BROADCOM®

White Paper

Improve Lithium-Ion Battery-Stack Safety in Electric Vehicles by Leveraging Optocouplers to Isolate High Voltages

Andy Poh, Product Marketing Manager, Broadcom, Inc.

Introduction

There are many challenges associated with high-voltage Li-ion battery-stack management in all-electric or hybrid automotive applications. Charge and discharge cycles must be monitored and controlled, and the battery stack, which often delivers voltages of several hundred volts, has to be isolated for safety concerns. In particular, this paper will examine the requirements for Li-ion cell monitoring, and review the architecture and components used in the cell-monitoring subsystem, digital-communications subsystem, and isolation interface.

Within the management system, the battery-monitoring boards use two key subsystems to reliably monitor cell health and deliver digital results to a host processor that orchestrates system operation. Separating those subsystems is a signal interface using optical isolation between high-voltage battery-sensing circuitry and communications devices on the boards, which ensures that the high voltages will not compromise the digital subsystem.

Li-ion Cell Characteristics

The sophisticated electronics system required to meet EV performance, safety, and reliability requirements is basically derived directly from the characteristics of Li-ion cells. In a discharging Li-ion cell, lithium is ionized in a (typically) graphite anode, and the Li ions move through an electrolyte to pass through a separator to a cathode, resulting in charge flow. The charging process reverses the flow, bringing Li-ions from the cathode through the separator to the anode.

The performance and reliability of this chemical process are dependent on cell temperature and cell voltage. At low temperatures, the chemical reaction slows, lowering cell voltage. As temperature increases, the reaction rate increases until the Li-ion cell components begin to break down. At temperatures above 100°C, the electrolyte begins to break down, releasing gases that can cause pressure to build within cells designed without pressure-relief mechanisms. At high enough temperatures, Li-ion cells can experience thermal runaway as oxides break down, releasing oxygen, which further accelerates the temperature increase.

Consequently, maintaining optimum operating conditions for Li-ion cells is a critical requirement for the battery-management system. The challenge in designing the control/management system is ensuring reliable data collection and analysis to monitor and control the state of the Li-ion cells in the vehicle-a problem exacerbated by the nature of Li-ion cells themselves.

In an EV, such as the Chevy Volt, the battery pack contains 288 prismatic Li-ion cells, which are, in turn, divided into 96 battery-cell groups that are connected to deliver a system voltage of 386.6V DC. Those battery-cell groups, in turn, are combined with temperature sensors and cooling elements into four main battery modules. Voltage-sense lines attached to each cell group terminate in a connector on top of each battery module, and a voltage-sense harness joins the connector to a battery-interface module that sits on top of each battery module. Here, four color- coded battery interface modules operate at different positions in the battery stack, corresponding to low-, medium-, and high-voltage ranges of DC voltage offset for the set of four modules.

To read the whole whitepaper,
please register **here**.