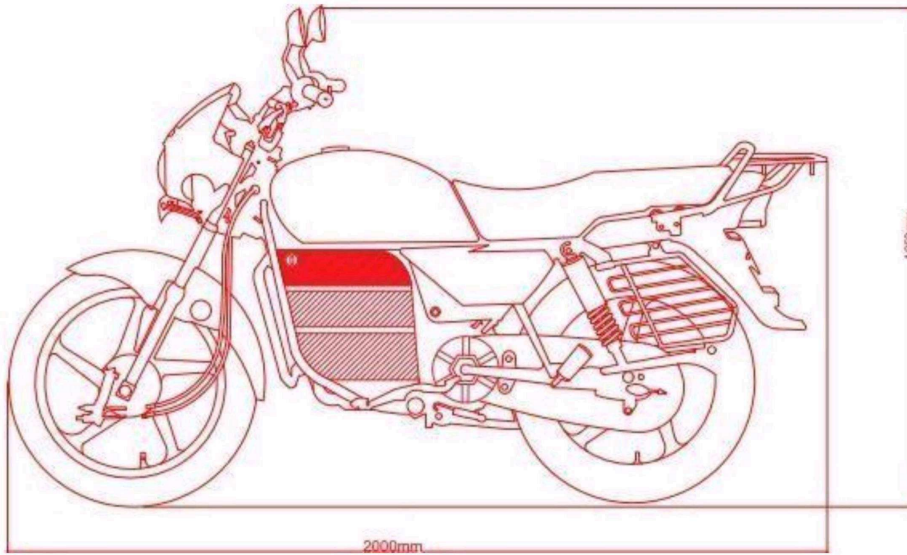


Fig: 4.5: Software Design of E-bike

4.6 Bike chain Drive to wheel

After the complete testing of components, the next step is fixing the components. We have to arrange the exact space for the components to be fixed properly in the bike. To fix the motor, we need an iron plate for support. We drill the iron plates and use screws to fix the motor. Already we fixed the sprocket to the shaft. The chain drive is connected between the rear wheel and the motor sprocket. After this work, we need to fix the battery, so again, we use the iron plate to fix the battery, and we can easily remove and insert the battery. The controller is placed on top of the motor. The below is the Fig 4.6 after inserting the chain drive to wheel.

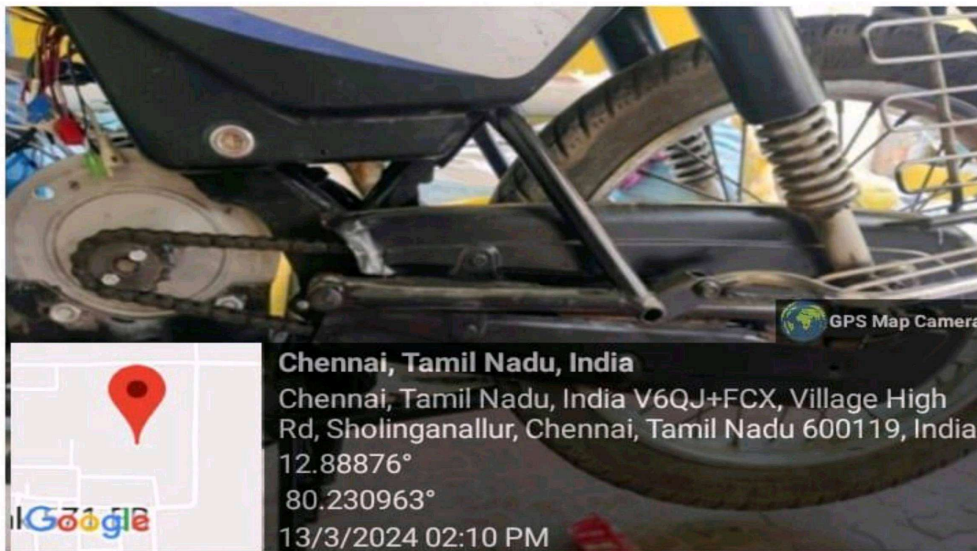


Fig: 4.6: Chain Drive to Wheel

4.7 FIXING COMPONENTS

After fixing all the components, some parts got rusted so we cleaned the rusting parts, to prevent rusting we did painting work. we fixed the display meter which helps to show battery percentage and speed, the throttle is connected to both sides of the handle, and the Headlight, and side indicator were also fixed with the help of a 12V DC battery lastly, we fixed the wiring connections for motor, controller, and battery and we did test again it working well.

