CHAPTER 1

1.1 INTRODUCTION

The transportation landscape is undergoing a significant transformation, driven by the urgent need for cleaner and more sustainable solutions. Electric vehicles (EVs) have emerged as a frontrunner in this revolution, offering a promising alternative to conventional gasoline-powered vehicles. However, unlike their internal combustion engine (ICE) counterparts, EVs rely on a fundamentally different architecture that governs their operation and performance.

This introduction delves into the core architecture of electric vehicles, dissecting the key components and their interactions. We will explore the intricate interplay between the battery, the electric motor, the power electronics controller, and other crucial elements that power an EV. Understanding this architecture is fundamental for appreciating the unique advantages and challenges associated with electric vehicle technology.

1.1.1 Motivation and Importance

As environmental concerns escalate and fossil fuel dependence becomes increasingly unsustainable, the need for cleaner transportation solutions intensifies. EVs offer a compelling alternative by emitting zero tailpipe emissions, contributing significantly to a cleaner and healthier environment. Additionally, with the depletion of fossil fuels and fluctuating oil prices, EVs offer a path towards energy independence and long-term cost savings.

However, to fully harness the potential of EVs, a comprehensive understanding of their underlying architecture is necessary. This knowledge empowers engineers to develop more efficient, reliable, and user-friendly EVs. Furthermore, it allows consumers to make informed decisions when considering electric vehicles as a viable transportation option.

1.2 KEY COMPONENETS AND THEIR INTERPLAY

The architecture of an electric vehicle can be broken down into several key components:
Battery: The heart of an EV, the battery pack stores the electrical energy that powers the vehicle. Lithium-ion batteries are currently the dominant technology due to their high energy density and efficiency.

Electric Motor: This component converts electrical energy from the battery into mechanical energy that rotates the wheels, propelling the vehicle forward. Different types of electric motors cater to various performance and efficiency requirements.

Power Electronics Controller: Acting as the brain of the EV, this sophisticated system manages the flow of power between the battery and the motor. It regulates voltage, current, and other parameters to ensure optimal performance and safety.

Onboard Charger: This unit allows the EV to be plugged into an external power source for charging the battery. Different charging levels (AC Level 1, Level 2, and DC fast charging) offer varying charging speeds and infrastructure requirements.

These core components work in a coordinated manner:
Energy Storage: The battery stores electrical energy, typically obtained from the grid through charging stations.

Energy Conversion: The onboard charger converts the incoming AC grid power to DC for battery charging.

Power Delivery: The power electronics controller regulates the flow of DC power from the battery to the electric motor.

Propulsion: The electric motor converts the received electrical energy into mechanical rotation, driving the wheels and propelling the vehicle.

By grasping the architecture of EVs, we can unlock several benefits:

Improved Design and Development: Engineers can optimize EV systems for better efficiency, power delivery, and range.

Enhanced Maintenance and Repair: Technicians can diagnose and troubleshoot issues more effectively.

Informed Consumer Decisions: Consumers can make well-considered choices when selecting an electric vehicle based on their needs and preferences.

Promoting Innovation: A deeper understanding of EV architecture can pave the way for the development of next-generation electric vehicles with improved performance and capabilities.

This introduction serves as a launchpad for a deeper exploration of the fascinating world of electric vehicle architecture. By delving into the intricacies of its components and their interactions, we gain a valuable insight into the technology shaping the future of sustainable transportation.

CHAPTER 2

2.1 DEEP DIVE INTO THE ELECTRIC SOLAR CARGO COMPONENTS

Electric solar cargo incorporates a range of innovative components working together to deliver a sustainable and efficient transportation solution. Here's a breakdown of the key elements and their specifications:

2.1. 1. Permanent Magnet Synchronous Motor (PMSM)

Type: 3-Phase Synchronous Motor

Specifications

Voltage: 48V DC (matches battery voltage)

Power: 800W (provides sufficient power for propulsion)

Current: 18A (maximum current drawn from the battery)

Fig 2.1 Permanent Magnet Synchronous Motor (PMSM)

Benefits

High Efficiency: PMSMs offer excellent efficiency compared to DC brushed motors, resulting in longer range and lower energy consumption.

High Torque: Delivers good starting torque and hill-climbing ability.

Compact and Lightweight: Enables efficient space utilization within the cargo frame.

Fig 2.2 PMSM used in the vehicle

2.1.2 Lithium-Ion Battery

Type: Lithium-ion battery pack (Li-ion)

Specifications

Voltage: 48V DC (nominal voltage for most electric vehicle applications)

Capacity: 18Ah (determines the total energy storage and potential range)

Benefits

High energy density: Li-ion batteries offer a good balance between energy storage capacity and weight, allowing for a decent range without excessive weight.

Long lifespan: Compared to other battery technologies, Li-ion batteries offer a relatively long lifespan with proper care.

Relatively low self-discharge: Li-ion batteries lose charge slowly when not in use, minimizing energy loss during storage.

Fig 2.3 Lithium-Ion Battery

Fig 2.4 Battery used in the vehicle

2.1.3 Battery Management System (BMS)

Function: This crucial component protects the battery pack and optimizes its performance.

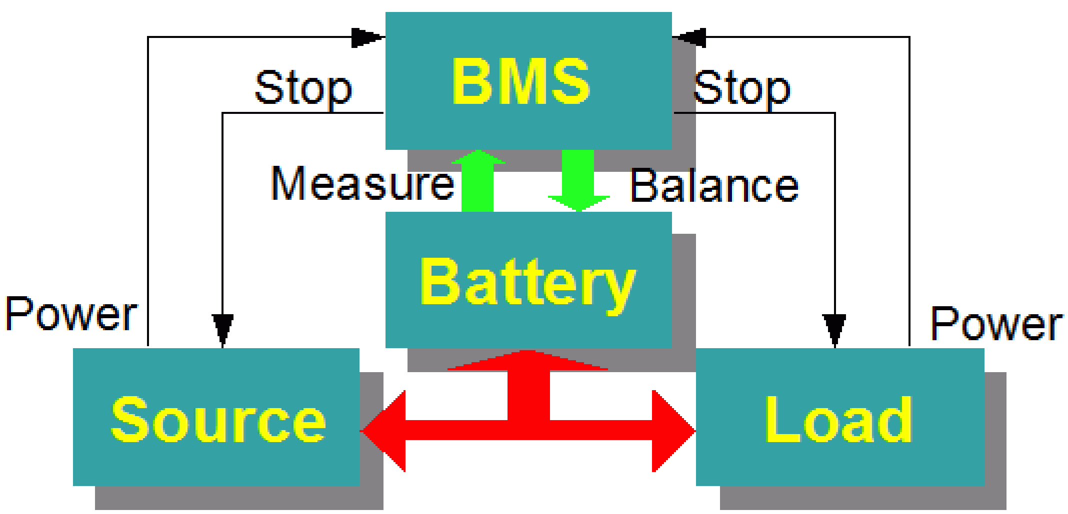


Fig 2.5 Block Diagram of BMS

Features

- Monitors battery voltage, current, temperature, and health.
- Prevents overcharging and over-discharging, prolonging battery life.
- Balances individual battery cells within the pack to ensure even charging and discharge.
- May communicate with the controller to adjust charging parameters based on battery health.

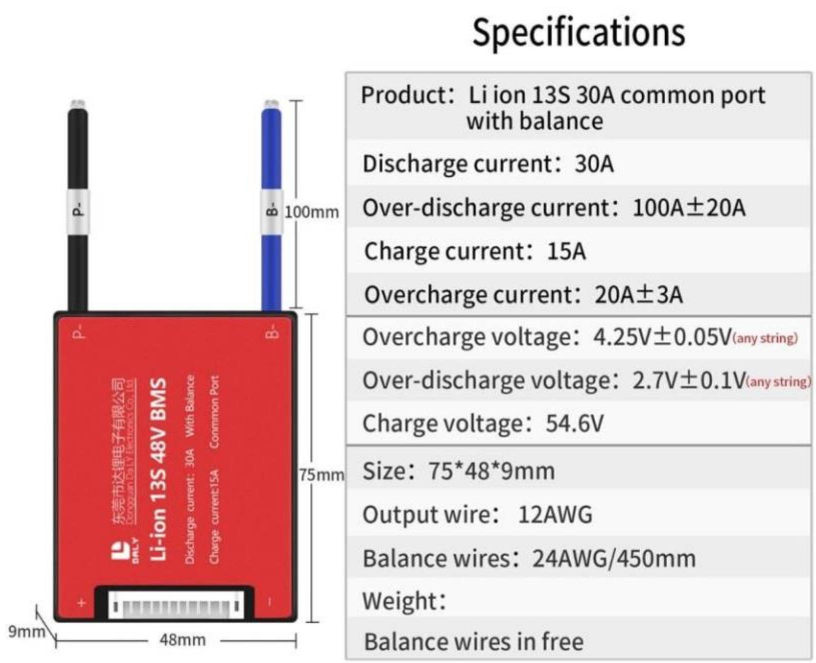


Fig 2.6 BMS Specifications

2.1.4 Solar Panel

Type: Silicon Solar Panel

Specifications

Voltage: 12V DC (typical output voltage of solar panels)

Power: 100W (provides additional charging power to the battery)

Benefits

Renewable energy source: Harnesses solar energy for battery charging, reducing reliance on grid electricity and promoting sustainability.

Low maintenance: Solar panels require minimal maintenance, making them a cost-effective long-term solution.

Fig 2.7 Solar Panel

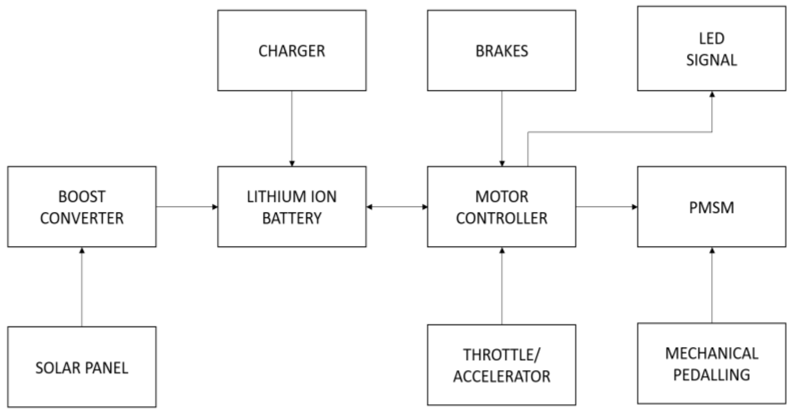


Fig 2.8 Circuit Connection of Solar Panel

2.1.5 Solar Boost Converter

Function: Increases the voltage output from the solar panel to match the battery voltage (48V).

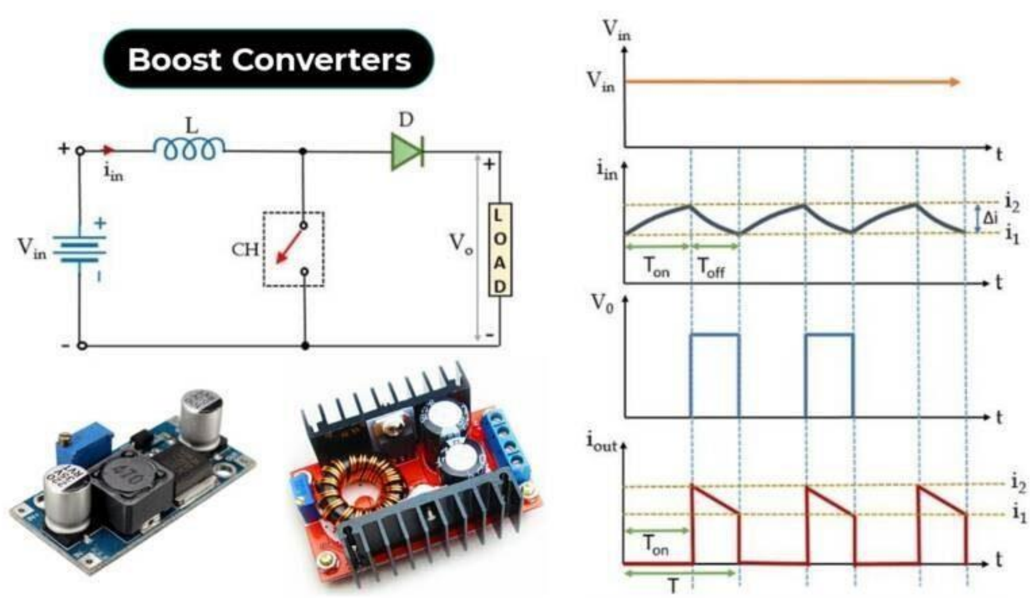


Fig 2.9 Solar Boost Converter Working

Specifications

Input Voltage: 12V DC (matches solar panel output).

Output Voltage: 48V DC (matches battery voltage for efficient charging)

Power Rating: Greater than or equal to 100W (to handle the maximum power from the solar panel)

Benefits

- Enables efficient charging of the battery using the solar panel's output.

