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Research Article

E-Vehicle

BMS For Self-Charging E-Vehicle

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The growth of electric vehicles (EVs) has sparked creative methods for increasing battery life and improving energy efficiency. In this work, a Battery Management System (BMS) for self-charging electric vehicles (SCEVs) is presented. The suggested solution comprises of a BLDC or induction motor for propulsion attached to the back wheel while an alternator is attached to the front tire that produces power while the vehicle runs. A pole switch is used for smooth transitioning between the two battery packs A and B. This aims in providing continuous vehicle motion while the alternator's activity charges the battery attached to the motor. The BMS is an essential part of this system since it not only stops overcharging but also uses active cell balancing technique during discharging and passive cell balancing technique during charging to maximize battery performance. This study demonstrates how well the suggested BMS works to extend the life SCEVs, providing a viable option for the development of EVs in the future.

Keywords: E-Vehicle, Battery, Pollution, Environment

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1. Introduction

A new decade of eco-friendly transportation has been sparked by the EV technologies' rapid growth. The Battery Management System (BMS) a vital component that guarantees optimal battery performance, safety and lifespan is essential to the efficiency and longevity of EVs. Traditional EVs have issues with accessibility, charging speed and energy sustainability because of their heavy reliance on external charging infrastructures. In response to these difficulties, the idea of self-charging electric cars has surfaced, including systems that permit constant energy replenishment while in use.

In this study, we investigate a new self-charging electric vehicle that utilizes two battery packs that work simultaneously, one for charging and the other for discharging. An alternator is positioned in the front wheel, which the system converts rotational motion into electrical energy. The motor is either an induction or Brushless DC motor placed at the back. It receives this energy and is connected to the battery pack. A pole switch mechanism controls the constant interaction between charging and discharging, allowing for smooth transitions and ongoing vehicle operation.

Preventing overcharging is crucial in this setup since it can negatively impact the longevity and health of the battery

Overcharging requires the inclusion of a strong BMS, as it is mainly caused by excessive voltage. In addition to providing protection against overvoltage situations, this system uses cell balancing techniques to maintain consistent cell voltages and maximize battery performance.

2. Problem Statement

Since fossil fuels like gasoline and diesel powers the traditional cars primarily, they discharge dangerous pollutants into the environment such as hydrocarbons and carbon monoxide. A potential solution to these environmental problems is the development of self-charging electric vehicles, which use the energy generated by the vehicle's own motion to regenerate its batteries. However, there are a number of technological challenges with this unique method. Overcharging increases the risk of overheating and battery deterioration, which is a consequence of the continual self-charging process.

To prevent performance problems and increase battery lifespan, it's also essential to maintain appropriate cell balancing, energy efficiency, and control over the battery packs' temperature. Thus, the main task is to create an advanced BMS that can handle these problems and guarantee the longevity, safety, and effectiveness of self-charging electric cars while also assisting in the decrease of environmental pollution.

3. Solution

To counter the challenges associated with self-charging EVs, a robust BMS is essential. The BMS must effectively manage battery packs used in these vehicles to tackle issues such as overcharging, overheating, and cell imbalance. The BMS addresses this by including advanced monitoring and control mechanisms. It continuously tracks voltage and current situations, employing algorithms to regulate the charging process and help fleecing. Safety features similar as automatic arrestment or diversion of redundant energy farther cover the battery packs, icing their life and maintaining vehicle performance. Thermal operation is another critical aspect of the BMS result. tone- charging processes can induce substantial heat, which needs to be managed to help overheating. The BMS integrates temperature detectors to cover the battery packs' temperature in real- time.

Grounded on this data, the system can spark cooling mechanisms to maintain optimal operating conditions. Active cooling similar as suckers or liquid cooling systems are employed to dissipate heat effectively. By managing thermal conditions effectively the BMS prevents thermal damage and ensures the battery packs remain within safe temperature ranges, thereby securing their performance and life.

Cell balancing is also a pivotal element of the BMS for self- charging electric vehicles. The battery packs bear harmonious cell balancing to ensure invariant performance and extend battery life. For the charging battery pack, unresistant cell balancing ways are used. This system involves redistributing redundant charge from further charged cells to those with lower charge, thereby maintaining balance and overall effectiveness. For the discharging battery pack, active cell balancing is employed. This fashion involves more sophisticated electronics to transfer charge between cells to ensure discharge.