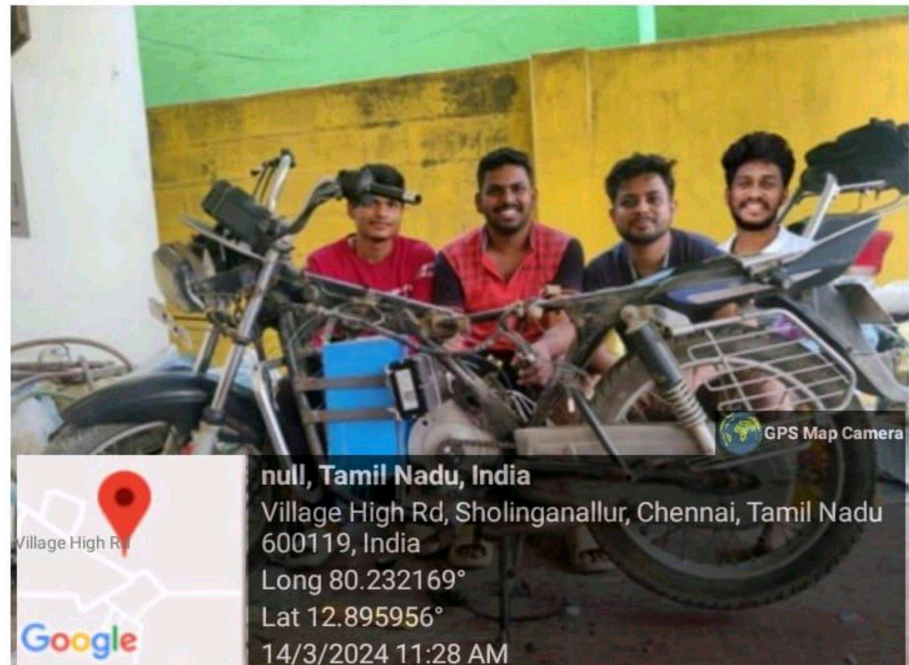


Fig: 4.7: Fixing components

4.7.1 After Fixing components

Here the Bike after fixing all components the Fig No 4.8, We have fixed all the components of the bike, including the headlight and side lights. The rusted rods of the bike have been coated with black paint. After the repairs, we checked the bike's weight, which is approximately 105kg. However, if we remove the petrol tank, the bike's appearance will not be nice, so we decided to keep the petrol tank in its original position. It may also be useful for future purposes, such as storing the tank and all the wires of the components inside the bike. All the components have been fixed perfectly."