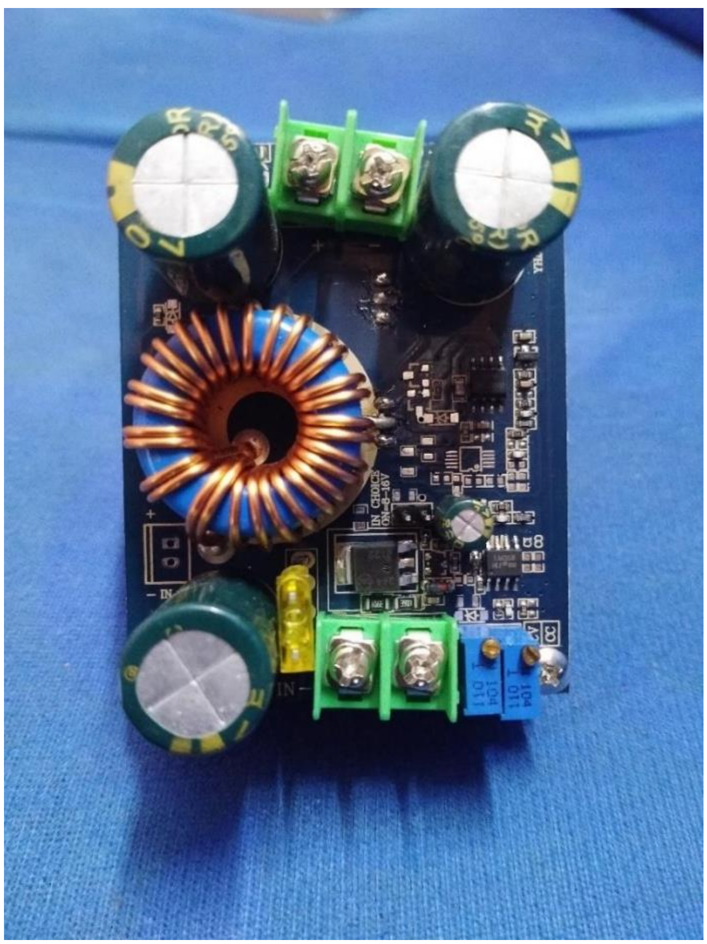


Fig 2.10 Solar Boost Converter

2.1.6 Charger (Off-board)

Type: Standard battery charger suitable for Li-ion batteries

Specifications

Input Voltage: AC Mains Voltage (e.g., 230V AC in India)

Output Voltage: 48V DC (matches battery voltage)

Charging Current: 5A (determines charging speed)

Benefits

- Provides primary means of charging the battery from the grid.
- 5A charging current offers a balance between charging speed and battery health.

Fig 2.11 Charger

2.1.7 Motor Controller

Type: Electric Motor Controller (usually integrated with BMS functionalities).

Specifications

Voltage Rating: 48V DC (matches battery and motor voltage)

Current Rating: Greater than or equal to 18A (to handle motor current)

Power Rating: 800W (matches motor power rating)

Functions

- Regulates the flow of power between the battery and the motor.
- Controls motor speed and torque based on user input (accelerator).
- May integrate with the BMS to monitor battery health and adjust charging/discharging parameters.

Fig 2.12 Motor Controller

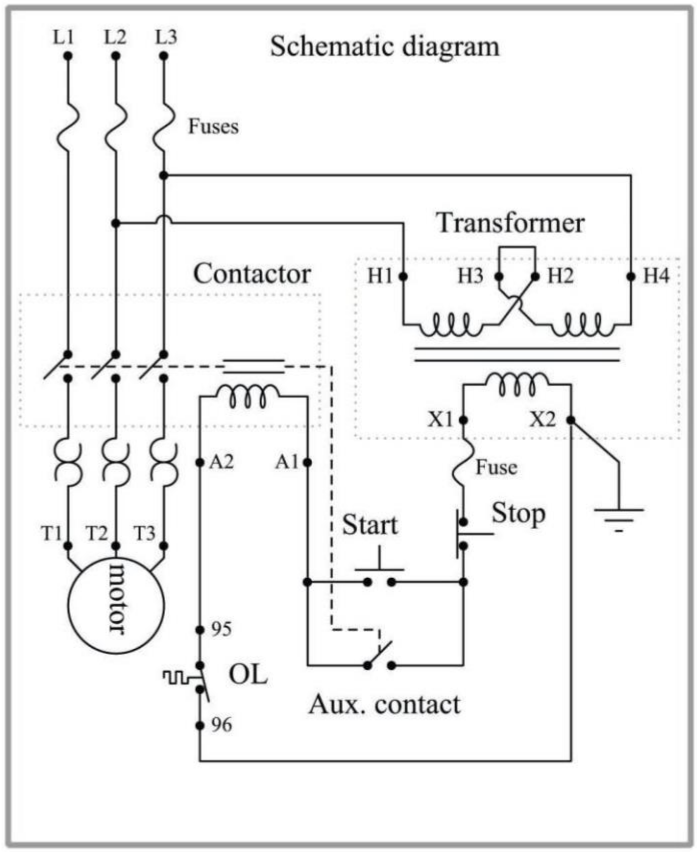


Fig 2.13 Schematic Diagram of Motor Controller

2.1.8 Headlight

Voltage: 12V DC (separate circuit powered directly from the battery)

This allows the headlight to operate independently without affecting the main 48V system.

Type: LED Headlight.

Fig 2.14 LED Headlight OFF

2.2 Block Diagram

Here's a block diagram representing the Electric solar cargo:

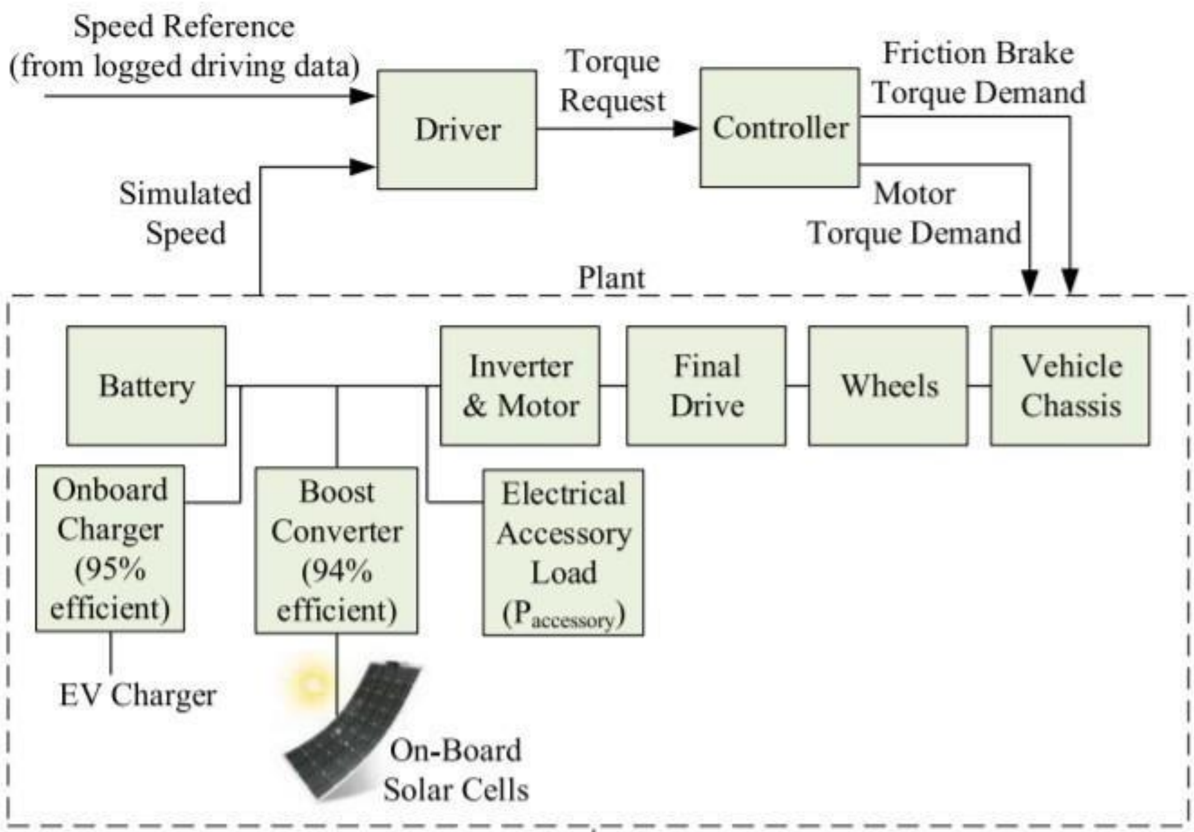


Fig 2.15 Block diagram representing the Electric solar cargo

Explanation

Solar Panel (12V): Captures solar energy and generates electricity at 12V DC.

Solar Boost Converter (12V -> 48V DC): Increases the voltage from the solar panel to match the battery voltage (48V) for efficient charging.

Battery (48V): Stores electrical energy from the solar panel (via boost converter) and off-board charger.

Battery Management System (BMS): Monitors battery health, protects against overcharging/discharging, and balances individual battery cells.

Off-board Charger (AC Mains -> 48V DC): Charges the battery from the AC power grid.

Controller (800W): Regulates the flow of power between the battery and the electric motor. Controls motor speed and torque based on user input (accelerator). May integrate with the BMS.

Electric Motor (48V DC, 800W): Converts electrical energy from the battery into mechanical rotation, propelling the cargo wheels.

Cargo Wheels: Transfer the motor's rotational power to movement.

Brakes: Slow down and stop the Electric solar cargo (may be disc brakes or rim brakes depending on design).

Headlight (12V, Optional): Provides illumination during low-light conditions.
Operates on a separate 12V circuit powered directly from the battery.

CHAPTER 3

3.1 PERMANENT MAGNET SYNCHRONOUS MOTOR (PMSM)

3.1.1 Introduction

Permanent Magnet Synchronous Motors (PMSMs) are a prominent technology choice for electric vehicle (EV) applications due to their high efficiency, power density, and excellent controllability. This report delves into the details of a 3phase, 48V, 800W, 18A PMSM selected for a Electric Solar Cargo. We will explore the operating principles, construction, advantages, and considerations for utilizing this motor in the trike's design.

Fig 3.1 Permanent Magnet Synchronous Motor (PMSM)

3.1.2 Operating Principle

A PMSM relies on the interaction between a rotating permanent magnet rotor and a stationary stator containing windings. The permanent magnets on the rotor generate a constant magnetic field. When electric current is supplied to the stator windings, a rotating magnetic field is created. This interaction between the rotating magnetic field of the stator and the fixed magnetic field of the rotor induces electromotive force (EMF) in the stator windings, according to Faraday's Law of electromagnetic induction. This EMF, when connected to a load (in this case, the cargo wheels), results in the generation of torque, causing the rotor to spin.

The key difference between a PMSM and a conventional AC synchronous motor lies in the rotor's magnetic field generation. In a synchronous motor, the rotor's magnetic field is generated by an external DC current supplied through brushes and slip rings. A PMSM eliminates the need for brushes and slip rings by utilizing permanent magnets on the rotor, offering several advantages discussed later.

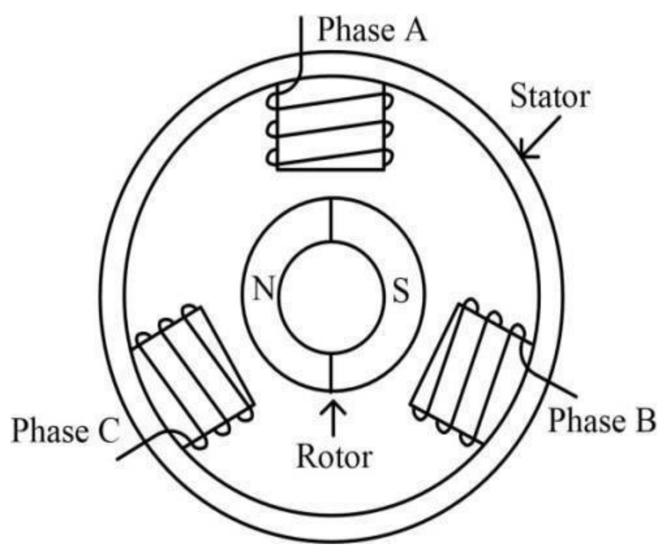


Fig 3.2 Operating Principle of PMSM

3.1.3 Key Components of PMSM

Stator: The stationary outer part of the motor. It houses the windings, typically made of copper wire, arranged in slots around the inner circumference. These windings are connected to form a 3-phase AC circuit.

Rotor: The rotating inner part of the motor. It consists of permanent magnets arranged in a specific pattern on the shaft. Different magnet configurations exist, each offering unique torque-speed characteristics.

Air Gap: The small space between the rotor and the stator. It is crucial to maintain a minimal air gap for optimal motor performance.

Frame: Provides structural support for the stator and bearings that house the rotating shaft.

Cooling System: Depending on the motor's power rating and duty cycle, a cooling system (air or liquid) might be necessary to dissipate heat generated during operation.

