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# Infero-shield smart battery management system

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ABSTRACT :

Infero Shield Battery Management Systems (BMS) are indispensable components utilized across various sectors, including electric vehicles (EVs), industrial automation, and telecom power supplies solar systems. These systems oversee the charging and discharging processes of rechargeable batteries to ensure optimal performance, safety, and longevity. Modern BMSs integrate temperature sensors and cooling fan systems to monitor and regulate battery temperature, preventing overheating and thermal runaway. Additionally, they employ voltage sensors to monitor battery voltage, current sensors to measure the current flow, and incorporate LCD displays to provide real-time data visualization to users. Leveraging Internet of Things (IoT) capabilities, these advanced BMSs enable remote monitoring, data sharing, and control, facilitating predictive maintenance and optimized energy utilization. With features such as multiple battery switching techniques and inverter functionality, compare the two battery voltages as load requirement the load automatically switch on high voltage battery, therefore it is a unique technique of inverter Switching. BMSs offer versatile energy management solutions tailored to specific application requirements, enhancing system efficiency and reliability across diverse industries. Furthermore, BMSs utilize fast-switching load techniques achieved by MOSFETs, further enhancing their capability for efficient energy management and ensuring seamless operation in demanding environments.

Keywords: battery storage; electric vehicle; battery thermal management; state of charge; state of health; battery equalization

## Introduction

Infero Shield Battery Management Systems (BMS) are integral to the efficient operation and maintenance of rechargeable batteries in various applications, including electric vehicles (EVs), industrial automation, and telecom power supplies. These systems are responsible for monitoring and controlling the charging and discharging processes of batteries to optimize performance, ensure safety, and prolong lifespan.

A key objective of BMSs is to accurately track the state of charge (SoC) and state of health (SoH) of the battery. SoC indicates the remaining capacity of the battery, while SoH provides insights into its overall condition and remaining lifespan. Achieving this requires precise monitoring of various parameters, including battery temperature, voltage, and current.

Temperature sensors play a critical role in managing battery temperature, preventing overheating, and mitigating the risk of thermal runaway. By continuously monitoring temperature levels, BMSs can implement appropriate cooling strategies or adjust charging rates to maintain optimal operating conditions.

Voltage sensors measure the battery's voltage to determine its charging level accurately. This information helps the BMS regulate charging processes, preventing overcharging or undercharging, which can degrade battery performance and reduce lifespan.

Current sensors track the flow of electric current during charging and discharging. By monitoring current levels, BMSs can detect abnormalities such as excessive discharge rates or charging currents, which may indicate faults or inefficiencies in the system.

Modern BMSs go beyond real-time monitoring by storing historical data on battery usage patterns. This data enables predictive maintenance and forecasting of battery health, allowing for proactive intervention to address potential issues before they escalate. For example, if the BMS detects a decline in battery performance or capacity over time, it can alert operators to schedule maintenance or replacement accordingly.

Despite the benefits of data storage and analysis, one challenge faced by BMSs is the effective sharing and accessibility of data. To address this challenge, many modern BMSs are equipped with Internet of Things (IoT) capabilities. This allows them to connect to the internet, enabling remote monitoring and management of batteries from anywhere in the world. IoT connectivity also facilitates data sharing among different systems and stakeholders, promoting collaboration and streamlined operations.

Furthermore, advanced features such as multiple battery switching techniques and inverter functionality enhance the versatility of BMSs. For example, by employing fast-switching load techniques achieved through MOSFETs, BMSs can optimize energy management and ensure seamless operation, particularly in applications with rapidly changing load demands.

***Component table***

| Sr.no | Component | Quantity |
|---|---|---|

| | | |
|---|---|---|
| 1 | Arduino | 1 |
| 2 | Node MCU8266 | 1 |
| 3 | Relay | 2 |
| 4 | Cooling Fan | 1 |
| 5 | Temperature Sensor | 1 |
| 6 | Current Sensor | 1 |
| 7 | Voltage Sensor | 1 |
| 8 | PCB | 1 |
| 9 | LCD 16*2 | 1 |
| 10 | LED | 5 |
| 11 | Resistor | 5 |
| 12 | Micro USB cable | 1 |
| 13 | Single stand | |
| 14 | Soldering Wire | |
| 15 | Battery | 2 |
| 16 | Diode | 5 |
| 17 | MOSFET | 2 |