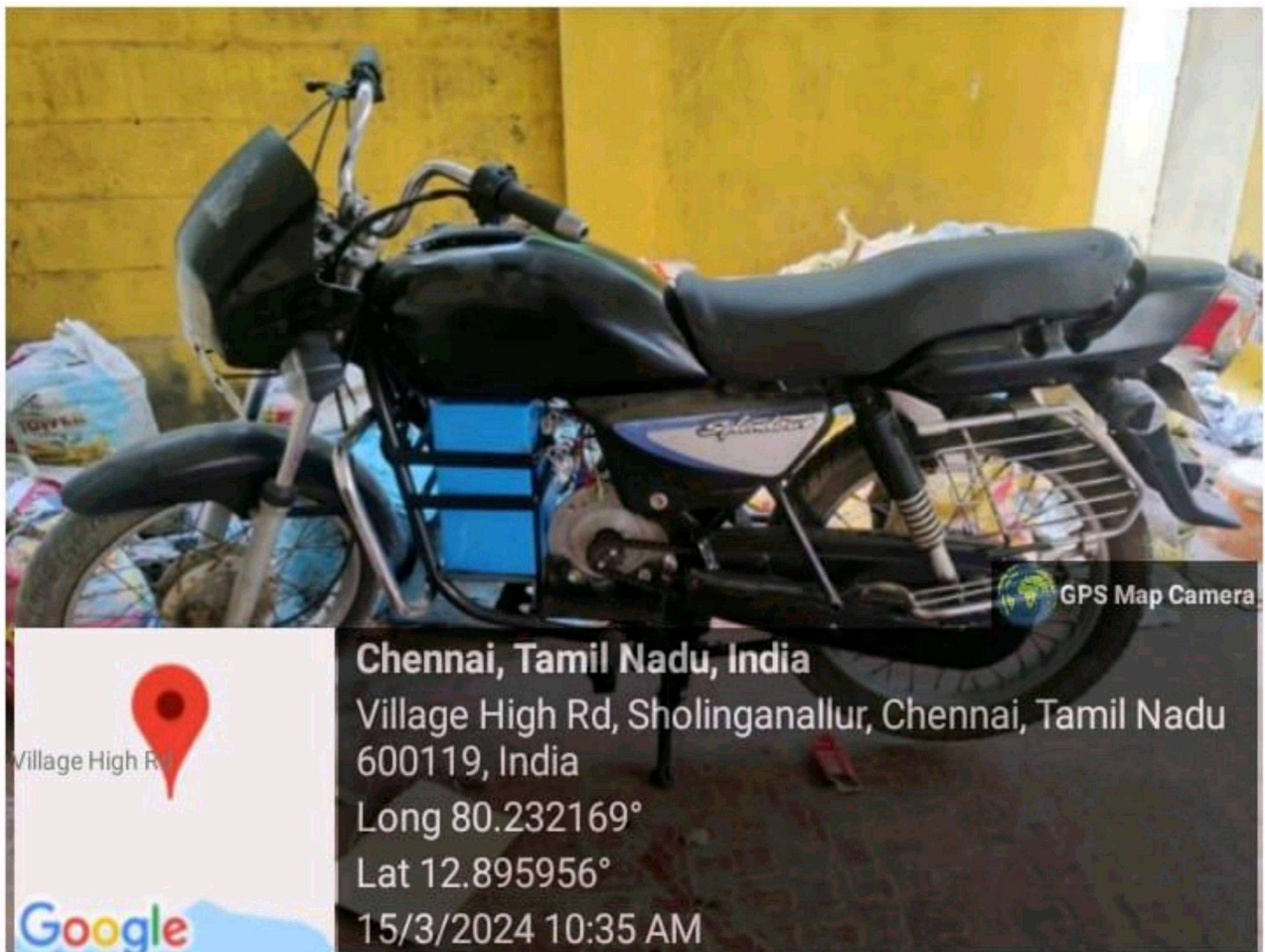


Fig: 4.8: Fixing components

4.8 Testing of BIKE

During our bike testing, we noticed that, the bike can travel up to 40 kilometers per charge at a speed of 60 kilometers per hour, without any load. The maximum speed of the bike is 80 kilometers per hour, but when carrying a normal load, it can travel at a speed of 50 kilometers per hour. However, if the load is increased, the speed and range decrease accordingly. It takes approximately 5 hours to charge the battery fully.

During the testing with more load, we found that the motor's permanent magnets broke and the winding was damaged. The reason behind this was the high stress on the motor, which occurred due to the absence of gear reduction. To control the high stress on the motor, we need to use gear reduction. The gear reduction process involves setting the gear reduction ratio accurately. A gear reducer is a mechanical system of gears arranged in such a way that the input speed can be lowered to a slower output speed, but with the same or more output torque. The gear reduction process is used when the drive gear is smaller and has fewer teeth than the driven gear.

"We sent the damaged motor to the manufacturer under warranty. They informed us that the cause of the damage was insufficient gear reduction ratio. After repairing the motor, they will install the necessary gear reduction and take steps to avoid making the same mistake again."

4.9 IEEE Standards:

- IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems. This standard provides guidelines for the interconnection of distributed energy resources, which may include electric bikes with battery storage systems.
- IEEE 2030: Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation with the Electric Power System (EPS), End-Use Applications, and Loads. This standard addresses the integration of electric vehicles and energy storage systems into smart grid infrastructure.
- IEEE 1801: Standard for Design and Verification of Low-Power Integrated Circuits. While primarily focused on integrated circuits, this standard can provide insights into efficient power management techniques for electronic components used in electric bike systems.
- IEEE 11073: Health informatics - Personal health device communication. This standard can be relevant for integrating health monitoring features into electric bike systems, such as monitoring battery health and motor performance.
- IEEE 1625: Rechargeable Batteries for Portable Computing. Although focused on computing devices, this standard provides guidance on the design and testing of rechargeable batteries, which can be applicable to electric bike battery systems.
- IEEE 2846: Standard for Systematic Review in Software Engineering. While not directly related to electric bikes, this standard provides guidelines for systematic review processes that can be applied to ensure quality and reliability in the development of software components, such as GPS tracking systems.
- IEEE 1451: Standard for a Smart Transducer Interface for Sensors and Actuators. This standard provides a framework for connecting sensors and actuators to electronic systems, which can be useful for integrating various sensors and control systems in electric bike designs.