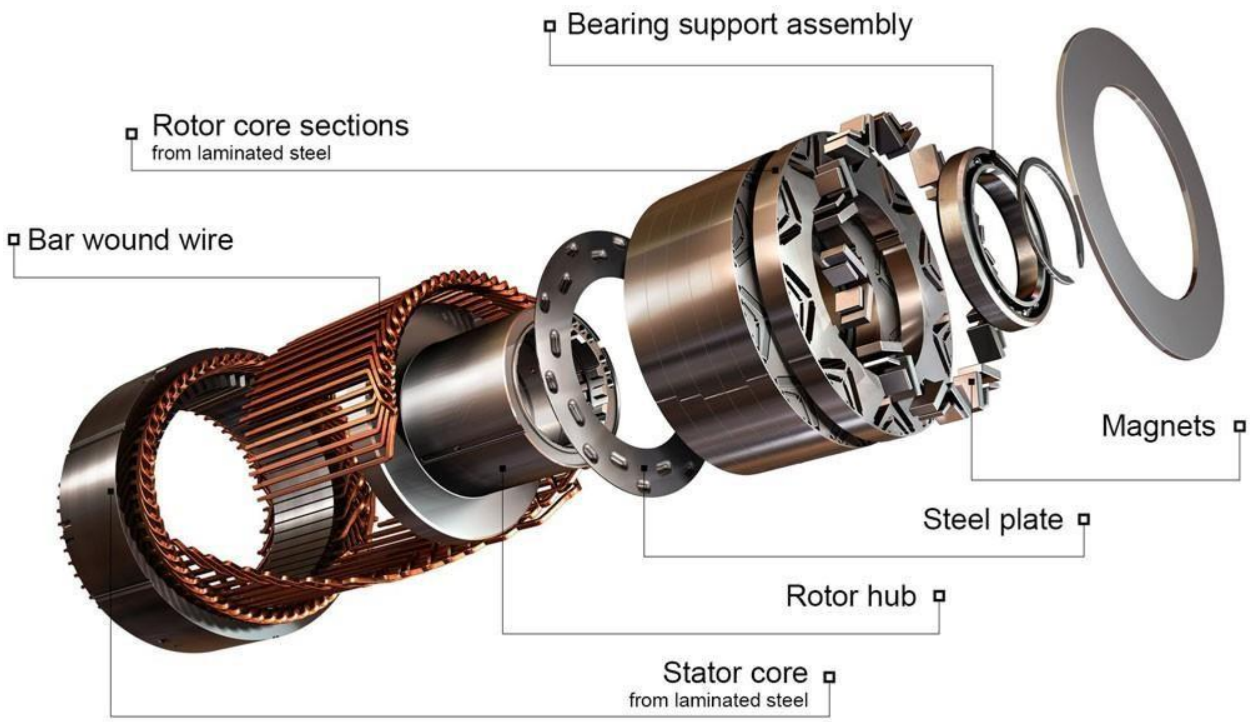


Fig 3.3 Components of PMSM

3.1.4 Advantages of PMSMs for Electric Solar Cargo

High Efficiency: PMSMs achieve superior efficiency compared to brushed DC motors or induction motors. This translates to lower energy consumption and a longer potential range for the electric cargo on a single battery charge. High **Power Density:** PMSMs offer a high power output for their size and weight. This allows for a compact and lightweight motor suitable for the space constraints of a cargo.

High Torque Density: PMSMs deliver high starting torque, essential for electric vehicles, especially when starting from a standstill or climbing inclines.

Smooth and Quiet Operation: The absence of brushes and the inherent design of PMSMs contribute to smoother and quieter operation compared to brushed DC motors.

Low Maintenance: PMSMs require minimal maintenance due to the absence of brushes and slip rings that wear out over time.

Fig 3.4 PMSM used in the vehicle

3.1.5 Considerations for Using a PMSM in the Electric Solar Cargo

Cost: PMSMs can be more expensive compared to brushed DC motors. However, the long-term benefits of higher efficiency and lower maintenance costs can offset the initial investment.

Controller Requirement: PMSMs require a sophisticated electronic motor controller to regulate current flow and achieve optimal performance. The controller needs to be compatible with the specific motor specifications (voltage, current, power rating).

Thermal Management: Efficient heat dissipation is crucial for maintaining motor performance and lifespan. The chosen motor and the cargo design should incorporate adequate cooling mechanisms to prevent overheating.

Selection Criteria for the 48V, 800W, 18A PMSM:

The chosen 48V, 800W, 18A PMSM aligns with the cargo design requirements based on the following considerations:

Voltage Compatibility: The 48V rating matches the voltage of the battery pack, ensuring efficient power delivery to the motor.

Power Rating: The 800W motor offers sufficient power to propel the cargo with the desired speed and handle potential inclines.

Current Rating: The 18A current draw stays within the capacity of the chosen battery and controller for safe and efficient operation.

Torque Characteristics: The specific rotor magnet configuration of the selected PMSM should provide adequate starting torque to meet the cargo's needs.

3.1.6 Future Considerations for PMSM Integration

As develop Electric solar cargo further, here are some additional points to consider regarding the PMSM integration:

Motor Controller Selection: Choosing a suitable motor controller is crucial. The controller needs to be compatible with the chosen PMSM's voltage, current, and power ratings. Additionally, features like regenerative braking capability can enhance the cargo's efficiency and functionality.

Gearing System: Depending on the motor's speed and torque characteristics, a gear reduction system might be necessary. This allows the motor to operate at its optimal speed range while delivering the required torque to the wheels for desired vehicle speed.

Thermal Management: During operation, the PMSM will generate heat. Depending on the motor's power rating, duty cycle, and ambient conditions, a cooling system might be required. Air cooling might suffice for a low-power motor operating in moderate climates. However, a liquid cooling system might be necessary for a high-power motor or operation in hot environments. Efficiency Optimization: Techniques like optimizing the motor controller settings and minimizing drivetrain friction losses can maximize the overall efficiency of the electric cargo, leading to a longer range on a single battery charge.

3.1.7 Conclusion

The selection of a Permanent Magnet Synchronous Motor (PMSM) with specifications of 48V, 800W, and 18A represents a well-suited choice for Electric solar cargo. PMSMs offer several advantages, including high efficiency, power density, and smooth operation. By carefully considering the motor's characteristics, selecting a compatible controller, and implementing efficient thermal management, can ensure optimal performance and a positive user experience for electric cargo. As progress in project, delve deeper into the details of motor controller selection, gearing systems, and thermal management strategies to refine the design and maximize the capabilities of Electric Solar Cargo.

CHAPTER 4

4.1 ANALYSIS OF MOTOR CONTROLLERS

A motor controller is a device or group of devices that can coordinate in a predetermined manner the performance of an electric motor. A motor controller might include a manual or automatic means for starting and stopping the motor, selecting forward or re verse rotation, selecting and regulating the speed, regulating or limiting the torque, and protecting against overloads and electrical faults. Motor controllers may use electromechanical switching, or may use power electronics devices to regulate the speed and direction of a motor.

The driving electronics are just as important as the stator and rotor in a BLDC motor if they are inherent to it. The next figure displays a block schematic of a typical Brushless DC Motor control or drive system.

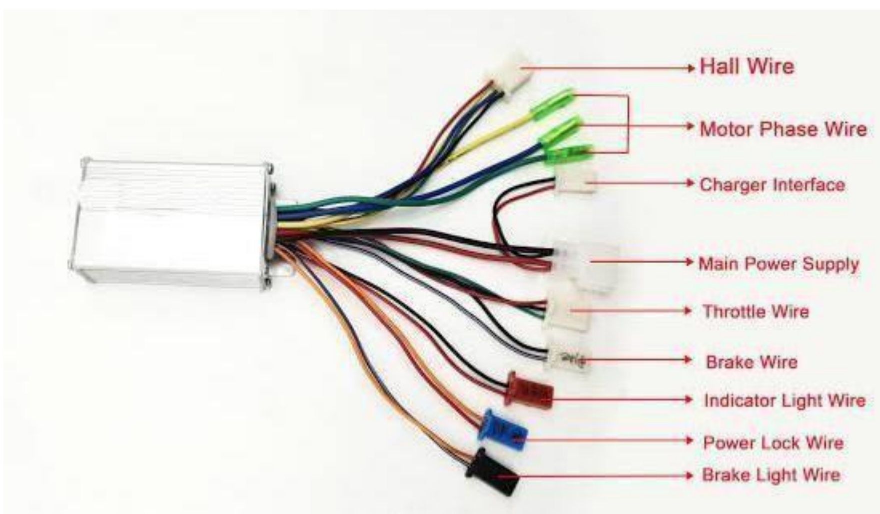


Fig 4.1 Motor Controller

4.2 BLOCK DIAGRAM OF MOTOR CONTROLLER

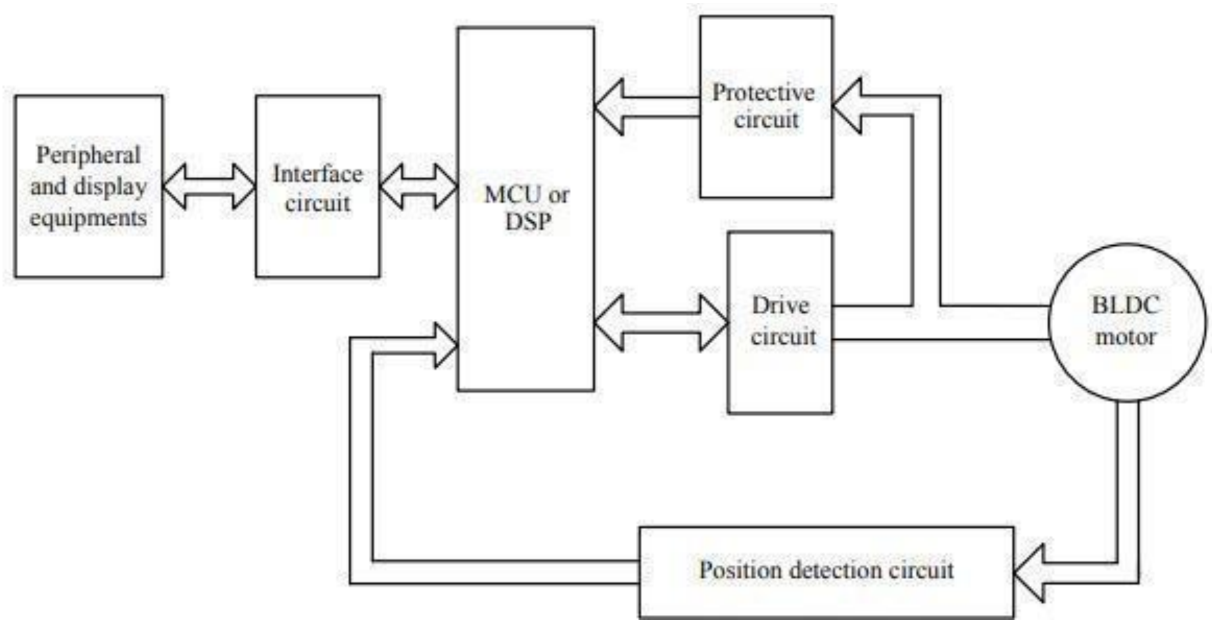


Fig 4.2 Block diagram of Motor Controller

4.3 ELECTRONIC SPEED CONTROLLER (ESC)

Electronic Speed Controller System, sometimes known as an ESC, is a common name for this driving circuitry. The Full Bridge Drive Circuit is a typical configuration. The system is made up of an MCU with PWM outputs, six MOSFETS for each of the three phases of the stator windings, feedback from the Hall sensors, and a few parts linked to the power supply.

Using the information from the Hall Sensors, the MCU may be programmed to switch the MOSFETS in the proper manner.

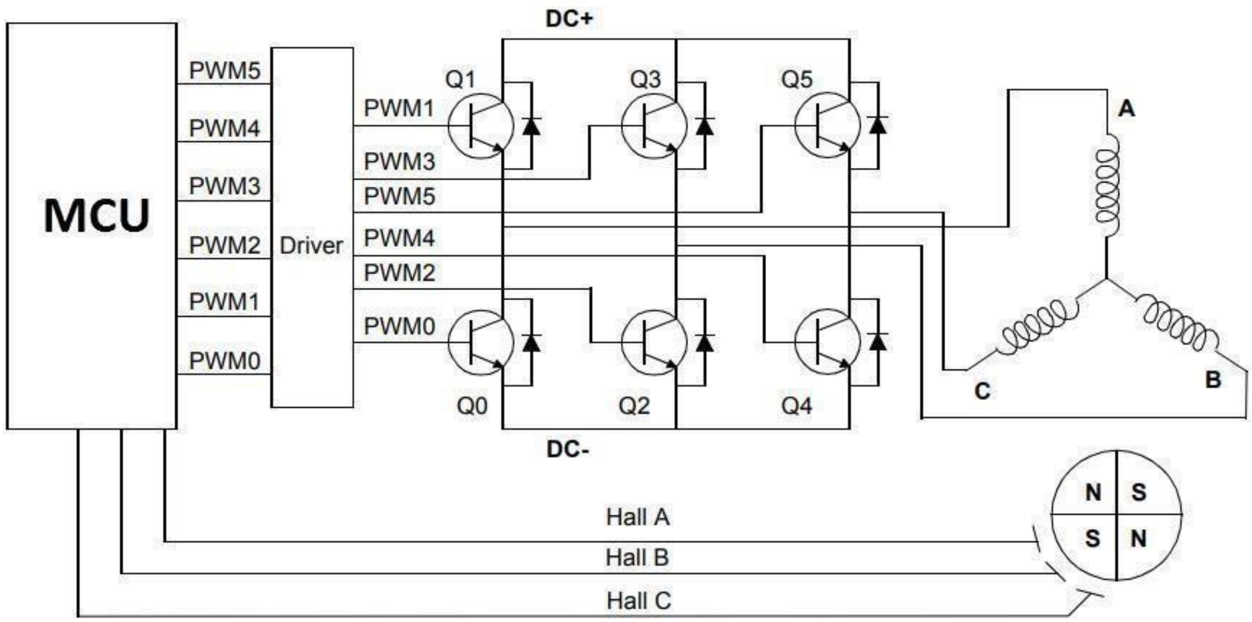


Fig 4.3 Block diagram of ESC

4.4 TYPES OF MOTOR CONTROLLERS

- Motor Starters
- Reduced Voltage Starters
- Adjustable Speed Drives
- Intelligent Drives

4.5 APPLICATIONS OF MOTOR CONTROLLERS

Motor controllers are used with both direct current and alternating current motors. A controller includes means to connect the motor to the electrical power supply, and may also include overload protection for the motor, and over-current protection for the motor and wiring. A motor controller may also supervise the motor's field circuit, or detect conditions such as low supply voltage, incorrect polarity or incorrect phase sequence, or high motor temperature. Some motor controllers limit the inrush starting current, allowing the motor to accelerate itself and connected mechanical load more slowly than a direct connection. Motor controllers may be manual, requiring an operator to sequence a starting switch through steps to accelerate the load, or may be fully automatic, using internal timers or current sensors to accelerate the motor.

