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Battery Temperature Management System for EV

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Abstract: *The Heating-Cooling Unit consists of three branches to switch operating modes to cool and heat the battery. The Heater represents an electrical heater for fast heating of the batteries under low-temperature conditions. The Radiator uses air-cooling and/or heating when the batteries are operated stably. The Refrigerant system is used for cooling the overheated batteries. The refrigeration cycle is represented by the amount of heat flow extracted from the cooling liquid.*

Keywords: Refrigerant system

I. INTRODUCTION

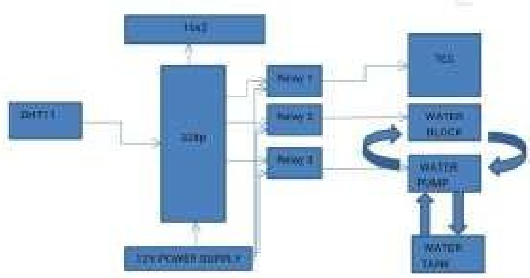
Air-cooled battery thermal management systems (BTMSs) have been developed to maintain battery modules at appropriate temperatures through design optimization, including enhanced airflow rates, spoiler structures, and improved channel shapes.

Despite these design improvements, the low thermal conductivity and uneven heat dissipation of air-cooled BTMSs remain problematic, leading to higher temperature variations between battery cells.

By contrast, liquid-cooled BTMSs have demonstrated superior cooling performance due to the high thermal conductivity of the cooling medium.

Although liquid cooling systems are commonly used for battery packs, they have drawbacks, such as their complex structure, high costs, and potential leakage problems, which may compromise the safety of the battery. Moreover, their indirect heat exchange between the coolant and surroundings may reduce heat exchange efficiency.

II. BLOCK DIAGRAM



III. COMPONENTS

USB Wire

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Data Transfer: The USB wire enables data transfer between the Arduino board and a computer, allowing for software updates, data logging, and real-time monitoring.
Power Supply: The USB wire can also supply power to the Arduino board, eliminating the need for an external power source.

Cooling Fan

Temperature Regulation: Maintains optimal battery temperature (usually between 20°C to 40°C) to ensure efficient charging and discharging.
Heat Dissipation: Removes heat generated by the battery during charging and discharging, preventing overheating.
Air Circulation: Provides airflow to prevent hotspots and ensure uniform temperature distribution within the battery pack.
Thermal Management: Works in conjunction with other thermal management components (e.g., heat sinks, thermal interfaces) to maintain optimal battery temperature.

16x2 LCD Display

Temperature Display: Shows the current battery temperature, allowing users to monitor thermal performance.
State of Charge (SoC) Display: Displays the battery's state of charge, providing users with information on the battery's energy level.
Error Messages: Displays error messages or warnings if the battery temperature exceeds safe limits or if other system faults occur.
System Status: Provides information on the BTMS's operational status, such as fan speed, cooling performance, and system alarms.
User Interface: Allows users to adjust settings, such as temperature thresholds, fan speed, and alarm configurations.
Data Logging: Stores historical data on battery temperature, SoC, and system performance for later analysis and maintenance.

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Relay

Battery Charging/Discharging Control: The relay controls the flow of electrical current to and from the batteries, enabling the BMS to manage the charging and discharging process.
Overcharge/Over-Discharge Protection: The relay helps prevent overcharging or over-discharging by disconnecting the battery from the charging/discharging circuit when necessary.

TEC (Thermoelectric Cooler)

Battery Temperature Regulation: The TEC helps regulate the battery temperature, keeping it within a safe operating range.
Heat Dissipation: The TEC dissipates heat generated by the batteries during charging and discharging, reducing the risk of overheating.
Increased Battery Life: By maintaining a stable temperature, the TEC helps extend the battery lifespan.

V. Battery without BTMS

1. Temperature Fluctuations: Batteries are exposed to ambient temperatures, which can affect performance, lifespan, and safety.
2. Reduced Efficiency: Temperature extremes can reduce battery efficiency, leading to decreased capacity and overall performance.
3. Shorter Lifespan: Temperature fluctuations can accelerate battery degradation, reducing its lifespan.
4. Safety Concerns: Extreme temperatures can lead to thermal runaway, fires, or explosions.

VI. BATTERY WITH BTMS

1. Temperature Regulation: BTMS actively regulates battery temperature, maintaining an optimal range (usually between 20°C to 30°C).
2. Improved Efficiency: By maintaining a stable temperature, batteries with BTMS operate more efficiently, retaining capacity and performance.

VII. ADVANTAGES

1. Improved Battery Lifespan: BTMS helps maintain optimal battery temperature, increasing lifespan.
2. Enhanced Performance: Optimal temperature ensures better battery efficiency, range, and acceleration.
3. Increased Safety: BTMS reduces the risk of thermal runaway, fires, and explosions.

4. Faster Charging: Temperature control enables faster and more efficient charging.
5. Optimized Energy Efficiency: BTMS minimizes energy losses due to temperature fluctuations.

VIII. DISADVANTAGES

1. Added Complexity: BTMS introduces additional components, increasing system complexity.
2. Higher Cost: Implementing BTMS adds expense to EV production.
3. Maintenance Requirements: BTMS requires regular maintenance to ensure optimal performance.

IX. APPLICATIONS

1. Electric Vehicles (EVs)
2. Hybrid Electric Vehicles (HEVs)
3. Plug-in Hybrid Electric Vehicles (PHEVs)
4. Battery Electric Vehicles (BEVs)
5. Electric Buses
6. Electric Trucks

X. FUTURE SCOPE

1. Integration with Advanced Materials: Explore the use of advanced materials with high thermal conductivity for improved heat management.
2. Artificial Intelligence (AI) and Machine Learning (ML): Implement AI and ML algorithms to optimize BTMS performance, predict battery health, and enable real-time monitoring.
3. Cloud Connectivity and Remote Monitoring: Develop a cloud-based platform for remote monitoring, data analytics, and software updates.

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