4.10 Constraints:

- **Cost Constraints:** The project report should detail the budget limitations and how they influenced design decisions, component selection, and manufacturing processes. It should discuss cost-saving measures implemented without compromising performance or safety.
- **Regulatory Constraints:** Compliance with relevant regulations and standards, such as safety standards for electric bikes and emissions regulations, should be documented. The report should outline how the design meets or exceeds these regulatory requirements.
- **Technical Constraints:** Technical limitations, such as the maximum power output of the PMSM motor, the capacity and voltage limitations of the lithium-ion phosphate battery, and the processing capabilities of the GPS tracking system, should be addressed. The report should explain how these constraints were considered in the design process.
- **Weight and Size Constraints:** The weight and size of the electric bike components, including the motor, battery, and GPS tracking system, may be limited by factors such as frame design, portability requirements, and user preferences. The report should discuss how weight and size constraints were managed to achieve the desired balance between performance and practicality.
- **Power Consumption Constraints:** The power consumption of the electric bike system, including the motor, battery management system, and GPS tracking system, should be optimized to ensure sufficient range and battery life. The report should describe how power consumption constraints were addressed through efficient component selection and system design.
- **Environmental Constraints:** Environmental considerations, such as temperature and weather conditions, may impact the performance and durability of the electric bike components. The report should discuss how environmental constraints were accounted for in the design, including measures taken to enhance durability and reliability in various operating conditions.

CHAPTER 5

GPS TRACKING SYSTEM

5.1 Introduction of GPS Tracking System

- A GPS tracking system is a technology that uses GPS satellites to accurately determine the location of a vehicle, asset, or individual in real-time.
- It consists of hardware components like GPS receivers and antennas, coupled with software for data interpretation and visualization.
- These systems have applications in fleet management, personal safety, asset tracking, and wildlife conservation, among others.

5.2 Components of GPS Tracking Systems

- **Hardware components:**

- **GPS Receiver:** Receives signals from GPS satellites to determine the device's location.



Fig: 5.2: Receiver

- **Antenna:** Captures GPS Signals and transmits them to the GPS receiver for processing.



- **Tracker unit:** Contains the GPS receiver and often includes additional features like cellular or satellite communication capabilities for transmitting location data.
- **Power source:** Battery to keep the tracking system operational.

Above hardware components of 5.2 work together to capture, process, and transmit location data for tracking purposes.

- **Software components:**

- **Mapping software:** Displays the real-time location of tracked assets or vehicles on digital maps.
- **Data analysis tools:** Analyze tracking data to generate reports, insights, and alerts based on predefined criteria.
- **User interface:** Allows users to interact with the tracking system, view live tracking data, set up notifications, and access historical tracking information.
- **Communication protocols:** Enable the exchange of data between the tracking devices and the software platform, often utilizing cellular networks or satellite communication.

These software components work together to provide users with the necessary tools to monitor, manage, and analyze tracking data effectively.

5.3 How to Install in Vehicle:

- Firstly, we have to Download the Qubo Go App.
- We will get this App in the Google Play store and App Store, once the installation is complete.
- Then we have to set up the account and follow the instructions on the App to complete the device commissioning.
- After completing the process then the device has the serial Number QR code at the back as shown in Fig No 5.3.
- Then capture an image of the QR code and save it to use in the device setup process within the app.



Fig: 5.3: QR code of GPS

5.4 Applications of GPS Tracking:

- **Fleet management:** Tracking vehicles for logistics, route optimization, and fuel efficiency.
- **Personal tracking:** Monitoring individuals for safety and security purposes.
- **Asset tracking:** Tracking valuable assets like containers, equipment, and shipments.
- **Wildlife tracking:** Studying animal movements and behaviors for research and conservation.

5.5 Benefits of GPS Tracking Systems:

- **Improved efficiency:** Real-time tracking allows for better resource allocation and management.
- **Enhanced safety and security:** Helps locate people and assets in case of emergencies or theft.
- **Cost savings:** Optimizing routes and reducing idle time can lead to fuel and labor savings.
- **Data-driven decision making:** Analyzing tracking data can provide insights for process improvement and optimization.

5.5.1 Challenges and Considerations:

- **Privacy concerns:** Balancing the benefits of tracking with individual privacy rights.
- **Technical limitations:** GPS signals can be obstructed by buildings, terrain, or weather conditions.
- **Cost implications:** Initial investment in hardware and software, ongoing maintenance costs.