Some types of motor controllers also allow adjustment of the speed of the electric motor. For direct-current motors, the controller may adjust the voltage applied to the motor, or adjust the current flowing in the motor's field winding.

Alternating current motors may have little or no speed response to adjusting terminal voltage, so controllers for alternating current instead adjust rotor circuit resistance (for wound rotor motors) or change the frequency of the AC applied to the motor for speed control using power electronic devices or electromechanical frequency changers.

The physical design and packaging of motor controllers is about as varied as that of electric motors themselves. A wall-mounted toggle switch with suitable ratings may be all that is needed for a household ventilation fan. Power tools and household appliances may have a trigger switch that only turns the motor on and off.

Industrial motors may be more complex controllers connected to automation systems, a factory may have a large number of motor controllers grouped in a motor control centre. Controllers for electric travelling cranes or electric vehicles may be mounted on the mobile equipment. The largest motor controllers are used with the pumping motors of pumped storage hydroelectric plants, and may cycle ratings of tens of thousands of horsepower (kilowatts).

CHAPTER 5

5.1 DEEP DIVE INTO THE LITHIUM-ION BATTERY

The heart of Electric Solar Cargo lies in its battery. This report delves into the details of the chosen Lithium-Ion (Li-ion) battery with specifications of 48V, 18Ah, and 864Wh. We will explore the working principles, types of Li-ion batteries, advantages and limitations, factors affecting range, and considerations for safe and efficient operation within cargo design.

Fig 5.1 Lithium-Ion Battery

5.2 LI-ION BATTERY FUNDAMENTALS

Li-ion batteries are rechargeable batteries that utilize lithium ions as the mobile charge carrier. During discharge, lithium ions move from the negative electrode (anode) to the positive electrode (cathode) through an electrolyte solution, generating electrical current. During charging, the process reverses, with lithium ions moving back to the anode.

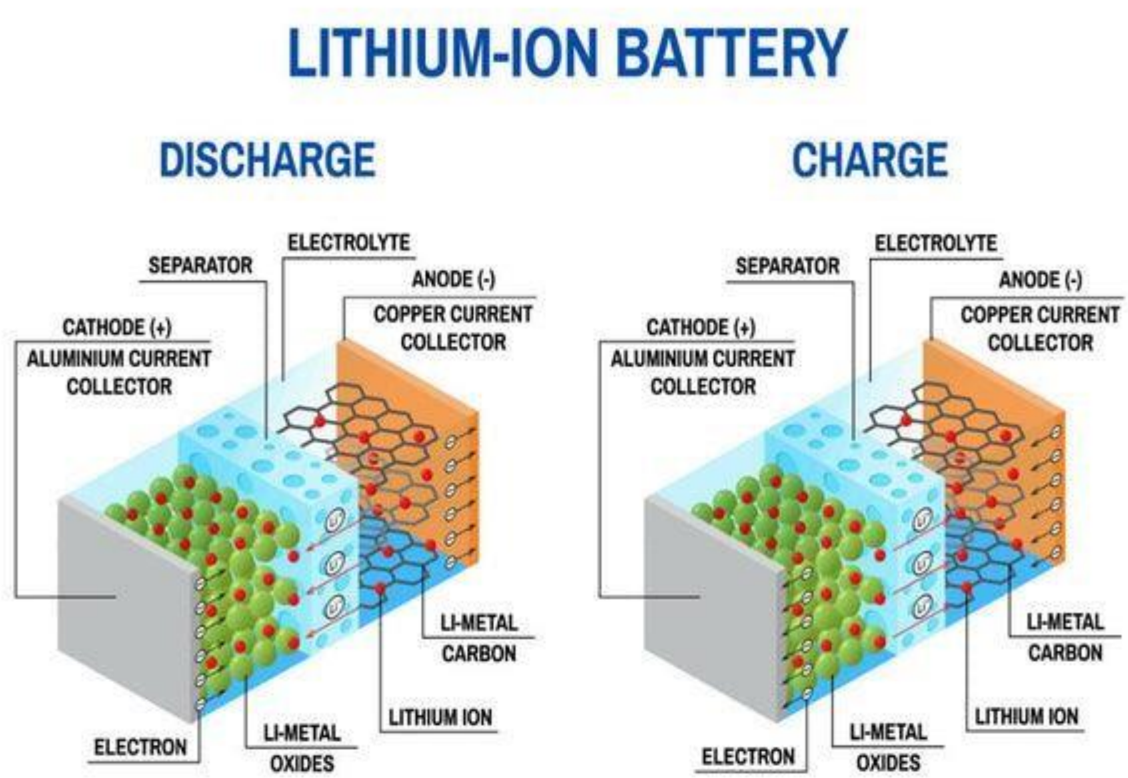


Fig 5.2 Charge and Discharge of Lithium-Ion Battery

5.3 TYPES OF LI-ION BATTERIES

Several types of Li-ion batteries exist, each with distinct characteristics:

Lithium Cobalt Oxide (LCO): Offers high energy density and good performance but can be susceptible to thermal runaway (overheating) and has a shorter lifespan.

Lithium Manganese Oxide (LMO): Provides good safety characteristics and a long lifespan but has a lower energy density compared to LCO.

Lithium Nickel Manganese Cobalt Oxide (NMC): Offers a good balance between energy density, safety, and lifespan, making it a popular choice for electric vehicles.

Lithium Iron Phosphate (LFP): Provides excellent safety and a long lifespan but has the lowest energy density among the mentioned types.

5.4 ADVANTAGES OF LI-ION BATTERIES FOR ELECTRIC CARGO

High Energy Density: Compared to traditional lead-acid batteries, Li-ion batteries store more energy per unit weight and volume. This allows for a lighter battery pack, contributing to the overall efficiency and range of the cargo.

Long Lifespan: Li-ion batteries offer a significantly longer lifespan compared to lead-acid batteries with proper care.

High Discharge Rate: Li-ion batteries can deliver high currents, suitable for powering the electric motor during acceleration or climbing hills.

Low Self-Discharge: Li-ion batteries have a lower self-discharge rate compared to other battery chemistries, minimizing energy loss during storage.

5.5 LIMITATIONS OF LI-ION BATTERIES

Cost: Li-ion batteries can be more expensive than lead-acid batteries upfront. However, their longer lifespan and higher efficiency can offset the initial cost over time.

Thermal Sensitivity: Li-ion batteries are sensitive to extreme temperatures. Operating outside the recommended temperature range can reduce performance and lifespan.

Safety Concerns: Li-ion batteries can pose a safety risk if damaged or mishandled. Implementing a Battery Management System (BMS) is crucial to ensure safe operation.

5.6 FACTORS AFFECTING THE RANGE OF ELECTRIC CARGO

The 40 km range estimate for cargo powered by the 48V, 18Ah Li-ion battery is a starting point. Several factors influence the actual achievable range:

Battery Capacity (Ah): Higher capacity batteries store more energy and offer a potentially longer range.

Motor Efficiency: A more efficient motor consumes less energy, allowing for a longer range.

Terrain: Climbing hills requires more energy compared to riding on flat surfaces.

Load: Carrying heavier loads increases energy consumption and reduces range. Riding **Style:** Frequent stops, starts, and accelerations deplete the battery faster compared to constant cruising.

Ambient Temperature: Extreme temperatures (both hot and cold) can affect battery performance and range. Maximizing Range and Battery Life:

5.7 TIPS TO MAXIMIZE THE RANGE AND LIFESPAN OF LI-ION BATTERY

Maintain Optimal Battery Charge: Avoid fully discharging or overcharging the battery. Frequent shallow discharges and recharges are preferable for long-term battery health.

Practice Eco-Friendly Riding: Maintain a moderate speed, avoid frequent stops and starts, and minimize unnecessary acceleration to reduce energy consumption.

Store the Battery Properly: Store the battery in a cool, dry place with a moderate charge level (around 50%) when not in use.

Use a Battery Management System (BMS): A BMS protects the battery from overcharging, over-discharging, and overheating, extending its lifespan and ensuring safe operation.

5.8 SPECIFICATIONS OF 48V, 18Ah, 864Wh LI-ION BATTERY

Nominal Voltage: 48V DC (typical voltage for many electric vehicle applications)

Capacity: 18Ah (amount of charge the battery can deliver)

Energy Rating: 864Wh (Capacity x Voltage = Energy stored)

Fig 5.3 Battery used in the vehicle

5.9 CHARGING TIME ESTIMATION

The estimated charging time of 5.4 hours for the 48V, 18Ah battery depends on the charger's specifications. Here's how to calculate the charging time more precisely:

Charging Current: This value is typically specified in Amps (A). Let's assume the charger delivers a charging current (I) of 5A.

Battery Capacity: This is given as 18Ah.

Charging Time (T) can be estimated using the formula:

T = Battery Capacity (Ah) / Charging Current (A)

T = 18Ah / 5A ≈ 3.6 hours

This calculation provides a closer estimate of the charging time. However, factors like charger efficiency and battery temperature variations can slightly affect the actual charging duration.

Fig 5.4 Charger

5.10 BATTERY MANAGEMENT SYSTEM (BMS)

As mentioned earlier, a BMS plays a critical role in ensuring safe and efficient battery operation. Here are some key functions of a BMS in Electric solar cargo:

Cell Voltage Monitoring: The BMS continuously monitors the voltage of individual cells within the battery pack. This helps identify any imbalance or malfunctioning cells that could compromise performance or safety.

Cell Balancing: If voltage imbalances are detected, the BMS employs cell balancing techniques to ensure all cells are charged and discharged evenly, extending battery life.

Overcharge and Over-discharge Protection: The BMS safeguards the battery from damage caused by excessive charging or discharging beyond its safe operating limits.

Temperature Monitoring: The BMS monitors the battery's temperature. If it exceeds a safe threshold, the BMS might limit charging or discharging to prevent thermal runaway.

Current Limiting: The BMS can regulate the current flow into and out of the battery to prevent excessive currents that could damage the battery or connected components.

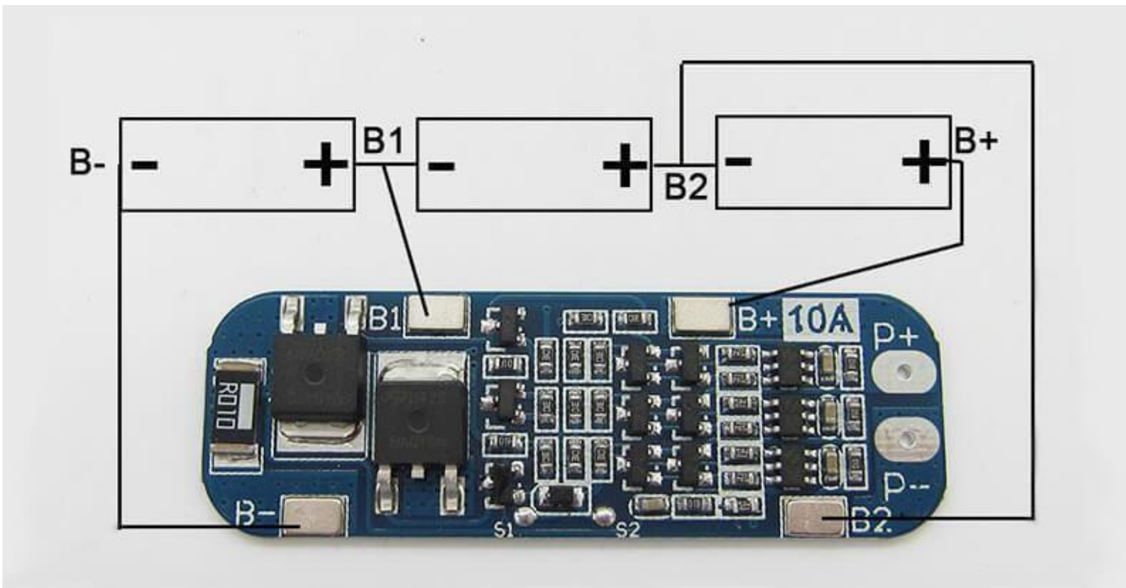


Fig 5.5 BMS

5.11 SAFETY CONSIDERATIONS FOR LI-ION BATTERIES

Li-ion batteries offer numerous advantages, but it's crucial to prioritize safety during their use and integration into electric cargo. Here are some key safety considerations:

Use a Certified Battery Pack: Ensure the chosen battery pack is certified by a reputable testing agency to meet safety standards.