## Literature survey

Batteries play a pivotal role across a myriad of modern applications, ranging from powering portable electronics like smartphones and laptops to propelling electric vehicles (EVs) and integrating renewable energy sources into the grid. They ensure uninterrupted power supply for critical systems in aerospace and defence sectors. As demands evolve, ongoing research focuses on enhancing energy density, safety, and lifespan Electric mobility, for example, aims to improve battery technology and expand charging infrastructure to encourage wider acceptance. Grid-scale energy storage systems are also optimizing energy usage and stabilizing power grids, while the integration of renewable energy sources necessitates efficient battery storage solutions to manage intermittency. This reliance on batteries across diverse sectors is driving continuous innovation and sustainability.

Within the realm of Battery Management System (BMS) technology, thermal management emerges as a critical facet to ensure optimal battery performance, safety, and longevity. Effective thermal control is paramount in preventing overheating, which can culminate in thermal runaway and subsequent battery degradation. Various strategies are being explored to dissipate excess heat generated during the charging and discharging processes. These encompass active cooling methods, such as liquid cooling, and passive cooling techniques, including heat sinks. Advanced thermal modelling and simulation tools further facilitate the design and optimization of BMS thermal management systems.

The integration of temperature sensors within battery packs enables real-time monitoring and control of thermal conditions, offering insights into temperature gradients within battery cells and packs.

Protection against thermal runaway remains a paramount concern in BMS design, given the associated risks such as rapid battery degradation, release of hazardous gases, and potential fire or explosion. To address this, robust protection mechanisms are being developed, encompassing both passive strategies like thermal barriers and insulating materials, and active cooling systems like liquid cooling and forced-air cooling. Integrated temperature sensors within the battery packs provide early warning signals of thermal abnormalities, facilitating timely intervention to prevent thermal runaway.

Furthermore, sophisticated thermal modelling tools aid in predicting thermal behaviour under different operating conditions, informing the design of effective thermal management strategies. The emergence of smart BMS technologies integrates predictive analytics and machine learning algorithms to anticipate thermal runaway events based on historical data and operational parameters. Proactive measures, such as adjusting charging rates or activating cooling mechanisms, can be implemented to mitigate risks.

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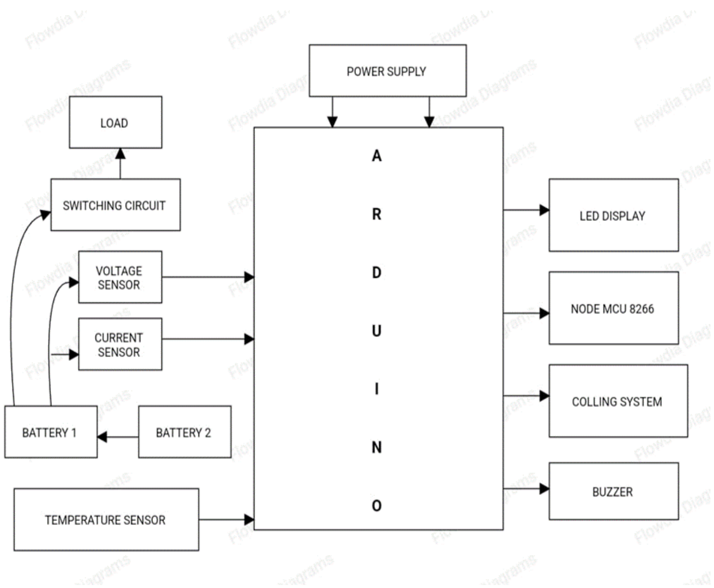
## Design Methodology

Smart battery management system design methodology involves a comprehensive understanding of battery characteristics, including chemistry, capacity, and discharge profiles. Engineers typically employ a combination of sensors, algorithms, and control systems to monitor and optimize battery performance, balancing factors like charging efficiency, lifespan, and safety.




***Temperature Sensor:***

The first component in the block diagram is the temperature sensor. This sensor continuously measures the temperature of the battery pack to ensure it remains within safe operating limits. The temperature data is then sent to the Arduino for processing and control.

***Voltage Sensor:***

The next component is the voltage sensor. It measures the battery's voltage, providing crucial information about the state of charge (SoC) and state of health (SoH) of the battery. The voltage data is also forwarded to the Arduino for analysis and decision-making.