5.6 Trade-Off:

- **Performance vs. Battery Life:** Increasing the performance of the electric bike, such as higher speed or greater acceleration, may reduce the battery life due to increased power consumption. Designers need to balance performance requirements with the need for sufficient battery capacity to ensure adequate range and longevity.
- **Weight vs. Range:** Adding features like a GPS tracking system or additional battery capacity to extend the range may increase the weight of the electric bike. There's a trade-off between the added weight and the desired range. More weight can decrease efficiency and handling, while a longer range may require sacrificing some weight savings in other components.
- **Cost vs. Features:** Integrating advanced features like a sophisticated GPS tracking system may significantly increase the cost of the electric bike. Designers must consider the target market and price sensitivity when deciding which features to include and which to omit in order to achieve a balance between cost and features.
- **Complexity vs. Maintenance:** A more complex electric bike design with advanced features may require more maintenance and troubleshooting over time. Simplifying the design can reduce maintenance requirements but may limit functionality and performance.
- **Integration vs. Compatibility:** Integrating multiple subsystems, such as the PMSM motor, battery, and GPS tracking system, requires careful consideration of compatibility and interoperability between components. Designers must ensure that all components work seamlessly together to avoid compatibility issues that could affect performance or reliability.
- **Safety vs. Performance:** Design decisions that enhance safety, such as implementing robust braking systems or redundant electrical systems, may add weight and complexity to the electric bike, potentially impacting performance. Balancing safety considerations with performance requirements is crucial to ensure a safe yet enjoyable riding experience.
- **Regulatory Compliance vs. Innovation:** Compliance with regulatory standards and certifications is essential for ensuring the electric bike meets safety and legal requirements. However, adhering to standards may impose limitations on design innovation and flexibility. Designers must navigate these regulations while still striving for innovation in their designs.

5.7 Problem Statement:

- **Efficient Motor Integration:** Develop a seamless integration of a PMSM motor into the electric bike's drivetrain system, ensuring optimal performance and efficiency.
- **Battery Management:** Design a robust Lithium-ion Phosphate battery system capable of providing sufficient power and range for the electric bike while ensuring safety and longevity.
- **GPS Tracking System:** Implement a GPS tracking system to enable real-time monitoring and tracking of the electric bike's location, enhancing security and facilitating fleet management.
- **User Experience Enhancement:** Focus on user-centric design principles to enhance the overall riding experience, including ergonomics, control interfaces, and ride comfort.
- **Safety and Regulatory Compliance:** Ensure compliance with relevant safety standards and regulations governing electric bikes, including but not limited to electrical safety, battery management, and roadworthiness.
- **Cost Optimization:** Strive to achieve a balance between performance and cost-effectiveness in component selection and system design, considering factors such as manufacturing feasibility and market competitiveness.
- **Environmental Sustainability:** Explore opportunities for reducing the environmental footprint of the electric bike through the use of energy-efficient components, recyclable materials, and eco-friendly manufacturing processes.

CHAPTER 6

CHALLENGES AND CONCLUSION

6.1 CHALLENGES AND FUTURE DIRECTIONS:

- While PMSM motors and LiFePO₄ batteries offer numerous advantages, challenges remain, including cost and range limitations.
- Future research should focus on addressing these challenges, optimizing motor and battery designs, and exploring innovative charging solutions.

6.2 CONCLUSION:

- PMSM motors and LiFePO₄ batteries have emerged as key to possible in evolution of electric bikes.
- Their contributions to performance, efficiency, safety, and environmental sustainability make them significant components of the e-bike industry.
- Continued research and development in this field will likely lead to further improvements in e-bike technology, making them even more attractive as a sustainable urban transportation option.

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PATENT FORMS

Form 1

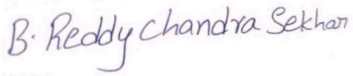
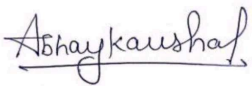
"FORM 1" THE PATENTS ACT 1970 (39 of 1970) and THE PATENTS RULES, 2003 APPLICATION FOR GRANT OF PATENT (See section 7, 54 and 135 and sub-rule (1) of rule 20)				(FOR OFFICE USE ONLY)	
		Application No.			
		Filing date:			
		Amount of Fee paid:			
		CBR No:			
		Signature:			
1. APPLICANT'S REFERENCE / IDENTIFICATION NO. (AS ALLOTTED BY OFFICE)					
2. TYPE OF APPLICATION [Please tick (✓) at the appropriate category]					
Ordinary (✓)		Convention ()		PCT-NP ()	
Divisional ()	Patent of Addition ()	Divisional ()	Patent of Addition ()	Divisional ()	Patent of Addition ()
3A. APPLICANT(S)					
Name in Full		Nationality	Country of Residence	Address of the Applicant	
SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY		INDIAN	INDIA	House No.	SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY
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				City	CHENNAI
				State	TAMIL NAIDU
				Country	INDIA
				Pin code	600119