Proper Ventilation: Design the battery compartment to allow for adequate ventilation to prevent heat build-up.

Short Circuit Protection: Implement measures within the cargo's electrical system to prevent short circuits that could damage the battery or pose a fire risk.

User Education: Provide clear instructions to users on safe charging practices, proper battery storage, and how to identify potential battery issues.

5.12 CONCLUSION

The 48V, 18Ah Li-ion battery with a capacity of 864Wh presents a suitable energy source for Electric Solar Cargo. Understanding the working principles, advantages, limitations, and safety considerations of Li-ion batteries is crucial for optimal performance, extended battery life, and safe operation within cargo design. By incorporating a Battery Management System (BMS) and implementing best practices for charging and storage, can ensure a reliable and efficient power source for sustainable transportation solution.

CHAPTER 6

6.1 ANALYSIS OF BATTERY MANAGEMENT SYSTEM (BMS)

Battery management system (BMS) is technology dedicated to the oversight of a battery pack, which is an assembly of battery cells, electrically organized in a row x column matrix configuration to enable delivery of targeted range of voltage and current for a duration of time against expected load scenarios.

The oversight that a BMS provides usually includes:

- Monitoring the battery
- Providing battery protection
- Estimating the battery's operational state
- Continually optimizing battery performance
- Reporting operational status to external devices

6.2 TYPES OF BMS

- Centralized BMS
- Distributed BMS
- Modular BMS

6.3 WORKING OF BATTERY MANAGEMENT SYSTEMS

Battery management systems do not have a fixed or unique set of criteria that must be adopted. The technology design scope and implemented features generally correlate with:

- The costs, complexity, and size of the battery pack.
- Application of the battery and any safety, lifespan, and warranty concerns.
- Certification requirements from various government regulations where costs and penalties are paramount if inadequate functional safety measures are in place.

There are many BMS design features, with battery pack protection management and capacity management being two essential features. We'll discuss how these two features work here. Battery pack protection management has two key arenas: electrical protection, which implies not allowing the battery to be damaged via usage outside its SOA, and thermal protection, which involves passive and/or active temperature control to maintain or bring the pack into its SOA.

6.4 ADVANTAGES AND DISADVASNTAGES OF BMS

6.4.1 Advantages

Advantages of BMS include substantial savings on air conditioning and heating costs. Your building's HVAC system can work on a management schedule for specific days, and specific times. Heating, ventilation and air-conditioning costs can be reduced by having these systems timed and scheduled properly.

6.4.2 Disadvantages

The issue is that there will be large blind spots because most building management systems do not control smaller equipment. Because the cost to install, maintain, and utilize is so high, most properties with a BMS only have it installed on the major loads, such as large HVAC equipment and lighting

6.5 UNVEILING THE GUARDIAN OF LITHIUM-ION BATTERIES – BATTERY MANAGEMENT SYSTEM (BMS)

The rise of Lithium-Ion (Li-ion) batteries as the dominant energy source for electric vehicles (EVs) and portable electronics has revolutionized our approach to sustainable transportation and portable power. However, unlocking the full potential of Li-ion technology requires a guardian – the Battery Management System (BMS). This report delves into the intricate workings of a BMS, exploring its construction, operating principles, functionalities, advantages, and limitations. By understanding the role of a BMS, we can ensure the safe, efficient, and reliable operation of Li-ion batteries in a wide range of applications.

Fig 6.1 BMS Fitted in Vehicle

6.6 CONSTRUCTION OF BMS

A BMS is an electronic system that acts as the brain of a Li-ion battery pack. It typically consists of the following key components:

Analog-to-Digital Converter (ADC): This component converts the analog voltage signals from individual battery cells into digital values that can be processed by the microcontroller.

Microcontroller Unit (MCU): The heart of the BMS, the MCU is a small computer responsible for collecting data from sensors, performing calculations, and controlling various functionalities.

Power Management Circuit: This circuit regulates the power supply to the BMS itself, ensuring its continuous operation.

Cell Voltage and Temperature Sensors: These sensors monitor the voltage and temperature of each cell within the battery pack.

Current Sensors: These sensors measure the current flowing into and out of the battery pack.

Communication Interface: This interface allows the BMS to communicate with external devices, such as a battery charger or a vehicle's control unit, providing valuable data on battery health and status.

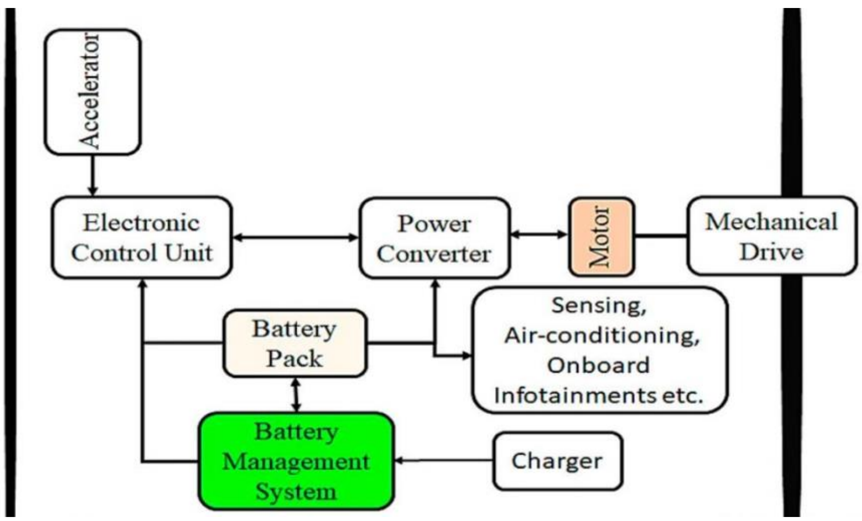


Fig 6.2 Block diagram of BMS

6.7 OPERATING PRINCIPLE OF BMS

The BMS operates by constantly monitoring and managing several crucial aspects of the Li-ion battery pack:

Cell Voltage Monitoring: Individual cell voltages are continuously monitored to ensure they stay within safe operating limits. Overcharging or over-discharging can damage battery cells and pose safety risks.

Cell Balancing: If voltage imbalances are detected between cells, the BMS employs cell balancing techniques. This may involve actively transferring a small amount of charge from higher-voltage cells to lower-voltage cells to maintain a balanced state, promoting longer battery life.

Temperature Monitoring: Battery temperature is a critical parameter. The BMS monitors cell temperature and may implement measures like reducing charging or discharging currents if it exceeds safe thresholds.

Current Limiting: The BMS regulates the current flow into and out of the battery to prevent excessive currents that could damage the battery or connected components.

State of Charge (SOC) Estimation: The BMS estimates the remaining capacity of the battery pack based on various parameters like voltage, current, and temperature. This information is crucial for providing accurate range estimates in electric vehicles.

State of Health (SOH) Estimation: Over time, the capacity and performance of a Li-ion battery degrade. The BMS monitors various data points to estimate the battery's overall health and alert users of potential issues.

6.8 FUNCTIONAL OVERVIEW OF A BMS

Here's a breakdown of the key functionalities performed by a BMS:

6.8.1 Protection Functions

Overcharge Protection: Prevents excessive charging voltage that could damage cells and pose a fire risk.

Over-discharge Protection: Prevents the battery from discharging beyond its safe limits, extending lifespan.

Overcurrent Protection: Limits current flow to prevent damage from excessive currents.

Short Circuit Protection: Detects and isolates short circuits within the battery pack to prevent overheating and potential fire hazards.

Temperature Protection: Monitors battery temperature and takes corrective actions like reducing charging/discharging if overheating occurs.

6.8.2 Monitoring Functions

Cell Voltage Monitoring: Tracks individual cell voltages to detect imbalances and ensure safe operation.

Cell Temperature Monitoring: Monitors cell temperatures to prevent thermal runaway.

Current Monitoring: Measures the current flowing into and out of the battery pack.

State of Charge (SOC) Estimation: Estimates the remaining battery capacity for user information and range prediction.

State of Health (SOH) Estimation: Tracks battery degradation and provides insights into its remaining lifespan.

6.8.3 Communication Functions

Communicates with external devices like battery chargers or vehicle control units to provide data on battery health, status, and remaining capacity.

May provide alerts to users regarding potential battery issues.

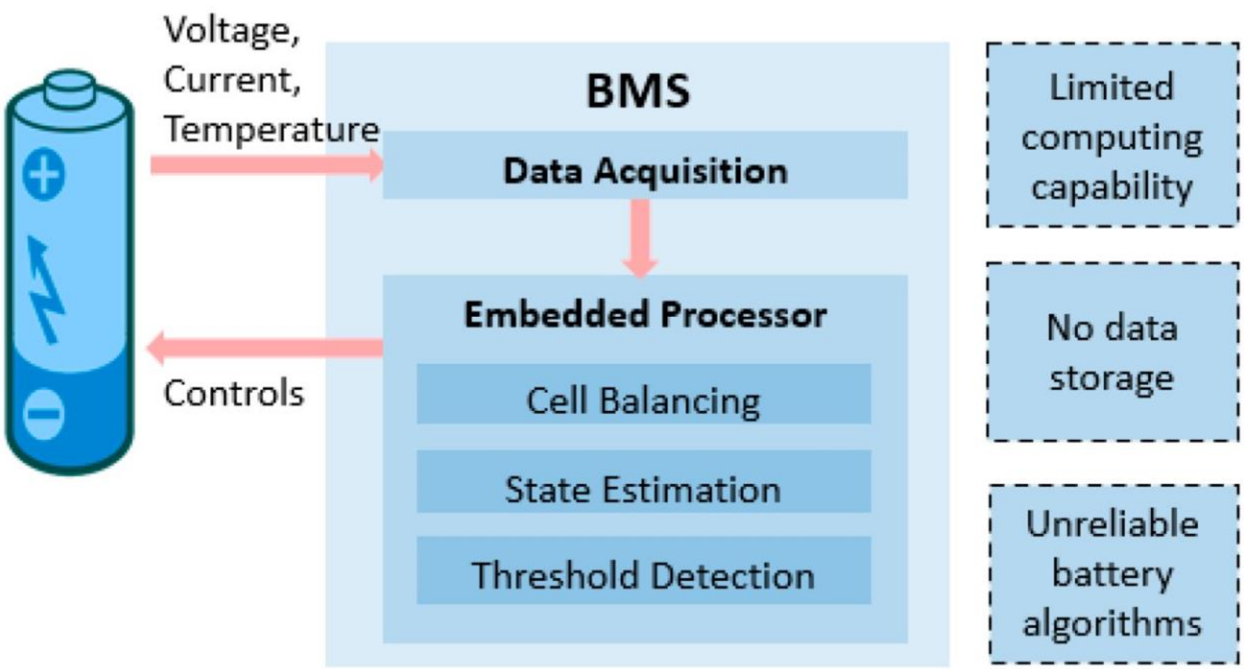


Fig 6.3 Functions of BMS

6.7 CONCLUSION

The Battery Management System (BMS) plays a critical role in ensuring the safe, efficient, and reliable operation of Li-ion batteries. By monitoring various parameters, implementing protective measures, and providing valuable data on battery health and status, the BMS acts as the guardian of these powerful energy sources. As Li-ion technology continues to evolve and power a wider range of applications, the importance of robust and sophisticated BMS systems will only increase.

This report has explored the construction principles, functionalities, advantages, and limitations of BMS. By understanding the intricate workings of a BMS, designers, engineers, and users alike can appreciate its significance in maximizing the potential of Li-ion batteries for a sustainable future.

The realm of BMS technology is constantly evolving. Future advancements might include:

Smarter Cell Balancing: More sophisticated algorithms and techniques for cell balancing to further optimize battery performance and lifespan.

Wireless Communication: Integration of wireless communication protocols for easier data transmission and remote monitoring of battery health.

AI-powered BMS: Leveraging artificial intelligence for real-time battery health assessment, predictive maintenance, and personalized charging strategies.

As these innovations emerge, the BMS will continue to play a vital role in unlocking the full potential of Li-ion batteries and propelling us towards a cleaner and more sustainable energy future.