***Current Sensor:***

The current sensor is another vital component. It measures the flow of electric current during charging and discharging, helping to monitor the battery's performance and efficiency. The current data is sent to the Arduino for real-time monitoring and control.

***Cooling Fan:***

To maintain optimal temperature conditions, a cooling fan is integrated into the system. The fan is activated by the Arduino when the temperature sensor detects elevated temperatures, ensuring efficient heat dissipation and preventing overheating. The cooling fan contributes to extending battery lifespan.

***LCD Display:***

The LCD display serves as the user interface, providing real-time data visualization. It displays key parameters such as temperature, voltage, and current, allowing users to monitor the battery's status at a glance. The LCD display is directly connected to the Arduino, which controls the data output and display updates.

***Arduino (Brain of the System):***

The Arduino serves as the central processing unit or the "brain" of the BMS. It collects data from the temperature, voltage, and current sensors, processes this data, and controls the overall system operation. The Arduino also interfaces with the LCD display to update and display the monitored parameters. Additionally, the Arduino activates the cooling fan based on temperature readings from the temperature sensor to maintain optimal temperature conditions.

***NodeMCU ESP8266:***

The NodeMCU ESP8266 acts as the communication gateway for the BMS. It is responsible for sending the collected and processed data to the IoT platform, specifically Thing Speak, for remote monitoring and data logging. The NodeMCU ESP8266 connects to the internet via Wi-Fi and transmits the data to the cloud-based Thing Speak platform at regular intervals.

***Integration and Data Transmission:***

The Arduino collects data from the temperature, voltage, and current sensors and updates the LCD display for real-time monitoring. Simultaneously, the Arduino sends this data to the NodeMCU ESP8266 for transmission to the Thing Speak IoT platform.

The NodeMCU ESP8266, with its Wi-Fi capabilities, establishes a connection to the internet and uploads the data to the designated Thing Speak channel. Users can then remotely access this data via the Thing Speak website, enabling them to monitor the battery's status and performance in real-time. (1)

## Sensors

### *4.1 Voltage sensor*

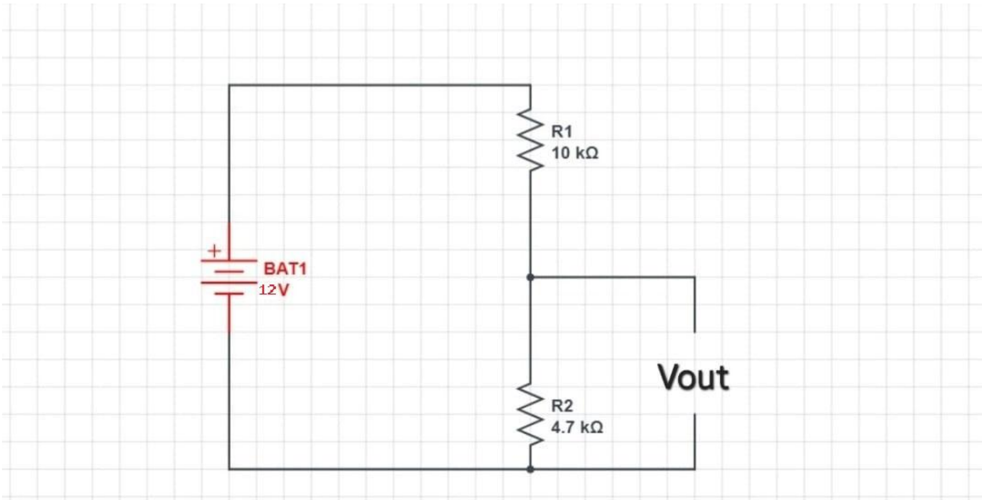



**Fig4.1 Voltage Sensor**

The voltage sensor is constructed using two resistors: a 10kΩ resistor (R1) and a 4.7kΩ resistor (R2). The voltage across the 4.7kΩ resistor is used to measure the battery's voltage.

The formula to calculate the output voltage (Vout) from this sensor is:

Vo = R2/R1+R2 * Vin

In simpler terms, you can think of this formula as determining a fraction of the input voltage (VIN) based on the ratio of the two resistors. The 10kΩ and 4.7kΩ resistors divide the input voltage, allowing us to measure a proportionate voltage that corresponds to the battery's actual voltage.