3B. CATEGORY OF APPLICANT [Please tick (✓) at the appropriate category]			
Natural Person ()	Other than Natural Person		
	Small Entity ()	Startup ()	Others (✓)
4. INVENTOR(S) [Please tick (✓) at the appropriate category]			
Are all the inventor(s)	Yes ()	No (✓)	

same as the applicant(s) named above?			
If "No", furnish the details of the inventor(s)			
Name in Full	Nationality	Country of Residence	Address of the Inventor
DR.A RAMESH BABU			House No. 5/676
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			City CHENNAI
			State TAMIL NADU
			Country INDIA
			Pin code 600126
Name in Full	Nationality	Country of Residence	Address of the Inventor
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			City CHENNAI
			State TAMIL NADU
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			Pin code 600126

Name in Full	Nationality	Country of Residence	Address of the Inventor	
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			City	KADAPA
			State	ANDHRA PRADESH
			Country	INDIA
			Pin code	516312
Name in Full	Nationality	Country of Residence	Address of the Inventor	
REDDY CHANDRA SEKHAR BUSINENI	INDIAN	INDIA	House No.	9/28-G
			Street	VARIGA ROAD
			City	RAYACHOTY
			State	ANDHRA PRADESH
			Country	INDIA
			Pin code	516270
Name in Full	Nationality	Country of Residence	Address of the Inventor	
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			Street	AYYAVARIPALLY
			City	WANAPARTHY
			State	TELANGANA
			Country	INDIA
			Pin code	509105
Name in Full	Nationality	Country of Residence	Address of the Inventor	
ABHAY KAUSHAL	INDIAN	INDIA	House No.	
			Street	SOUTH OF KRISHNANIKETHAN

				City	PATNA
				State	BIHAR
				Country	INDIA
				Pin code	800001
5. TITLE OF THE INVENTION					
Design and fabrication of an electric bike with a lithium battery, PMPM, and GPS tracking.					
6. AUTHORISED REGISTERED PATENT AGENT(S)			IN/PA No.		
			Name		
			Mobile No.		
7. ADDRESS FOR SERVICE OF APPLICANT IN INDIA			Name		
			Postal Address		
			Telephone No.		
			Mobile No.		
			Fax No.		
			E-mail ID		
8. IN CASE OF APPLICATION CLAIMING PRIORITY OF APPLICATION FILED IN CONVENTION COUNTRY, PARTICULARS OF CONVENTION APPLICATION					
Country	Application Number	Filing date	Name of the applicant	Title of the invention	IPC (as classified in the convention country)
9. IN CASE OF PCT NATIONAL PHASE APPLICATION, PARTICULARS OF INTERNATIONAL APPLICATION FILED UNDER PATENT CO-OPERATION TREATY (PCT)					
International application number			International filing date		
10. IN CASE OF DIVISIONAL APPLICATION FILED UNDER SECTION 16, PARTICULARS OF ORIGINAL (FIRST) APPLICATION					
Original (first) application No.			Date of filing of original (first) application		

11. IN CASE OF PATENT OF ADDITION FILED UNDER SECTION 54, PARTICULARS OF MAIN APPLICATION OR PATENT	
Main application/patent No.	Date of filing of main application
12. DECLARATIONS	
(i) Declaration by the inventor(s) (In case the applicant is an assignee: the inventor(s) may sign herein below or the applicant may upload the assignment or enclose the assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period). I/We, the above named inventor(s) is/are the true & first inventor(s) for this Invention and declare that the applicant(s) herein is/are my/our assignee or legal representative. (a) Date 08.04.2024 (b) Signature(s)  (c) Name(s) DR. A RAMESH BABU (a) Date 08.04.2024 (b) Signature(s)  (c) Name(s) DR. BARNABAS PAUL GLADY (a) Date 08.04.2024 (b) Signature(s)  (c) Name(s) B.TARUN (a) Date 08.04.2024 (b) Signatur(s)  (c) Name(s) REDDY CHANDRA SEKHAR BUSINENI (a) Date 08.04.2024 (b) Signature(s)  (c) Name(s) S.RAKESH (a) Date 08.04.2024 (b) Signature(s)  (c) Name(s) ABHAY KAUSHAL	

~~(ii) Declaration by the applicant(s) in the convention country~~

~~(In case the applicant in India is different than the applicant in the convention country: the applicant in the convention country may sign herein below or applicant in India may upload the assignment from the applicant in the convention country or enclose the said assignment with this application for patent or send the assignment by post/electronic transmission duly authenticated within the prescribed period)~~

~~I/We, the applicant(s) in the convention country declare that the applicant(s) herein is/are my/our assignee or legal representative.~~