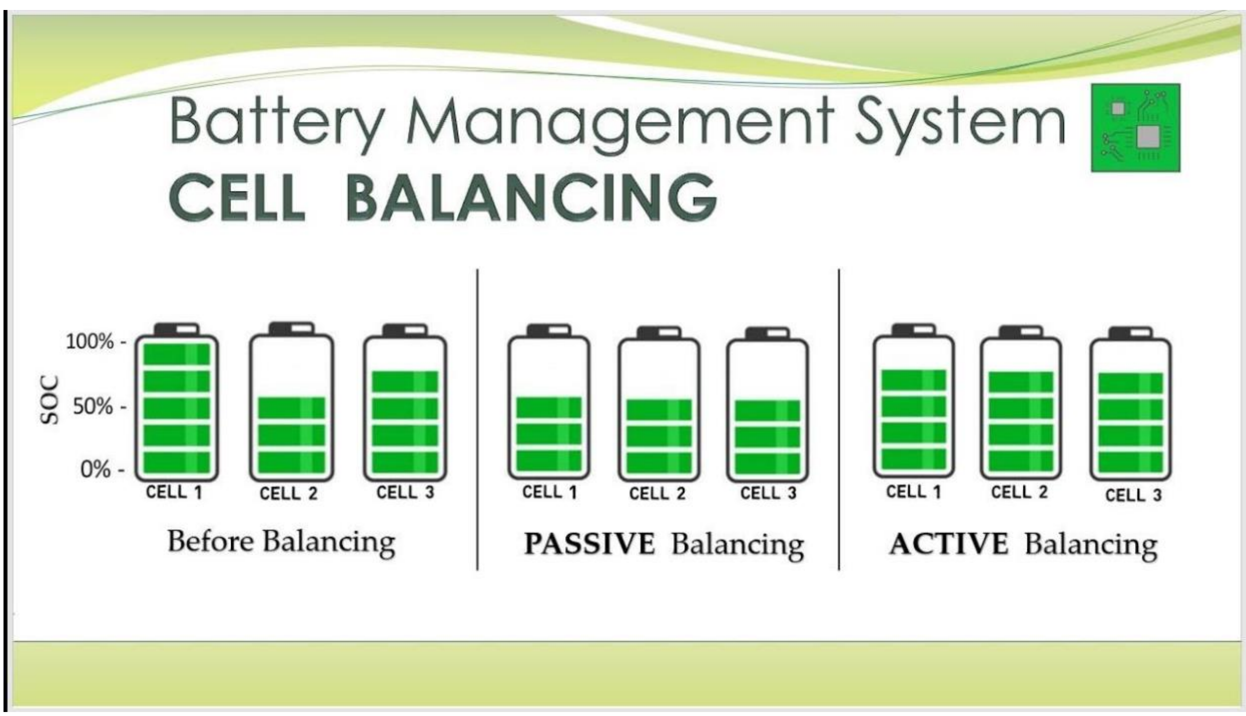


Fig 6.4 Cell Balancing

CHAPTER 7

7.1 A DEEP DIVE INTO SOLAR PANEL INTEGRATION

The concept of a Electric Solar Cargo embodies sustainability and innovation. This report delves into the details of integrating a 12V, 100W solar panel mounted on the cargo's roof to recharge the battery on the go. We will explore the construction, operating principles, advantages, and limitations of this system, focusing on the crucial role of the solar panel and its connection to the battery management system (BMS).

Fig 7.1 Solar Panel

7.2 SOLAR PANEL CONSTRUCTION

A solar panel, also known as a photovoltaic (PV) panel, converts sunlight into electricity using the photovoltaic effect. Here's a breakdown of its construction: Semiconductor Material: The core component is a thin layer of a light-sensitive semiconductor material, typically silicon. When sunlight strikes the silicon, it excites electrons, creating an electric current.

Anti-Reflective Coating: A special coating on the front surface minimizes light reflection, allowing more sunlight to reach the active semiconductor layer.

Electrical Contacts: Metallic contacts collect the generated electricity from the semiconductor layer.

Encapsulation: The entire assembly is encapsulated in a weatherproof material for protection against environmental factors.

Junction Box: A sealed box at the back of the panel houses electrical connections and protects them from moisture and dust.

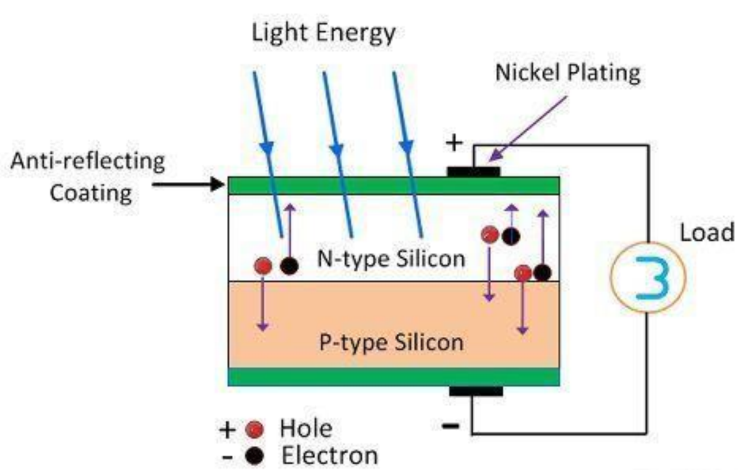


Fig 7.2 Basic idea about Solar panel

7.3 OPERATING PRINCIPLE OF A SOLAR PANEL

The photovoltaic effect explains how a solar panel converts sunlight into electricity. Here's a simplified explanation:

Sunlight Absorption: Sunlight photons (particles of light) strike the silicon atoms in the semiconductor material.

Electron Excitation: The photon energy excites electrons within the silicon, bumping them to a higher energy state.

Electron Flow: The excited electrons create a flow of electric current within the semiconductor material.

P-N Junction: The solar panel is constructed with a P-N junction, where P and N regions have different electrical properties. This junction allows for directed electron flow when sunlight excites them.

Electricity Generation: The current generated by the movement of excited electrons can be collected by the electrical contacts and used to power various applications.

7.4 SOLAR PANEL INTEGRATION

The chosen 12V, 100W solar panel will be mounted on the roof of the cargo.

Here's how it connects to the battery and BMS:

Mounting: The solar panel requires a secure and weatherproof mounting system on the cargo's roof. It should be positioned for optimal sunlight exposure while considering weight distribution and wind resistance.

Electrical Connections: The solar panel's output cables connect to a solar charge controller. This controller is crucial as it regulates the voltage and current from the panel to match the battery's requirements. Overcharging the battery can damage it.

Voltage Boost Converter: Since the solar panel generates 12V, a voltage boost converter is necessary to increase the voltage to 48V to match the battery pack's voltage. This allows for efficient charging.

Battery Management System (BMS): A switch allows manual control over connecting the boosted 48V output to the BMS. This enables users to turn on charging when sunlight is available and disconnect it when needed (e.g., during storage or parking). The BMS then manages the charging process, ensuring safety and optimal battery health.

Fig 7.3 Solar Panel Integration on the Cargo

7.5 WORKING OF SOLAR CHARGING SYSTEM

Sunlight Conversion: Sunlight strikes the solar panel, and the photovoltaic effect generates electricity.

Voltage Regulation: The solar charge controller regulates the voltage and current output from the panel to protect the battery.

Voltage Boosting: The voltage boost converter increases the voltage from 12V to 48V to match the battery pack's voltage.

Manual Control: The user turns on the switch to connect the boosted 48V output to the BMS.

Battery Charging: The BMS manages the charging process, ensuring a safe and efficient transfer of energy from the solar panel to the battery, gradually replenishing its energy.

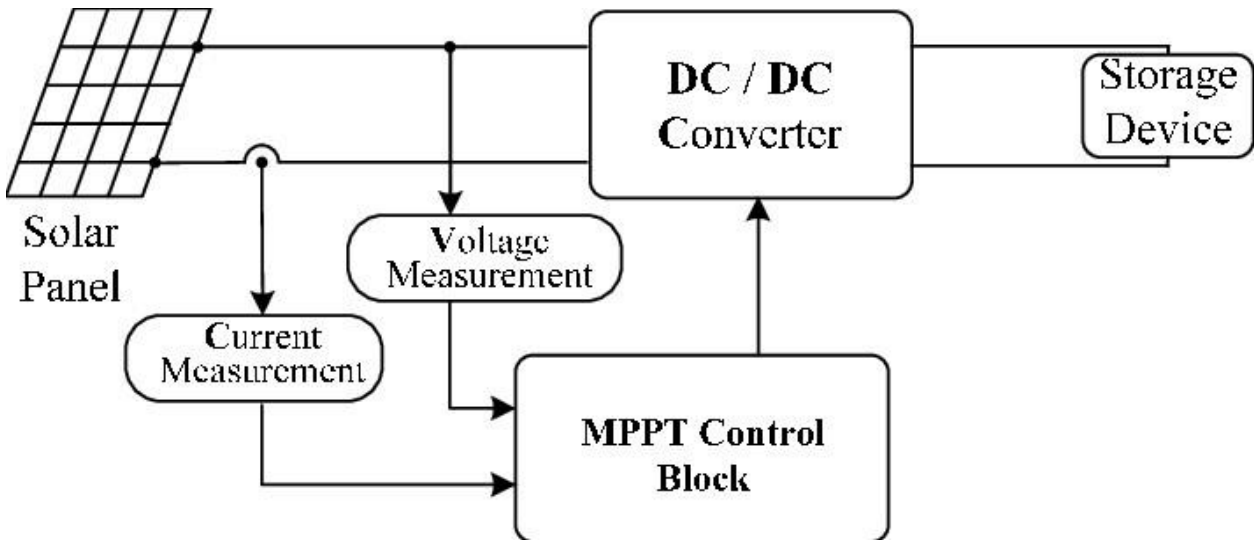


Fig 7.4 Working of Solar Panel

7.6 ADVANTAGES OF SOLAR PANEL INREGRATION

Sustainable Charging: Utilizes renewable solar energy to recharge the battery, reducing reliance on grid electricity and minimizing carbon footprint.

Increased Range: Even with limited power generation, the solar panel can provide additional energy input, potentially extending the cargo's range on a single battery charge.

Off-Grid Operation: The ability to charge the battery using solar power enables the cargo to operate even in remote locations without access to grid electricity.

Cost Savings: Over time, the use of solar energy can lead to cost savings on electricity bills for charging the cargo's battery.

7.7 DISADVANTAGES AND LIMITATIONS OF SOLAR PANEL INTEGRATION

Limited Power Generation: A 12V, 100W solar panel offers limited power generation. The amount of energy recharged into the battery will depend on sunlight intensity and duration of exposure. Full battery recharge might take a significant amount of time, especially under less than ideal sunlight conditions.

Weather Dependence: The effectiveness of the solar panel relies heavily on sunlight availability. Rain, clouds, or low sunlight conditions significantly reduce the amount of energy generated.

Space Constraints: Mounting a solar panel on the cargo introduces space limitations. The size and position of the panel need careful consideration to ensure optimal sunlight exposure without compromising manoeuvrability or aesthetics.

Weight and Size: Adding a solar panel increases the cargo's weight, which can affect its overall performance, range, and handling.

Cost: The initial cost of purchasing and installing the solar panel and related components (charge controller, voltage booster) adds to the overall cost of the cargo.

Maintenance: The solar panel requires periodic cleaning to maintain optimal efficiency. Additionally, the voltage booster and charge controller might need occasional maintenance or replacement.

Theft Deterrence: Depending on the mounting location, the solar panel might be more susceptible to theft compared to a rooftop installation on a house.

7.8 CONCLUSION

Integrating a 12V, 100W solar panel on electric cargo presents a unique opportunity to harness renewable energy for on-the-go charging. While the power generation might be limited, the benefits of sustainability, potential range extension, and reduced reliance on grid electricity are noteworthy. Understanding the advantages and limitations allows to make an informed decision about incorporating solar charging into cargo design.

7.9 FURTHER CONSIDERATIONS

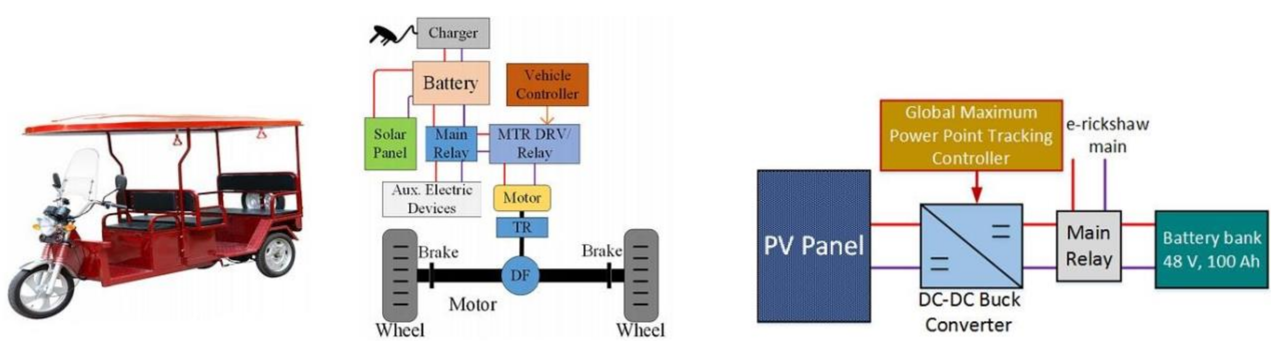
For a more comprehensive analysis, consider these additional factors:

Solar Irradiance: Researching average solar irradiance data for region can provide insights into the potential energy generation from the solar panel throughout the year.

Cargo Usage Patterns: Understanding how plan to use the cargo (average daily distance, frequency of use) can help assess the potential impact of solar charging on range.

Alternative Solar Panel Options: Exploring higher wattage solar panels can increase power generation but might also add weight and size constraints.

Battery Capacity: The capacity of battery pack will influence how much energy can be stored and how long it takes to recharge using solar power.



Existing Electrical Rickshaw — Block diagram of solar e-rickshaw — Circuit diagram for the connection of PV panel

Fig 7.5 Overall view of solar panel integration

CHAPTER 8

8.1 UNVEILING THE GREEN MACHINE

The concept of Electric Solar Cargo embodies sustainability and innovation. This report delves into the intricate workings of cargo, exploring its components, principles of operation, functionalities, advantages, and limitations. With specifications like a 48V Li-ion battery, 800W Permanent Magnet Synchronous Motor (PMSM), 100W solar panel, and a sophisticated control system, cargo offers a unique blend of efficiency, performance, and environmental consciousness.