Effective cell balancing enhances battery performance prevents imbalances that could lead to unseasonable battery wear and tear, and improves the vehicle's overall effectiveness.

Eventually the embedding of BMS with the vehicle's alternator and motor is essential for optimal energy operation. The BMS ensures that the energy generated by the alternator is efficiently stored in the battery packs and employed effectively during operation. This involves optimizing the energy inflow to minimize losses and enhance the effectiveness of the tone- charging process. The BMS also manages the flawless operation of all factors, icing that the alternator, motor, and battery packs work together harmoniously. By addressing the challenges of overcharging, thermal operation, and cell balancing, the BMS supports the effective and dependable operation of tone- charging electric vehicles, advancing the thing of sustainable and environmentally friendly transportation.

4. Plan of Implementation

Hardware Components (self-charging)

1. Arduino Controller:

Function: The Arduino Uno is a multipurpose microcontroller board that may be used to automate and control a range of electronic devices and systems. Because of its simplicity and ease of usage, it is frequently used for embedded program development and prototyping.

Operation: The Arduino Uno is powered by the ATmega328 microcontroller, which interprets sensor data and transmits preprogrammed instructions to drive relays, LEDs, and other outputs. It can carry out functions including data collection, control, and communication in a variety of applications since it can be programmed using the Arduino Integrated Development Environment (IDE) and can communicate with other components via digital and analog I/O ports

Figure 1: Arduino Controller

2. Induction Motor:

Function: The propulsion system of a self-charging electric car is the induction motor, which transforms electrical energy into mechanical motion to move the car forward. Its absence of permanent magnets makes it a reliable and affordable option that may be used in a variety of settings.

Operation: The motor gets electricity from the battery and generates motion by electromagnetic induction when driving. It works as a generator when the car is regeneratively braking, transforming the motion of the vehicle back into electrical energy that is then stored in the battery to increase efficiency.

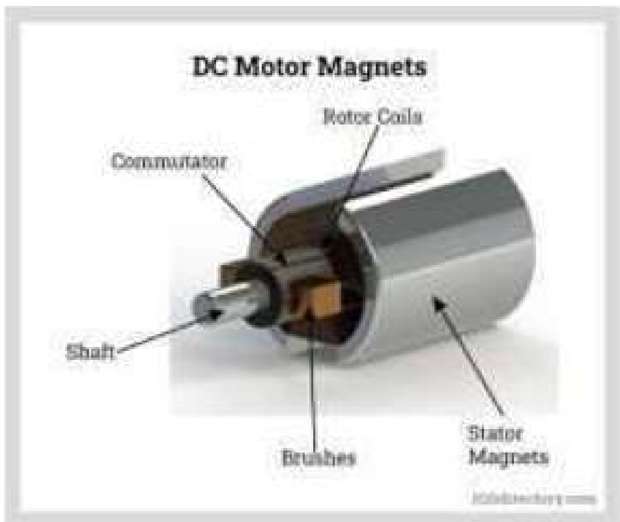

Figure **2:** Induction motor

3. DC Generator:

Function: Electromagnetic induction is a technique used by DC generators to convert mechanical energy into electrical energy. It is done by rotating a conductor inside a magnetic field, which produces a direct current.

Operation: The generator runs on the principle of *Faraday's law of electromagnetic induction* that states current is induced by the mechanical motion of a conductor through a magnetic field. Direct current (DC) is produced by the interaction of the conductor and magnetic field in this process.

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Figure 3: Dynamo

5. Charger Controller:

Function: In off-grid or backup power systems, a charger controller controls the connection between a generator and a battery, guaranteeing effective and secure battery charging.

Operation: In order to prevent overcharging and maximize charging efficiency, the controller is responsible for the current flow from the generator to the battery during the charging process. This guarantees that the battery is charged efficiently.

Figure 4: Charger controller

6. Chassis:

Function: To maintain structural integrity and safety, the self-charging EV chassis integrates and supports the other components of the regenerative charging system.

Operation: The alternator and battery packs among other parts involved in regenerative charging are fitted into the chassis. It must offer a strong framework to sustain these parts and preserve the general safety of the vehicle.

