Top Three Design Considerations for Battery Management in Electric Vehicles

By Gary MacDonald, Intersil Corporation

Designing battery management systems (BMS) for electric vehicles (EVs) is one of the more complex design challenges facing engineers, and the most important design consideration is BMS IC selection. That's because distributed powertrain battery systems require a robust communications architecture to mitigate the many ways transients can be introduced into the system. Engineers must also give careful consideration to printed circuit board (PCB) layout and other implementation techniques to deliver efficient system performance.

This article examines the top three BMS design considerations, including a close look at battery pack architectures, inter-module communications or daisy chaining BMS modules, and the optimum PCB layout configuration.

Battery Pack Architectures

First, we will review typical EV battery pack architectures. High voltage battery packs for electric vehicle drivetrain applications typically comprise a number of discrete cells, which are configured, or "stacked" into blocks to form the battery. These blocks are connected to each other in various series and parallel combinations to achieve the required terminal voltage and energy rating. Each individual block of cells in the stack is managed by a battery control module, which typically incorporates a battery management IC to handle cell control, monitoring and balancing functionality. The modules are connected or "daisy chained" to each other and back to the vehicle control system using interconnecting communications cables (see Figure 1).

These cables carry the communications required between the modules for optimal and safe battery operation; however, they can be susceptible to general electrical switching transients. This includes (but is not limited to inverter and battery charger switching noise) externally generated EMC/EMI and other electrical disturbances. Similarly, in a centralized battery management system, where all control electronics are incorporated onto a single PCB, communication occurs between individual BMS ICs using copper tracks. Copper PCB tracks, being fixed in position, are typically more easily controlled and communications distances can be kept to a minimum; however, the PCB still requires careful design, track routing, and component placement and selection.

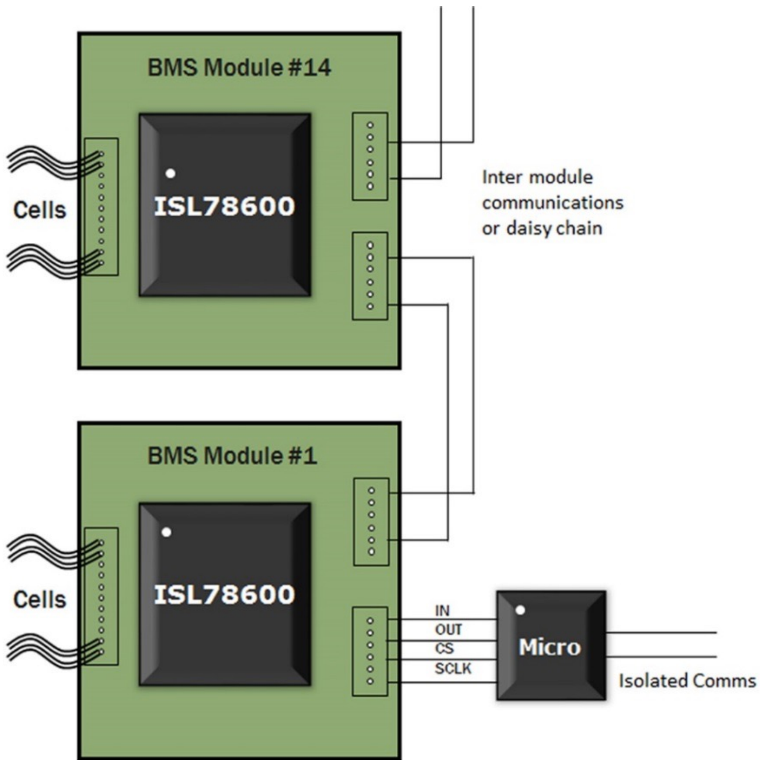

Figure 1. Multiple BMS modules can be daisy chained to each other and back to the vehicle control system.

Inter-module Communications

The method of inter-module communications, or daisy chaining, is a critical design consideration, particularly for the selection of the battery management IC. The IC must support protocols that meet stringent safety, regulatory and communication integrity standards and address the extremely hostile under-the-hood environment where the modules are exposed to significant transients and stresses that can disrupt communications.

Inter-module communications can be implemented using a range of automotive standard topologies and protocols, such as SPI or CAN. Regardless of the topology employed, all require some form of electrical DC isolation between the “hot” high-voltage domain and the “cold” low-voltage or vehicle-chassis-voltage domain. This isolation can be realized using digital techniques; however, digital isolators require a complementary power supply and can be relatively expensive.