(a) Date _____

(b) Signature(s) _____

(c) Name(s) of the signatory _____

(iii) Declaration by the applicant(s)

I/We the applicant(s) hereby declare(s) that: -

- ☒ I am/ We are in possession of the above-mentioned invention.
- ☒ The ~~provisional~~/complete specification relating to the invention is filed with this application.
- ☐ ~~The invention as disclosed in the specification uses the biological material from India and the necessary permission from the competent authority shall be submitted by me/us before the grant of patent to me/us.~~
- ☒ There is no lawful ground of objection(s) to the grant of the Patent to me/us.
- ☐ ~~I am/we are the true & first inventor(s).~~
- ☒ I am/we are the assignee or legal representative of true & first inventor(s).
- ☐ ~~The application or each of the applications, particulars of which are given in Paragraph-8, was the first application in convention country/countries in respect of my/our invention(s).~~
- ☐ ~~I/We claim the priority from the above mentioned application(s) filed in convention country/countries and state that no application for protection in respect of the invention had been made in a convention country before that date by me/us or by any person from which I/We derive the title.~~
- ☐ ~~My/our application in India is based on international application under Patent Cooperation Treaty (PCT) as mentioned in Paragraph-9.~~
- ☐ ~~The application is divided out of my /our application particulars of which is given in Paragraph-10 and pray that this application may be treated as deemed to have been filed on DD/MM/YYYY under section 16 of the Act.~~
- ☐ ~~The said invention is an improvement in or modification of the invention particulars of which are given in Paragraph-11.~~

13. FOLLOWING ARE THE ATTACHMENTS WITH THE APPLICATION

(a) Form 2

Item	Details	Fee	Remarks
Complete/ provisional specification)#	No. of pages		
No. of Claim(s)	No. of claims and No. of pages		
Abstract	No. of pages		

No. of Drawing(s)	No. of drawings and No. of pages		
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In case of a complete specification, if the applicant desires to adopt the drawings filed with his provisional specification as the drawings or part of the drawings for the complete specification under rule 13(4), the number of such pages filed with the provisional specification are required to be mentioned here.

- (b) Complete specification (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).
- (c) Sequence listing in electronic form
- (d) Drawings (in conformation with the international application)/as amended before the International Preliminary Examination Authority (IPEA), as applicable (2 copies).
- (e) Priority document(s) or a request to retrieve the priority document(s) from DAS (Digital Access Service) if the applicant had already requested the office of first filing to make the priority document(s) available to DAS.
- (f) Translation of priority document/Specification/International Search Report/International Preliminary Report on Patentability.
- (g) Statement and Undertaking on Form 3
- (h) Declaration of Inventorship on Form 5
- (i) Power of Authority
- (j).....

**Total fee ₹.....in Cash/ Banker's Cheque /Bank Draft bearing No..... Date.....on
..... Bank.**

I/We hereby declare that to the best of my/our knowledge, information and belief the fact and matters slated herein are correct and I/We request that a patent may be granted to me/us for the said invention.

Dated this.....day of.....20.....

Signature:

Name:

SATHYABAMA INSTITUTE OF
SCIENCE AND TECHNOLOGY
(Signature of Official stamp)

To,
The Controller of Patents
The Patent Office, at.....

Note: -

- * Repeat boxes in case of more than one entry.
- * To be signed by the applicant(s) or by authorized registered patent agent otherwise where mentioned.
- * Tick (✓)/cross (x) whichever is applicable/not applicable in declaration in paragraph-12.
- * Name of the inventor and applicant should be given in full, family name in the beginning.
- * Strike out the portion which is/are not applicable.
- * For fee: See First Schedule”;