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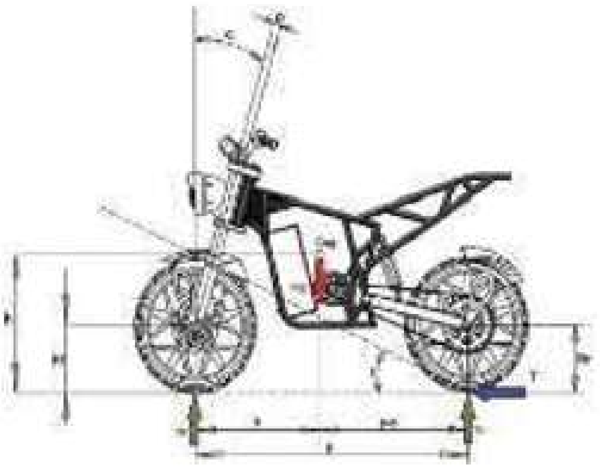

Figure 5: Bike chassis

Hardware Components (BMS)

8. Lithium-ion Battery:

Function: The Li-ion battery offers a power source for electric cars by storing electrical energy with a high energy density. It is perfect for applications which needs a large amount of power storage because of its capacity to maintain a high charge-to-weight ratio.

Operation: Chemical reactions within the battery cells store energy, which is subsequently transformed back into electrical energy to power the vehicle's motor and other systems as needed. The battery goes through cycles of charging and discharging, and how these cycles are managed affects the battery's lifespan and performance.

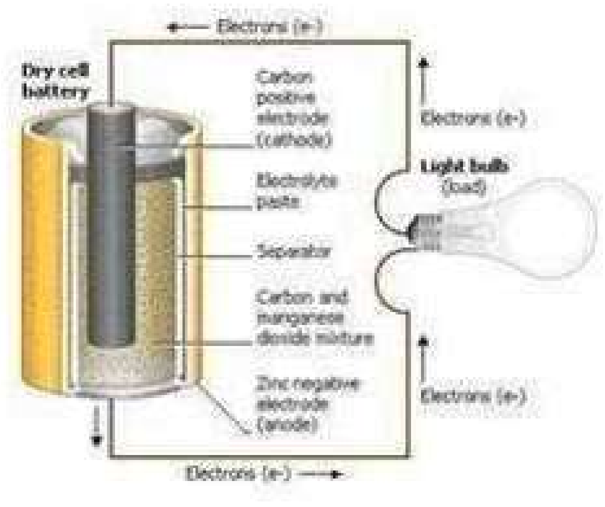

Figure 6: Lithium-ion Battery

9. Current Sensor:

Function: To precisely control the charging and discharging processes, the current sensor detects the current passing through the battery pack. In order to avoid overcurrent scenarios and make sure the battery runs within safe parameters, this measurement is crucial.

Operation: To determine the current magnitude, the sensor usually makes use of shunt resistors or Hall Effect technology. The BMS receives the current data and utilizes it to control power flow and preserve ideal battery performance.

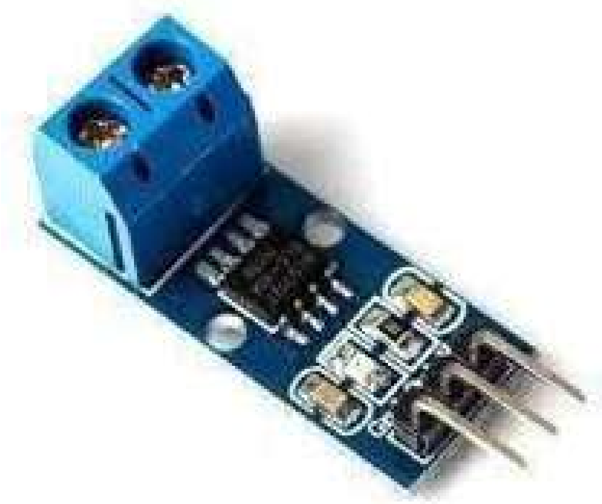

Figure 7: Current sensor

10. Relay Modules:

Function: Manages how two batteries in a dual-battery system are connected, allowing one battery to be charged by the charger and the other to be connected to the load for discharging. This configuration guarantees effective battery management.

Operation: To switch the connections between the batteries and the load or charger, the relay switch's electromagnetic or mechanical components must be activated or deactivated. For applications in automotive, marine, recreational vehicle, and solar power systems, this enables the dynamic selection of the battery that is currently being used for power transmission or charging.

