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APPLICATION NOTE 6638

CHOOSING AN ACCURATE BATTERY MANAGEMENT SYSTEM FOR AUTOMOTIVE DESIGNS

Abstract: By 2025, a quarter of cars sold will have electric engines, according to projections by industry experts. Various countries, in an effort to address the effects of pollution as well as climate change, are pushing this trend forward. This makes proper management of the vehicles' lithium-ion battery packs essential. This application note examines criteria for selecting an accurate battery management system for automotive applications. A similar version of this application note originally appeared on Electronic Specifier in its February 2018 print edition.

Introduction

The large lithium-ion battery packs that power electric, hybrid, and plug-in hybrid vehicles must operate in a difficult environment, withstanding potentially long periods of inactivity. Inside these packs are hundreds or even thousands of individual battery cells that must be precisely managed. In addition, the voltages between cells must be carefully monitored and balanced. There are some important criteria worth considering in order to promote a long lifecycle for lithium-ion batteries. Following these guidelines contribute to safe, efficient, and lasting vehicle operation, helping to extend vehicle driving range:

- Avoid charging any cell to 100% of its state-of-charge (SOC) or discharging it to 0% SOC, as both degrade capacity
- Maximize battery pack capacity and minimize degradation by accurately controlling the SOC for each cell
- Ensure that the charge level of all the cells stays within the recommended SOC range via cell balancing
- Keep a close watch on battery temperature

Figure 1. Manage vehicle lithium-ion battery packs carefully for lasting performance.

An effective, efficient way to maintain a close watch on these battery packs is by using a fast and accurate battery management system (BMS). A BMS can monitor these areas and provide real-time diagnostics to ensure proper operation of the BMS hardware and batteries. This application note examines key features to consider for an effective BMS to support your automotive application.

Important BMS Functions

Because cars are considered harsh and sometimes unpredictable environments, a BMS for a vehicle must be able to meet some demanding criteria. Above all, it must work with high accuracy and in real time in an environment where charging and discharging happens rapidly. It also must interface with various other in-vehicle systems. Voltage, temperature, and charging and discharging current are among the specs that need to be measured. Each of these factor into accurate measurements of capacity. Key BMS functions include the following:

- Determining battery pack SOC and state of health (SOH) to provide accurate predictions of vehicle range and life expectancy
- Preventing conditions that can damage the battery and lead to safety concerns for the vehicle and its occupants, such as:
    - Overvoltage, or charging at excessive currents, which is conducive to thermal runaway.
    - Undervoltage. A single overdischarge won't cause catastrophic failure but will start to dissolve the anode conductor. Repeated overdischarge leads to lithium plating (from the recharging cell) and potential thermal runaway.
    - Overtemperature, which affects the cell electrolyte material, reducing the SOC. This condition can also increase solid-electrolyte interphase (SEI) formation, resulting in increased and non-uniform resistivity and power loss.
    - Undertemperature from the deposition of lithium, which results in capacity loss.
    - Overcurrent, which is internal heating due to uneven internal impedance and eventual thermal runaway. This condition can increase the SEI layers in the battery and increase resistivity.

The BMS's two main modules are the cell-monitoring controller (CMC) and the battery monitoring controller (BMC). The CMC reports voltage and temperature data to the BMC. Communication of BMS summary data is performed by the BMC to the main vehicle electronic control unit (ECU) via a controller area network (CAN) bus. Where the CMC and BMC are located depends on the application and on whether the system is distributed or centralized. The advantages of a distributed system include reduced or eliminated cell wiring, high accuracy, a common platform design for the hybrid, plug-in hybrid, and electric vehicle systems, and hot-plug robustness. A centralized system reduces requirements on the communication interface as the communication cables are removed. It also optimizes temperature sampling via the BMC and offers potential thermal and cost optimization benefits. However, some drawbacks of the centralized approach include lower accuracy during balancing, lack of scalability, and difficulties for wire harness routing through the battery pack.

Figure 2. For optimal vehicle driving range, plug-in hybrids, as well as their hybrid and electric counterparts, need fast, accurate battery management systems.

Evaluating BMS Architectures

There are different BMS architecture types to consider. Which is most effective? An isolated CAN architecture, based on a star configuration, provides a robust option. If there's a break in the communications wire in the isolated CAN architecture, this would disrupt only one IC. The rest of the battery pack would remain safe. On the other hand, the CAN architecture does boast high bill of materials (BOM) costs, requires a microprocessor and CAN for each IC, and provides relatively slow communication speeds.

The daisy-chain architecture offers a more cost-effective option. In particular, a UART daisy chain can deliver reliable and fast communication without the complexity of CAN. By not only eliminating expensive microcontroller and CAN physical layers, a UART daisy-chain solution also is robust in noisy environments, with capacitive isolation providing further system cost benefits (even over other distributed systems using transformers). A communications wire break in the daisy-chain architecture can disrupt communication; however, some such systems do allow for various degrees of operation during the wire break as well as signaling of these conditions to avoid the system safety concerns. Yet another option combines a daisy-chain architecture with a fast successive-approximation register (SAR) analog-to-digital converter (ADC), resulting in both fast and accurate battery system measurements.

The daisy chain plus SAR ADC architecture, available in Maxim's new MAX17843 12-channel, high-voltage smart sensor data acquisition interface, delivers reliable communication within any automotive specification for centralized as well as distributed architectures. The MAX17843 provides differential UART communication, high noise immunity, capacitive and transformer isolation, and support for 100m-long daisy-chain segments. The battery management IC also provides a single-chip solution that achieves Automotive Safety Integrity Level (ASIL) D compliance. Defined by the ISO 26262 – Functional Safety for Road Vehicles standard, ASIL D represents the most stringent level. Because this IC allows you to replace the transformer with a capacitor, you can save up to 90% of your isolation BOM costs. Aside from electric, hybrid, and plug-in vehicles, a BMS can also be integrated into applications such as 48V systems, electric bikes, battery-powered tools, battery-backup systems, and high-voltage battery stacks.

Summary

A fast and accurate BMS can help extend battery life as well as vehicle driving range for electric, hybrid, and plug-in hybrid vehicles. Considering the various BMS architectures available, a daisy-chain architecture with a SAR ADC offers a good option for providing the fast and accurate voltage measurements that are integral to safe, reliable performance of these vehicles.

Sources

http://www.mpoweruk.com/bms.htm

Related Parts		
MAX17843	12-Channel, High-Voltage Smart Sensor Data-Acquisition Interface	Free Samples

More Information
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