Fig 8.1 Electric solar cargo

8.2 INTRODUCTION

Electric cargos are gaining traction as a sustainable and efficient mode of transportation. They offer numerous advantages over traditional gasoline powered vehicles, including reduced emissions, lower operating costs, and quieter operation. Electric solar cargo takes this concept a step further by harnessing the power of the sun to recharge the battery, minimizing reliance on grid electricity. This report serves as a comprehensive guide to understanding the various components, their interaction, and the overall operation of innovative cargo.

8.3 CONSTRUCTION AND KEY COMPONENTS

Permanent Magnet Synchronous Motor (PMSM): This brushless DC motor offers high efficiency, power density, and smooth operation. Specifications: 48V, 800W, 18A.

Fig 8.2 PMSM

Construction: Consists of a permanent magnet rotor and a stator with windings. As the rotor spins within the stator's magnetic field, electricity is induced in the windings, generating torque to propel the cargo.

Lithium-Ion Battery (Li-ion): Provides energy storage for the Electric solar cargo.

Specifications: 48V, 18Ah (864Wh).

Fig 8.3 Battery

Construction: Composed of multiple cells containing lithium ions that move between electrodes during charging and discharging.

Battery Management System (BMS): This crucial electronic system safeguards the battery by monitoring voltage, temperature, current, and implementing various protective measures like overcharge/discharge protection and cell balancing.

Fig 8.4 BMS

Charger (5A): Replenishes the battery's energy from an external AC power source.

Fig 8.5 Charger

Solar Panel (100W, 12V): Converts sunlight into electricity using the photovoltaic effect.

Fig 8.6 Solar Panel

Construction: Composed of semiconductor material (typically silicon) that absorbs sunlight and generates electricity through the movement of excited electrons.

Solar Boost Converter (600W): Increases the voltage output from the solar panel (12V) to match the battery voltage (48V) for efficient charging.

Motor Controller (800W): This electronic control unit regulates the motor's speed and torque based on user input (accelerator pedal).

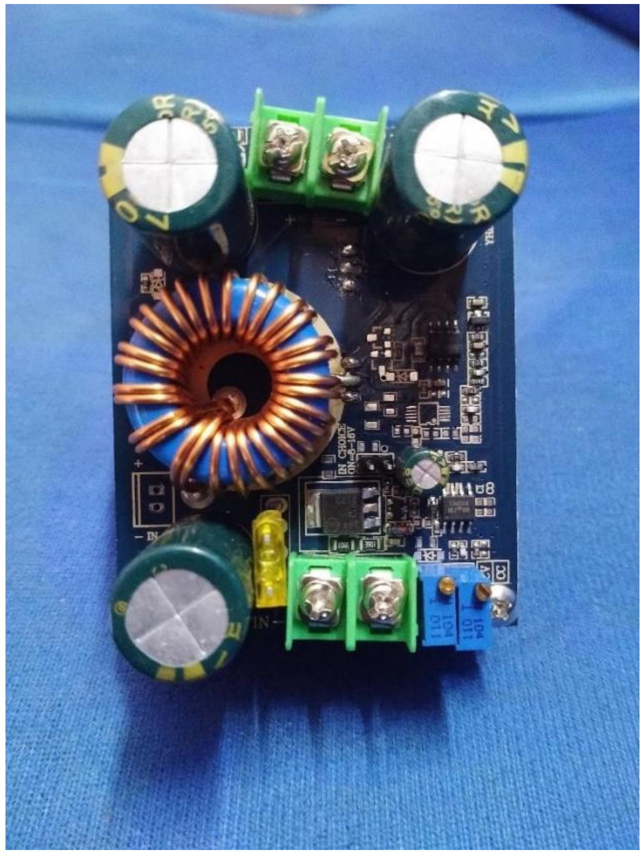


Fig 8.7 Boost Converter

Headlight (12V): Illuminates the road during low-light conditions.

Fig 8.8 Headlight

8.4 BRAKING SYSTEM

Electric regenerative braking: When the handlebar brake lever is engaged, the motor acts as a generator, converting kinetic energy into electrical energy that is fed back into the battery (partially recharging it) while slowing down the cargo.

Fig 8.9 Electrical Regenerative Braking

Mechanical drum brake: Provides a secondary braking system for additional stopping power and redundancy.

Fig 8.10 Mechanical Braking

8.5 PRINCIPLE OF OPERATION

Ignition: When the key is turned on, the BMS checks battery health and system status. If all is clear, the control system energizes.

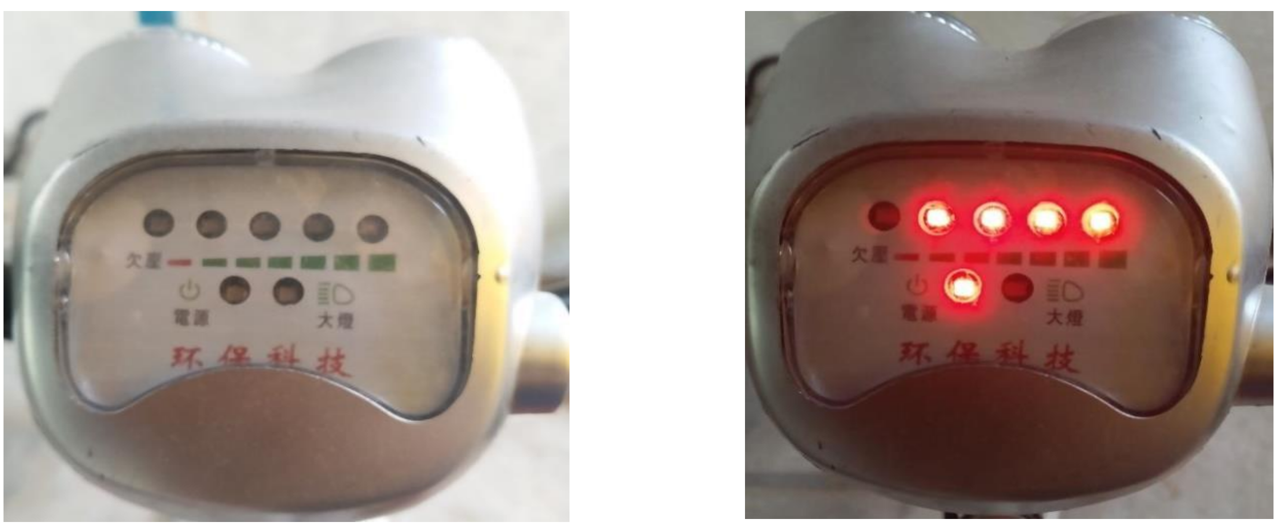


Fig 8.11 Ignition

Acceleration: Depressing the accelerator pedal sends a signal to the motor controller. The controller regulates the amount of current supplied to the PMSM motor, determining its speed and torque. As the motor spins, it rotates the rear wheel, propelling the cargo forward.

Fig 8.12 Acceleration

Electric Braking: Upon engaging the handlebar brake lever, the motor controller reverses the polarity of the voltage applied to the PMSM motor. This converts the motor into a generator, resisting the rotation and slowing down the cargo. The generated electricity can be fed back into the battery (regenerative braking).

Mechanical Braking: Engaging the foot brake lever applies mechanical pressure to the drum brakes on the wheels, providing additional stopping power.

Solar Charging: Sunlight strikes the solar panel, generating electricity. The solar boost converter increases the voltage from 12V to 48V to match the battery voltage. The BMS manages the charging process, ensuring safety and optimal battery health.

8.6 FEATURES

Sustainable Operation: The solar panel offers the potential to extend the cargo's range and reduce reliance on grid electricity.

Regenerative Braking: Partially recharges the battery while braking, increasing efficiency.

Safety Features: The BMS safeguards the battery, and the dual braking system provides enhanced stopping power.

Headlight: Improves visibility during low-light conditions.

User-Friendly Controls: The ignition key, accelerator pedal, and handlebar brake lever provide intuitive control for the rider.

Silent Operation: The electric motor offers a quieter ride compared to gasoline powered vehicles.

Loading Capacity: The 400 kg loading capacity makes it suitable for carrying cargo or passengers.

8.7 WORKING IN HARMONY

The various components of Electric solar cargo work in a coordinated manner:

Starting the Cargo: Turning the ignition key activates the BMS. Once the BMS verifies battery health and system readiness, the motor controller and other systems are energized.

Acceleration and Power Delivery: Pressing the accelerator pedal sends a signal to the motor controller. The controller interprets this signal and adjusts the current provided to the PMSM motor. As current increases, the motor generates more torque, propelling the cargo forward at a faster speed.

Braking and Energy Recovery: Engaging the handlebar brake lever reverses the polarity of the voltage applied to the PMSM motor. This converts the motor's function from propulsion to generation. The motor acts as a generator, resisting the rotation of the wheels and slowing down the cargo. Additionally, the generated electricity can be fed back into the battery, partially recharging it during braking (regenerative braking).

Solar Charging: When sunlight strikes the solar panel, it generates electricity. The current flows through the solar boost converter, where the voltage is increased from 12V to 48V to match the battery voltage. The BMS manages the charging process, regulating the current and voltage to ensure safe and efficient battery charging. The charged battery provides the energy required for operating the motor and other electrical components.

Fig 8.13 Right view

Headlight Operation: A dedicated switch allows the rider to turn on the 12V headlight when needed for improved visibility during low-light conditions.

8.8 ADVANTAGES OF ELECTRIC SOLAR CARGO

Environmental Sustainability: Reduces reliance on fossil fuels and minimizes greenhouse gas emissions compared to gasoline-powered vehicles.

Cost Savings: Lower operating costs due to the use of renewable solar energy and reduced maintenance requirements of electric motors.

Quiet Operation: Offers a quieter ride, contributing to a less noise-polluted environment.

Efficiency: Electric motors offer higher efficiency compared to gasoline engines, leading to less energy waste.

Regenerative Braking: Partially recharges the battery while braking, extending the range.

Multi-Purpose Use: With a 400 kg loading capacity, it can be used for various purposes like personal transportation, cargo delivery, or recreational activities.

Fig 8.14 left view

8.9 DISADVANTAGES AND LIMITATIONS

Limited Range: While the solar panel can potentially extend the range, the primary source of energy is the battery, limiting the overall range compared to gasoline-powered vehicles. Factors like battery capacity, terrain, and weather conditions can significantly impact the range.

Weather Dependence: The effectiveness of solar charging heavily relies on sunlight availability. Rain, clouds, or low sunlight conditions significantly reduce the amount of energy generated.

Charging Time: The 5A charger might require a longer time to fully recharge the battery compared to faster chargers. Integrating a higher-amperage charger can improve charging times, but it needs careful consideration regarding battery health and safety.

Solar Panel Integration: Mounting the solar panel adds weight and might affect the cargo's aesthetics. Additionally, theft deterrence needs to be considered.

Battery Degradation: Li-ion batteries experience degradation over time, gradually reducing their capacity. Proper charging practices and thermal management can help extend battery lifespan.

Fig 8.18 Back view

8.10 EXPLORING ADDITIONAL TECHNICAL DETAILS

8.10.1 Battery Management System (BMS) in Action

The BMS plays a critical role in ensuring the safe and efficient operation of the Li-ion battery. Here's a closer look at some of its key functions:

Cell Voltage Monitoring: The BMS continuously monitors the voltage of each individual cell within the battery pack. This helps to identify any imbalances that could develop over time and potentially damage the battery. The BMS can implement cell balancing techniques to ensure all cells maintain similar voltages.

Temperature Monitoring: Battery temperature is a crucial parameter. The BMS constantly monitors the battery temperature and can take corrective actions (like reducing charging/discharging currents) if it exceeds safe thresholds.

State of Charge (SOC) Estimation: The BMS estimates the remaining capacity of the battery based on various parameters like voltage, current, and temperature. This information is crucial for providing accurate range estimates on the instrument cluster of the cargo.

State of Health (SOH) Estimation: Over time, the capacity and performance of a Li-ion battery degrade. The BMS monitors various data points to estimate the battery's overall health and alert users of potential issues, allowing them to take preventive measures.

8.10.2. Solar Panel and Boost Converter

Solar Panel Efficiency: The efficiency of a solar panel refers to the percentage of sunlight energy it converts into electricity. Typical efficiencies for monocrystalline silicon solar panels, like the one might be using, range from 18% to 20%. Understanding the efficiency helps calculate the expected energy generation under different sunlight conditions.

Solar Boost Converter Operation: The solar boost converter utilizes a switching circuit to increase the voltage from the solar panel (12V) to match the battery voltage (48V). This allows for efficient charging of the battery by overcoming the voltage difference. The converter operates based on the principle of Pulse Width Modulation (PWM), where the duty cycle of the switching signal determines the output voltage.

8.10.3. Motor Controller and Regenerative Braking

Motor Controller Functions: The motor controller receives signals from the accelerator pedal and other sensors. It interprets these signals and regulates the amount of current delivered to the PMSM motor, controlling its speed and torque. Additionally, the controller monitors various motor parameters like temperature and current to ensure safe operation.

Regenerative Braking Efficiency: The efficiency of regenerative braking depends on various factors, including motor type, controller design, and system losses. While it helps to partially recharge the battery during braking, some energy is lost as heat due to friction within the system.

Fig 8.16 Top view

8.10.4. Safety Considerations

Overcharge and Over-discharge Protection: The BMS safeguards the battery from overcharging and over-discharge conditions, which can significantly damage the battery cells and pose safety risks.

Short Circuit Protection: The BMS can detect and isolate short circuits within the battery pack, preventing overheating and potential fire hazards.