Figure 8: Relay Module

11. Volatage Sensor:

Function: To avoid overcharging and deep draining, which can harm the battery, the voltage sensor monitors the voltage levels of the battery cells. It takes an accurate voltage measurement to ensure the safety and health of batteries.

Operation: The voltage of each cell is measured using integrated monitoring circuits (ICs) or voltage dividers. The BMS receives this data and utilizes it to regulate the charging and discharging procedures, guaranteeing that the battery stays within safe voltage limits.

Figure 9: Voltage Sensor

12. Temperature Sensor:

Function: The temperature sensor monitors the temperature of the battery pack to prevent overheating and ensure safe operation. Overheating can lead to reduced battery life or safety hazards, making temperature monitoring critical.

Operation: The sensor uses thermistors or resistance temperature detectors (RTDs) to measure the temperature of the battery. This data is sent to the Battery Management System (BMS), which adjusts cooling systems or charging parameters to manage thermal conditions effectively.

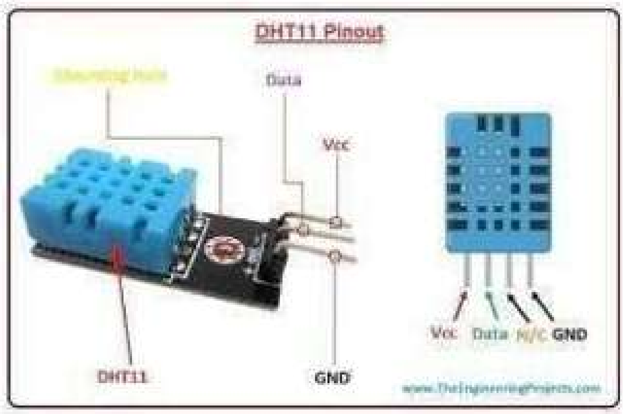

Figure 10: Temperature Sensor

13. Power Supply:

Figure 11: Power Supply

Any electronic system need electricity to run, and the power supply provides that electricity. Choosing the appropriate power source can be the crucial factor for a device to perform at its peak. In addition to alternating current (AC) to direct current (DC) power sources, DC to DC converter is also helpful. If you already have a DC system, then a DC to DC converter would be a better design choice than the AC. DC power supply can be classified as either regulated or uncontrolled. There are numerous variations of regulated supply systems, including switching, linear, and battery-based.

Software Components

1. Arduino IDE:

Function: Arduino controller programming environment.

Operation: Creates and uploads control algorithms to the Arduino to enable hardware component integration and operation without a hitch.

Figure 12: Arduino IDE

2. Data Logging and Analysis Software:

Function: Logs sensor data and analyses it to assess the effectiveness of the system.

Operation: Gathers past information, spots patterns, and helps with treatment process optimization using empirical data.

5. Function and Solution

1. Original Motor Activation:

Powering the Motor The cycle begins with the induction or BLDC motor being powered by Battery Pack A. The vehicle is propelled forward by this motor, which is attached to the hinder wheel.

Movement As the motor turns, it drives the hinder wheel, which in turn propels the vehicle forward.

2. Front Wheel Alternator Activation:

Alternator Rotation contemporaneously, the forward stir of the vehicle causes the anterior wheel to rotate. The alternator attached to the anterior wheel is driven by this gyration.

Energy production the anterior wheel's spinning mechanical energy is transformed into electrical energy by the alternator. This generated electricity is also directed towards charging Battery Pack B, which is presently in the charging phase.

3. Charging Battery Pack B:

Energy Flow: The electrical energy generated by the alternator flows into Battery Pack B. The BMS continuously monitors this process to ensure safe and effective charging.

Passive Cell Balancing technique is done while battery pack B is being charged, the BMS employs unresistant cell balancing. This process ensures that each cell within the battery pack reaches the same voltage position by dissipating spare energy from the advanced- voltage cells as heat.

4. Battery Pack Role Switching:

As Battery Pack A powers the motor, it gradationally depletes its stored energy. The BMS monitors the SoC of Battery Pack A, and when it reaches a predefined lower limit, the system prepares to switch places between the two battery packs.

Pole Switch Activation The pole switch medium is actuated to reverse the places of the two battery packs. Battery Pack B, which has been charging, now takes over the discharging part to power the motor. Battery Pack A, now depleted, switches to the charging phase.