A cost effective alternative are solutions offered by a number of vendors that use proprietary communication protocols specifically designed for EVs. DC isolation is achieved using capacitors, transformers or a mixture of both. There are two basic techniques used to implement proprietary communication schemes, voltage-mode and current-mode voltage. Voltage-mode utilizes a low impedance transmitter and high impedance receiver, which has good transient immunity but is susceptible to EMI/EMC. Current-mode, on the other hand, uses a high impedance transmitter and low impedance receiver. It is less capable than voltage-mode schemes at handling transients, but has good EMI/EMC immunity.

The ability to handle transients is critical. Even at the battery assembly and testing stage there are significant transients and stresses to consider, as they can disrupt communications, or even cause damage to parts on the PCB that are not optimized or properly protected. Assembly and test transients are typically caused by “hot plugging”, the point at which the cell strings or communications lines are connected to the battery management module or the inter-module communication cables are plugged together. Significant energy levels can be present at this stage and cell connection sequencing can be random and highly unpredictable. As a result, the connected circuit must be able to handle this, and the system design should incorporate suitable external protection components.

There are a number of options for battery management ICs in EV applications. For example, Intersil's ISL78600 battery management IC incorporates a proprietary communication protocol that consists of a symmetrical, two-wire, bi-directional, asynchronous daisy chain (see Figure 2). By using capacitive source and load characteristics, the ISL78600 combines the best of both voltage and current-mode schemes, giving optimal transient and EMI/EMC immunity. Low-cost capacitive coupling provides isolation and in distributed systems, the connection wiring can be a simple unshielded twisted pair (UTP). Up to 14 battery management modules can be daisy chained together to realize battery systems of up to 168 cells.

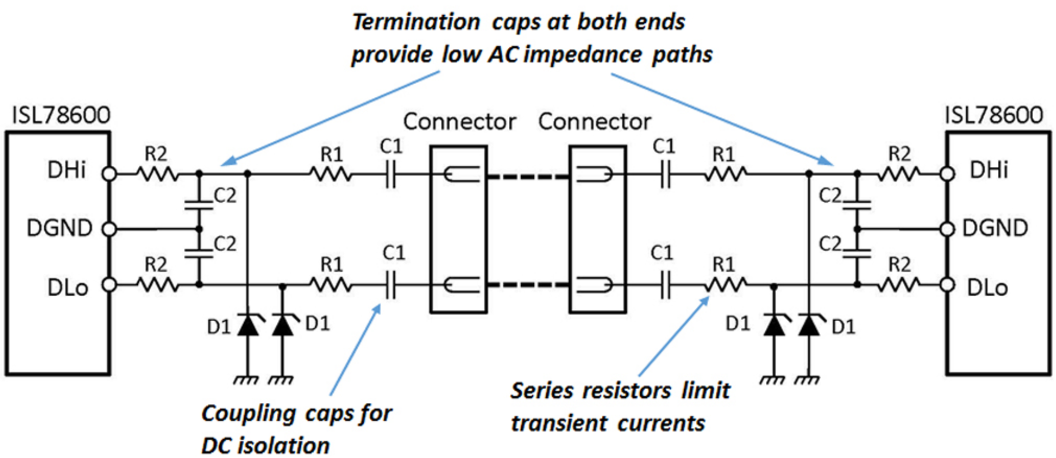

Figure 2. The ISL78600 provides optimal transient and EMI/EMC immunity.

The ISL78600 demonstrates the benefits of a proprietary communications protocol designed specifically for EMC/EMI, hot plug immunity and to handle the other high-speed, high-energy transients experienced in EVs, plug-in hybrid electric vehicles (PHEVs) and hybrid vehicles. It requires only low-cost, twisted pair cabling between the modules, and minimal external components. It is suitable for use where the highest levels of communications integrity (stipulated by the ASIL standards committee) is required and optimizes the system designer's' ability to meet targeted ISO26262 functional safety requirements. The proven ISL78600 meets and exceeds the most difficult hot plug and EMI requirements, including the stringent EMC evaluation stipulated by automotive OEMs. The EMC standard focuses on CAN transceivers and the extended hardware requirements for LIN, CAN and FlexRay interfaces in automotive applications.