### *4.2 Temperature sensor*

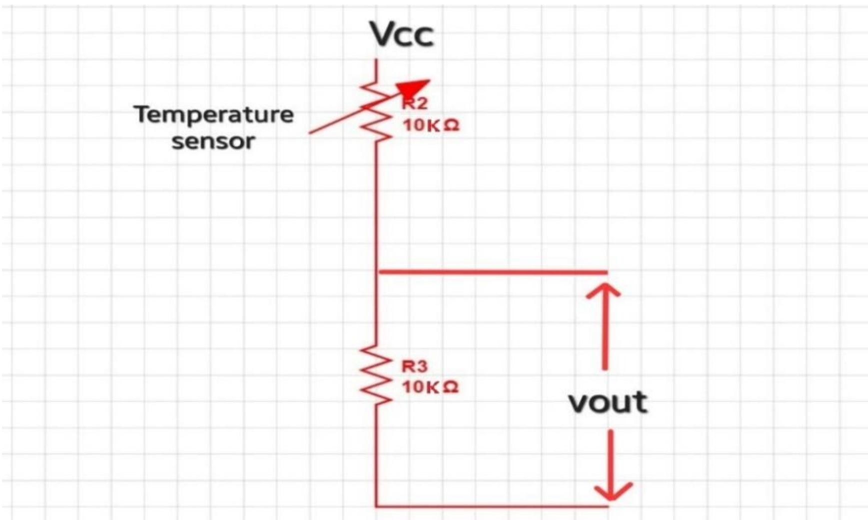


**Fig4.2 Temperature Sensor**

A thermistor is a type of temperature sensor that changes its resistance value based on the temperature. In this setup, a 10kΩ PTC (Positive Temperature Coefficient) thermistor is used.
When the temperature changes, the resistance of the thermistor changes accordingly. In this circuit configuration, the 10kΩ PTC thermistor is connected in series with another resistor (often referred to as a pull-up resistor) to form a voltage divider circuit.
basic explanation of the setup:
The 10kΩ PTC thermistor is connected in series with the pull-up resistor. This series combination is then connected between the power supply (usually VCC) and ground. The voltage across the thermistor, which changes with temperature, is measured at the point between the thermistor and the pull-up resistor. As the temperature changes, the resistance of the PTC thermistor changes, which in turn changes the voltage at the measuring point. By measuring this voltage, we can determine the temperature using a formula or calibration curve specific to the thermistor's characteristics. This setup allows for temperature-dependent voltage readings that can be interpreted to determine the temperature of the environment or object being monitored

***4.3 Current sensor***

A current sensor in a smart battery system is a crucial component that measures the electrical current flowing through the battery or the load. It helps in monitoring and managing the battery's performance, efficiency, and health.

## Technologies used in the system

### 1. Sensors:

- Temperature Sensor: Monitors and controls the battery's temperature to prevent overheating and thermal runaway.
- Voltage Sensor: Measures the battery's voltage levels to determine its state of charge (SoC) and overall health.
- Current Sensor: Tracks the flow of electric current during charging and discharging cycles to monitor the battery's performance.
- LCD Display: Provides real-time data visualization to users, showing critical parameters such as temperature, voltage, and current for easy monitoring.

### 2. Processor:

- Arduino: Acts as the brain of the system, handling overall control and data processing.

### 3. Connectivity:

- NodeMCU8266: Enables IoT connectivity by sending data to the Thing Speak website for real-time monitoring and analysis.

### 4. Battery Switching Techniques:

- Dual Battery Switching: Allows for efficient utilization of two battery packs, extending the overall battery life and optimizing energy usage.

### 5.Intelligent Battery Switching:

- Utilizes smart algorithms to switch between battery packs based on specific criteria such as SoC, ensuring continuous power supply and enhancing system reliability.

## Conclusion

In this Infero Shield Battery Management Systems (BMS) stand as crucial components in today's technological landscape, spanning across sectors like electric vehicles, industrial automation, and renewable energy systems. Their role in overseeing battery health, optimizing performance, and ensuring safety is paramount. With the integration of advanced sensors, cooling mechanisms, and IoT capabilities, modern BMSs not only enhance operational efficiency but also pave the way for predictive maintenance and remote monitoring. Their adaptability through features like multiple battery switching techniques and inverter functionality underscores their versatility, catering to the unique energy management needs of various applications. As technology continues to evolve, the significance of BMSs in ensuring reliable and efficient energy utilization across diverse industries remains undiminished.

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