Fuse Protection: Fuses are crucial safety components that interrupt the current flow in case of excessive currents, protecting the electrical components of the cargo.

Fig 8.17 Head setup

8.10.5. Real-World Data Collection and Analysis

By incorporating data logging features into the BMS or motor controller, can collect valuable data on various parameters like battery voltage, current, temperature, motor speed, and solar panel output. Analyzing this data can provide insights into the Electric solar cargo performance under different conditions (terrain, weather, load) and help:

Optimize Range: Identify factors that impact range and implement strategies to maximize it (e.g., adjusting riding style, optimizing solar charging times).

Monitor Battery Health: Track changes in battery performance over time and identify potential issues early on.

Evaluate System Efficiency: Analyze the efficiency of the solar charging system and regenerative braking to identify areas for improvement.

Fig 8.18 Front view

8.11 FURTHER CONSIDERATIONS

This report provides a comprehensive overview of Electric solar cargo.

Here are some additional factors to consider:

Real-world Range Testing: Conducting real-world testing under various conditions (terrain, weather, load) can provide a more accurate understanding of the cargo's achievable range.

Battery Maintenance Practices: Following proper charging practices and thermal management techniques can significantly extend the lifespan of the Li-ion battery. Consulting the battery manufacturer's recommendations is crucial.

Solar Panel Maintenance: Cleaning the solar panel regularly ensures optimal efficiency in generating electricity.

Safety Precautions: Use proper safety gear like a helmet and reflective clothing, especially during night rides. Adhere to traffic regulations and ride defensively.

Customization Options: Depending on specific needs and preferences, might explore customizing certain aspects of the cargo. This could include:

Upgrading the Solar Panel: A higher wattage solar panel can potentially increase the amount of energy generated, but weight and space constraints need to be considered.

Faster Charger Integration: While a faster charger can reduce charging time, ensure compatibility with the battery and BMS to avoid compromising safety or battery health.

Additional Features: Depending on needs, might consider adding features like a rearview mirror, turn signals, or a cargo box.

Fig 8.19 Wheel setup

8.12 FUTURE ADVANCEMENTS

The world of electric vehicles and solar technology is constantly evolving. Here's a glimpse into potential future advancements that could further enhance Electric solar cargo:

Solid-State Batteries: Solid-state batteries offer higher energy density, faster charging times, and improved safety compared to Li-ion batteries. If these become commercially viable, they could significantly increase the cargo's range and charging efficiency. **Integrated Solar Panels:** Advancements in solar cell technology might lead to the development of flexible, lightweight solar panels that can be seamlessly integrated into the cargo's bodywork, minimizing the visual impact and potentially increasing the overall energy generation capacity.

Smarter Battery Management Systems (BMS): Future BMS systems might incorporate advanced algorithms for more efficient charging, real-time battery health monitoring, and predictive maintenance capabilities, further extending battery lifespan and optimizing cargo performance.

Advanced Motor Controllers: More sophisticated motor controllers could offer features like regenerative braking with higher energy recovery efficiency and improved motor control for smoother and more efficient operation.

8.13 CONCLUSION

In conclusion, Electric solar cargo represents a pioneering step towards sustainable transportation. By harnessing the power of renewable energy, offering a clean and efficient alternative to gasoline-powered vehicles, it contributes to a greener tomorrow. This report has provided a detailed exploration of its components, operation principles, functionalities, and potential for further advancements. As technology continues to evolve, the possibilities for even more efficient and sustainable electric cargos become ever more exciting.

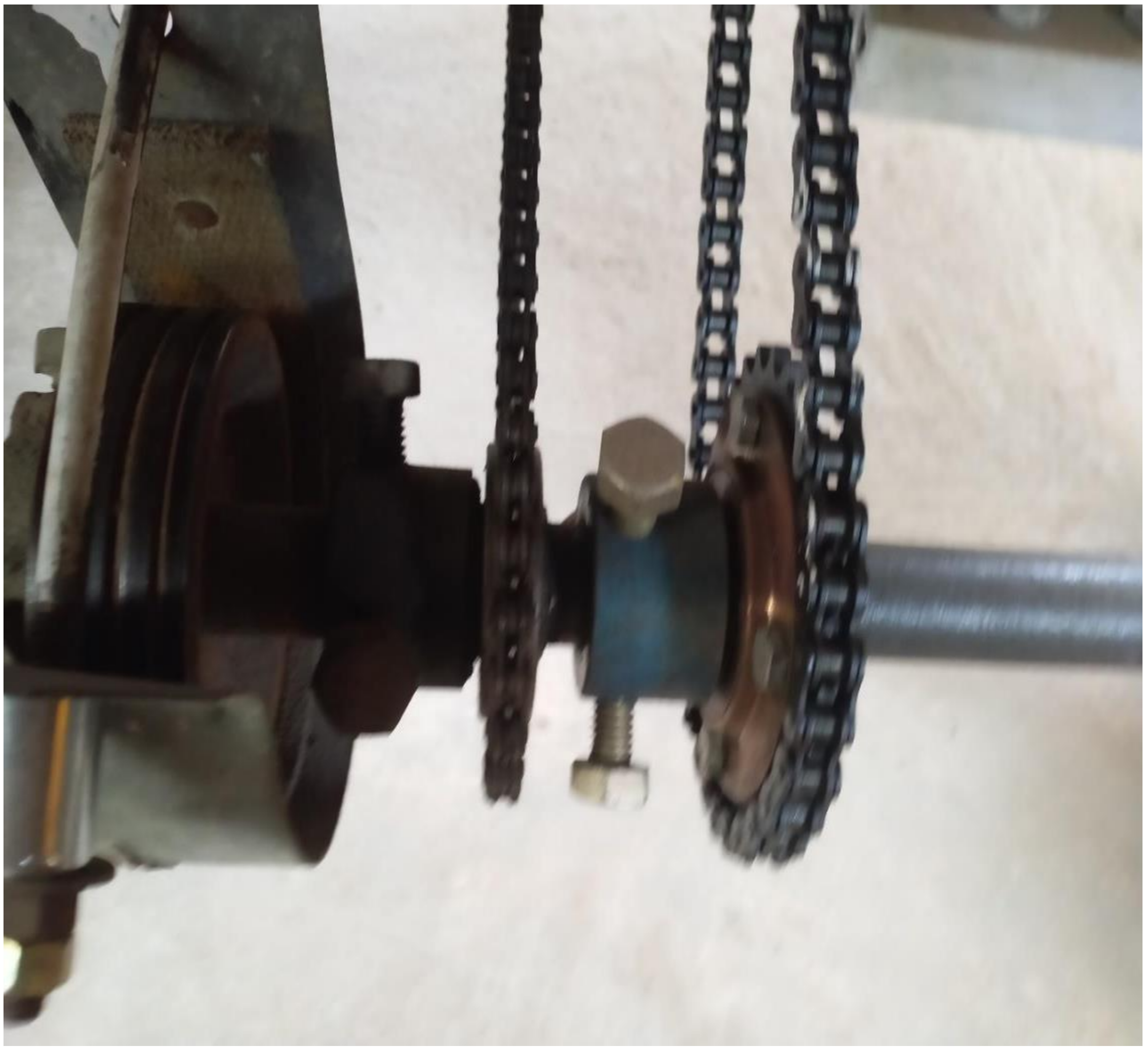


Fig 8.20 Chain drive system

CONCLUSION

Our electric cargo stands as a beacon of sustainability in the realm of urban transport, embodying innovation, efficiency, and environmental stewardship. With its powerful 48V, 800W motor and lithium-ion battery system, the cargo offers a compelling alternative to fossil fuel-powered vehicles, enabling efficient and eco-friendly goods transportation in urban environments. By integrating solar panels into its design, the cargo harnesses renewable energy to extend its range and reduce its carbon footprint, underscoring our commitment to sustainable mobility.

Beyond its environmental benefits, the cargo excels in performance, reliability, and operational efficiency, with rapid charging capabilities and impressive range. Its compact design and manoeuvrability make it ideal for navigating congested city streets, while its low maintenance requirements ensure dependable service over extended periods. Through collaboration with stakeholders, we've laid the groundwork for broader adoption and integration of electric cargo cargos into urban transport networks, paving the way for a cleaner, greener future. In embracing electric mobility, we chart a course towards a brighter, more sustainable urban landscape for generations to come.

APPENDIX - I

EXPLORING ADDITIONAL TECHNICAL DETAILS

This appendix delves deeper into some of the technical aspects of Electric solar cargo, providing a more granular understanding of its operation.

1. Battery Management System (BMS) in Action

The BMS plays a critical role in ensuring the safe and efficient operation of the Li-ion battery. Here's a closer look at some of its key functions:

Cell Voltage Monitoring: The BMS continuously monitors the voltage of each individual cell within the battery pack. This helps to identify any imbalances that could develop over time and potentially damage the battery. The BMS can implement cell balancing techniques to ensure all cells maintain similar voltages. Temperature Monitoring: Battery temperature is a crucial parameter. The BMS constantly monitors the battery temperature and can take corrective actions (like reducing charging/discharging currents) if it exceeds safe thresholds.

State of Charge (SOC) Estimation: The BMS estimates the remaining capacity of the battery based on various parameters like voltage, current, and temperature. This information is crucial for providing accurate range estimates on the instrument cluster of the cargo.

State of Health (SOH) Estimation: Over time, the capacity and performance of a Li-ion battery degrade. The BMS monitors various data points to estimate the battery's overall health and alert users of potential issues, allowing them to take preventive measures.

2.Solar Panel and Boost Converter

Solar Panel Efficiency: The efficiency of a solar panel refers to the percentage of sunlight energy it converts into electricity. Typical efficiencies for monocrystalline silicon solar panels, like the one might be using, range from 18% to 20%. Understanding the efficiency helps calculate the expected energy generation under different sunlight conditions.

Solar Boost Converter Operation: The solar boost converter utilizes a switching circuit to increase the voltage from the solar panel (12V) to match the battery voltage (48V). This allows for efficient charging of the battery by overcoming the voltage difference. The converter operates based on the principle of Pulse Width Modulation (PWM), where the duty cycle of the switching signal determines the output voltage.

3.Motor Controller and Regenerative Braking:

Motor Controller Functions: The motor controller receives signals from the accelerator pedal and other sensors. It interprets these signals and regulates the amount of current delivered to the PMSM motor, controlling its speed and torque. Additionally, the controller monitors various motor parameters like temperature and current to ensure safe operation.

Regenerative Braking Efficiency: The efficiency of regenerative braking depends on various factors, including motor type, controller design, and system losses. While it helps to partially recharge the battery during braking, some energy is lost as heat due to friction within the system.

4.Safety Considerations:

Overcharge and Over-discharge Protection: The BMS safeguards the battery from overcharging and over-discharge conditions, which can significantly damage the battery cells and pose safety risks.

Short Circuit Protection: The BMS can detect and isolate short circuits within the battery pack, preventing overheating and potential fire hazards.

Fuse Protection: Fuses are crucial safety components that interrupt the current flow in case of excessive currents, protecting the electrical components of the cargo.

5.Real-World Data Collection and Analysis:

By incorporating data logging features into the BMS or motor controller, we can collect valuable data on various parameters like battery voltage, current, temperature, motor speed, and solar panel output. Analyzing this data can provide insights into the cargo's performance under different conditions (terrain, weather, load).

Optimize Range: Identify factors that impact range and implement strategies to maximize it (e.g., adjusting riding style, optimizing solar charging times). Monitor Battery Health: Track changes in battery performance over time and identify potential issues early on.

Evaluate System Efficiency: Analyze the efficiency of the solar charging system and regenerative braking to identify areas for improvement.

REFERENCE

1. British Standards Institution, 2017. EN 15194:2017: Cycles-Electrically Power Assisted Cycles-EPAC Bicycles, Brussels: Cen.

2. Manas Rajan Panda, Vivek Ranjan, Pramod Lakra (2017, April). Electric Bicycle. ISSN: 2455-2631.

3. Lorenzo Stilo, Diana Segura-Velandia, Heinz Lugo, Paul P. Conway, Andrew A. West (2021, October). Electric Bicycle, Next Generation Low CYCLE Bon Transport System: A Survey. Transportation Research Interdisciplinary Perspectives, 100347.

4. "The Future of Electric Vehicles in the United States: Challenges and Opportunities." National Renewable Energy Laboratory, 2020.

5. Ranjan Kumar, Munna Kumar, Pradyumn Sah, Mustaim Alam, Dr. M. Ashok Raj Kumar (2018). Design and Fabrication of Electric Bicycle. IJERT. ISSN: 2278-0181.

6. W. Chlebosz, G. Ombach, J. Junak, 2010. Comparison of Permanent Magnet Brushless Motor With Outer And Inner Rotor Used In E-Cycle. Rome, Italy.

7. "Electric Vehicle Battery Technologies: State-of-the-Art and Challenges." Journal of Power Sources, 2020

8. K.W.E CHENG, etc. al., this paper provides an overview of the "Recent work of electric vehicle "in the region. The paper describes the development and the comparison of different part of components.

9. "Consumer Adoption of Electric Vehicles: A Literature Review." Transportation Research Part D: Transport and Environment, 2020.

10. Mohamed M, has proposed a paper on " Study of electric vehicles in India opportunities and challenges" Battery Electric Vehicles are complete electric vehicles that are powered by only electricity and do not include a petrol/diesel engine, fuel storage or exhaust pipe.