FORM 2

GAZETTE OF INDIA: EXTRAORDINARY THE PATENT ACT 1970 (39 of 1970)		[PART II—SEC. 3(ii)]				
FORM 2 THE PATENT ACT 1970 (39 of 1970) The Patents Rules, 2003 PROVISIONAL COMPLETE SPECIFICATION (See section 10 and rule 13)						
1. TITLE OF THE INVENTION: DESIGN AND FABRICATION OF ELECTRIC BIKE WITH LITHIUM BATTERY, PMSM AND GPS TRACKING.						
2. APPLICANT (S) (a) NAME: BELLAM TARUN (b) NATIONALITY: INDIAN (c) ADDRESS: F-11, V.V REDDY NAGAR, KADAPA, ANDHRA PRADESH, 516312. (a) NAME: REDDY CHANDRA SEKHAR BUSINENI (b) NATIONALITY: INDIAN (c) ADDRESS: 9/28-G, VARIGA ROAD, RAYACHOTY, ANDHRA PRADESH, 516270. (a) NAME: S. RAKESH (b) NATIONALITY: INDIAN (c) ADDRESS: AYYAVARIPALLY, WANAPARTHY, TELANGANA, 509105. (a) NAME: ABHAY KAUSHAL (b) NATIONALITY: INDIAN (c) ADDRESS: SOUTH OF KRISHNANIKETHAN, PATNA, BIHAR, 800001.						
3. PREAMBLE TO THE DESCRIPTION <table border="1"> <thead> <tr> <th>PROVISIONAL</th> <th>COMPLETE</th> </tr> </thead> <tbody> <tr> <td>The following specification describes the invention.</td> <td>The following specification particularly describes the invention and the manner in which it is to be performed.</td> </tr> </tbody> </table>			PROVISIONAL	COMPLETE	The following specification describes the invention.	The following specification particularly describes the invention and the manner in which it is to be performed.
PROVISIONAL	COMPLETE					
The following specification describes the invention.	The following specification particularly describes the invention and the manner in which it is to be performed.					
4. DESCRIPTION (Description shall start from next page.)						
5. CLAIMS (not applicable for provisional specification, Claims should start with the preamble — "%/we claim" on separate page)						
6. DATE AND SIGNATURE (to be given at the end of last page of specification)						

7. ABSTRACT OF THE INVENTION (to be given along with complete specification on separate page)

Note: -

*Repeat boxes in case of more than one entry.

be signed by the applicant(s) or by authorized registered patent agent.

*Name of the applicant should be given in full family name in the beginning.

*Complete address of the applicant should be given stating the postal index state and country.

*Strike out the column which is are not applicable.

FORM 5
THE PATENTS ACT,
1970
 (39 of 1970)

The Patents Rules, 2003
 DECLARATION AS TO
 INVENTORSHIP
 [See section 10(6) and rule

1. NAME OF APPLICANT (S): REDDY CHANDRA SEKHAR BUSINENI

Hereby declare that the true and first inventor(s) of the invention disclosed in the complete specification filed in pursuance of my / our application numbered _____ dated _____ is /are.

2. INVENTOR (S)

(a) NAME: DR. A RAMESH BABU

(b) NATIONALITY: INDIAN

(c) ADDRESS : 5/ 676 , VIVEKANANDA NAGAR, SITHALAPAKKAM, CHENNAI, TAMIL NADU, 600126.

(a) NAME: DR. J. BARNABAS PAUL GLADY

(b) NATIONALITY: INDIAN

(c) ADDRESS: VIVEKANANDA NAGAR, SITHALAPAKKAM, CHENNAI, TAMIL NADU, 600126.

(a) NAME: BELLAM TARUN

(b) NATIONALITY: INDIAN

(c) ADDRESS: F-11, V.V REDDY NAGAR, KADAPA, ANDHRA PRADESH, 516312.

(a) NAME: REDDY CHANDRA SEKHAR BUSINENI

(b) NATIONALITY: INDIAN

(c) ADDRESS: 9/28G, VARIGA ROAD, RAYACHOTY, ANDHRA PRADESH, 516270

(a) NAME: S. RAKESH

(b) NATIONALITY: INDIAN

(c) ADDRESS: AYYAVARIPALLY, WANAPARTHY, TELANGANA, 509105.

(a) NAME: ABHAY KAUSHAL

(b) NATIONALITY: INDIAN

(c) ADDRESS: SOUTH OF KRISHNANIKETHAN, PATNA, BIHAR, 800001.

Dated this

day of

2024

Signature: -

Name of the signatory: -
3. DECLARATION TO BE GIVEN WHEN TÄEFFLICATION IN INDIA IS FILED BY THE APPLICANT (S) IN THE CONVENTION COUNTRY: We the applicant(s) in the convention country hereby declare that our right to apply for a patent in India is by way of assignment from the true and first inventor(s). ***** Dated this day of 2024 Signature: - Name of the signatory: -
4. STATEMENT (to be signed by the additional inventor(s) not mentioned in the application form) I/We assent to the invention referred to in the above declaration, being included jn the complete specification filed in pursuance of the stated applicätiön..... Dated this day of 2024 Signature of the additional inventor(s): Name: - To, The Controller of Patent the Patent Offices
Note 'Repeat boxes jn case of more than one entry. *To be signed by the applicant(s) or by authorized registered patent agent otherwise where mentioned. *Name of the inventor and applicant should be given in full, family name in the beginning. *Completeaddress of the inventor should be given stating the postal index no./code, state and country. *Strike out the column which is/ are not applicable