Don't Forget About PCB Layout and Configuration Considerations

To mitigate the possible effects of hot plug transients, careful PCB board layout, critical part positioning and suitable protection should be factored into the design (see Figure 3). Battery management ICs are precision parts, so using standard precision handling-and-assembly techniques can eliminate many potential issues.

Careful routing of tracks reduces the opportunity for transient-induced circulating currents to cross the PCB, and placing sensitive parts like the battery manager IC well away from the potential paths of transients all serve to reduce their possible effects. It is recommended to design with high quality multilayer PCBs, with at least one of the layers dedicated as a continuous ground plane. Keeping battery interface connectors close to each other and making track routing short maximizes the opportunity to contain circulating current (caused by hot plug events) within the battery connector's immediate location.

Additionally, the use of Zener diode protection devices, particularly across the communications interface, offers simple, cost-effective and efficient clamping of both +Ve and -Ve transients induced in the communication interface cabling. These protection devices should be placed close to the cable termination points on the PCB.

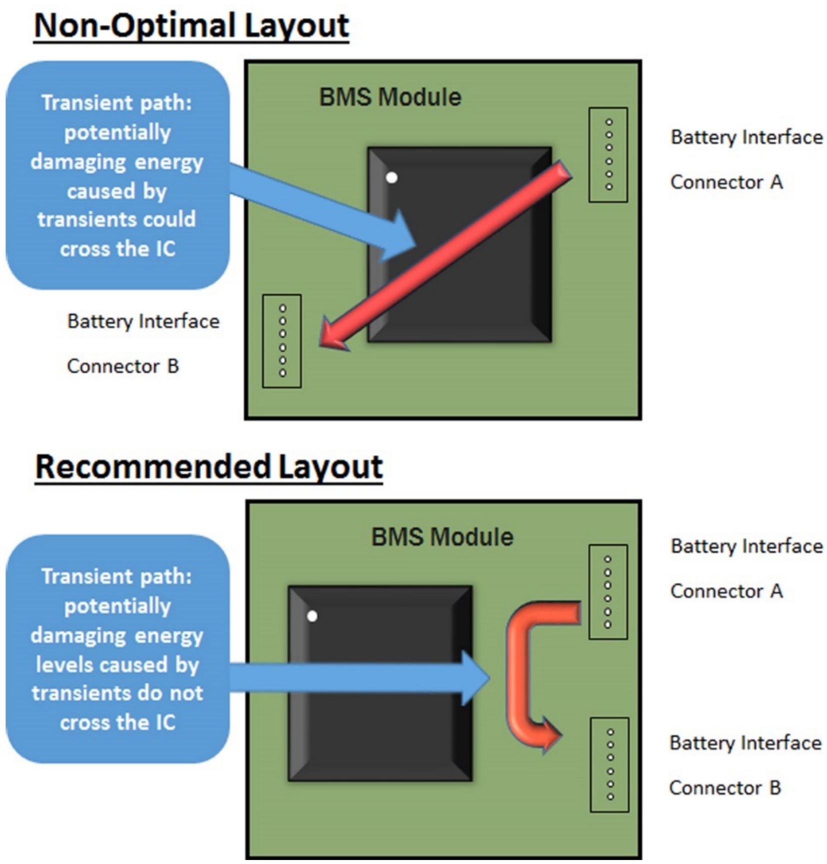

Figure 3. Careful PCB board layout will mitigate hot plug transients.

Conclusion

Battery management design for electric and hybrid vehicle systems requires careful selection of the right battery management solution, including support for the inter-module communication protocol and a thoughtful PCB layout. This will ensure the system provides the best possible performance, and consistently reliable performance over time.

References:

Find out more about Intersil's battery management solutions at www.intersil.com/battery-management.

About the Author

Gary Macdonald is a Senior Strategic Marketing Manager for Precision Products at Intersil Corporation. He is responsible for developing and driving strategic plans and product roadmaps for Intersil's Multi Cell Balancing products for automotive applications. Prior to joining Intersil, he was a Senior Manager for Energy Technology Commercialization at Scottish Enterprise, and CEO and co-founder of Xipower, Ltd. Mr. Macdonald holds a B.Sc. in Computing & Electronic Technology and an Executive MBA from the University of the West of Scotland.