5. Nonstop Operation:

Ongoing vehicle propulsion battery pack B, now powers the motor, continuing to propel the vehicle forward. The anterior wheel with alternator continues to do induction of electricity, which is directed towards charging Battery Pack A.

While Battery Pack B is discharging, the BMS employs active cell balancing. This process redistributes energy among the cells within the pack.

6. Regenerative Braking and Energy Recovery:

Braking and Deceleration during retardation it transforms the moving vehicle's kinetic energy into electrical energy.

The regenerated energy is directed back into the battery pack presently in the charging phase Battery Pack A or B, depending on the cycle. This process further enhances the effectiveness of the system by recovering wasted energy.

7. Cycle Reiteration:

Battery pack B depletes and battery pack A becomes sufficiently charged, the pole switch again reverses their places, allowing the vehicle to continue operating without interruption.

With constant energy management, the BMS continues to manage both battery packs, optimal charging and discharging, while also guarding the batteries from overcharging, overheating, and other implicit issues.

8. System Monitoring and Safety:

Real- time Monitoring Throughout the entire operation, the BMS monitors vital parameters similar as voltage, current, temperature, and SoC for both battery packs .However, similar as overheating or overvoltage, the BMS can take corrective conduct, If any abnormal condition is detected.

Effective energy operation is done by managing the energy flux between alternator, motor and battery packs. The BMS ensures that the vehicle operates efficiently, maximizing the use of generated and recovered energy while minimizing waste.

9. System Shutdown:

End of Operation: When the vehicle is turned off, the BMS safely disconnects the battery packs from the motor and alternator.

Energy Storage: The BMS continues to cover the batteries during standby mode, conserving their charge and precluding any implicit issues that could arise during storehouse.

6. Prototype

System Overview of BMS with switching implementation: An intangible strategy is employed in the self-charging EV system to improve efficiency and increase the car's range. The system includes two rechargeable batteries, a generator, an intelligent battery management system, and a primary motor. Here's a thorough explanation:

Main Motor:

Motor rotational speed: 500 RPM.

Power source are the rechargeable batteries.

Generator:

Is connected to the primary drive motor.

Function: When the main motor is running, this component generates about 6 Volts of energy.

Energy Utilization: An additional rechargeable battery that acts as an EV's backup power source is charged by the energy produced.

Additional Battery:

Function: Provides supplemental power to the vehicle.

Charging Controller:

The TP-4056 is used to control the auxiliary battery charges, making sure effectiveness and security.

Battery Management System (BMS):

The goal is to prolong battery life and avoid overcharging**.**

Uses:

Voltage monitoring: makes certain that no battery is exposed to an excessive amount of voltage.

Temperature Monitoring: Prevents overheating by keeping tabs on the battery's temperature**.**

State of Charge (SoC) Calculation: Ascertains each battery's remaining capacity.

State of Health (SoH) Assessment: Assesses the lifespan and performance of batteries.

Balancing of Cells:

To control excess charge, passive balancing is applied to the battery during charging**.**

For the battery that is discharging, active balancing is used to guarantee uniform energy distribution among the cells.

Mechanism of Charging and Discharging: Battery Packs: One is used for charging and the other for discharging two rechargeable batteries**.**

Mechanism of Switching:

Present: The two batteries are switched out using a Single Pole Double Throw (SPDT) switch. This switch makes sure that the motor runs on one battery while the other is being charged.

Future Plan:

To improve functionality and enable more flexible switching between cell balancing, charging, and discharging, a Double Pole Double Throw (DPDT) switch will be implemented.

Switching Between Charging, Discharging, and Balancing:

SPDT Switch: The two batteries are alternately charged and drained by this switch. The energy produced is used to charge the second battery while the first is discharging, powering the motor.

The DPDT switch can be implemented in the following ways in the future:

To guarantee ongoing operation, switch between the two batteries while they are charging or discharging.

Change Between Passive and Active Cell Balancing: Permit dynamic cell balancing techniques to be adjusted in accordance with the battery's condition (discharging or charging).

Prototype (Self Charging):

Figure 13: Prototype

Our prototype's motor operates at a speed of 1000 revolutions per minute (rpm). This motor, generating approximately 8 volts, spins the dynamo. By employing a DC-DC boost converter, it'sfeasible to raise the voltage from 8V to 13V. The main function of the DC-DC boost converter is to provide the necessary voltage for the battery. The voltage generated through the boost conversion is utilized to power the 12-volt battery. Furthermore, this component incorporates a solar panel as an additional power source, connected in a series with the dynamo, to counteract the decrease in speed caused by the use of two batteries. A diode is also installed to limit the flow of current in the opposite direction of the dynamo. Relays are used to replace the battery connections, making the charging process automatic.

Block Diagram for Self Charging:

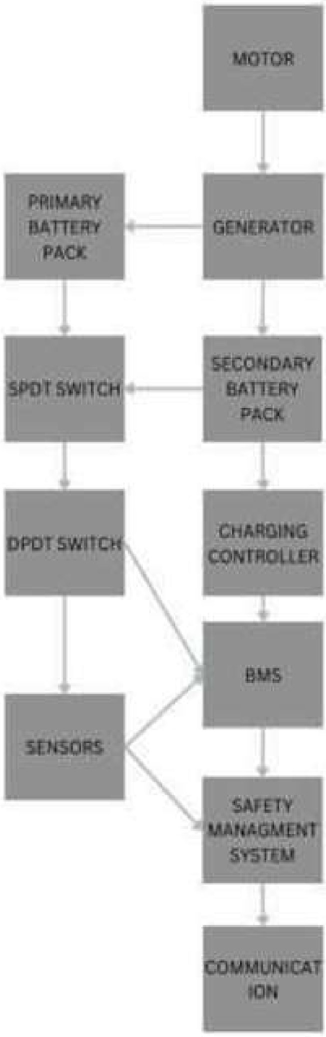

Figure 14: Block diagram for self-charging

The block diagram given below shows the implementation of battery management system for self-charging electric vehicles.

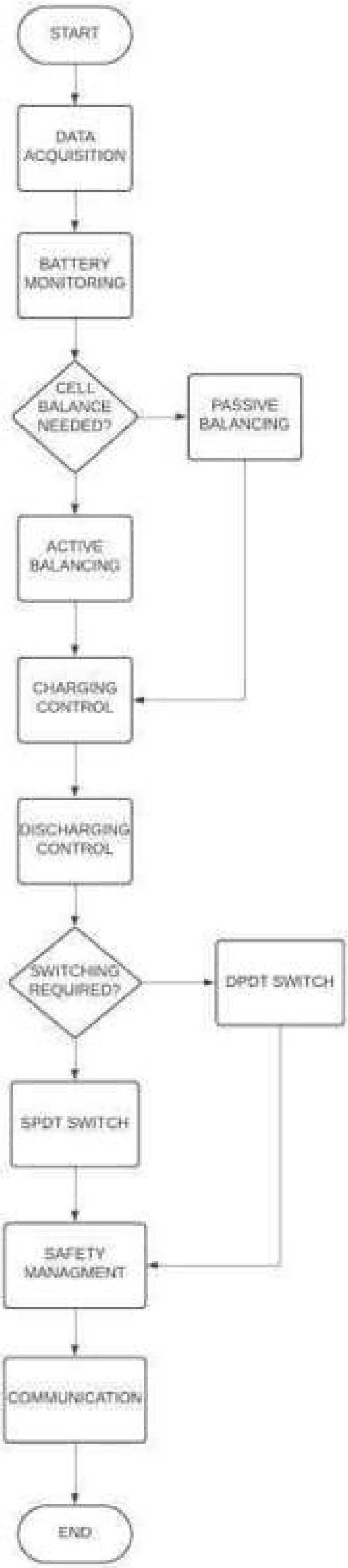

Figure 15: Block diagram for BMS

7. Conclusion

An effective and continuous energy management system is necessary in a self-charging EV with two battery packs, an alternator, and a motor. Two battery packs are installed in the vehicle: one for charging and one for draining. The alternator is mounted in the front wheel, which rotates to produce current. While the alternator charges the other battery pack, this current is routed toward the battery pack attached to the rear motor.

In this configuration, a BMS is vital because it keeps the batteries from being overcharged and extends their lifespan. The BMS does regulation of the battery conditions to prevent overcharging which is a result of high voltage. For charging the battery pack, the BMS uses passive cell balancing technique. This efficiently manages excess charge by dissipating it as heat to maximize battery performance. To ensure balanced performance and effective battery use, active cell balancing technique is employed for the discharging of battery pack to redistribute energy among cells appropriately.

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