

## PXI and Electric Transportation

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Pickering Interfaces

As we start the second decade of the 21<sup>st</sup> century, it is clear that the transportation scene for most people in the world is changing and may change drastically. With depleting petroleum stocks and leaks in the Gulf, the next big “thing” in personal transportation will likely be electric vehicles, be they a shuttle cart at a resort, warehouse forklifts/order pickers, hybrid vehicle systems, or a full electric vehicle – even the subway trains are electric! JD Powers predicts that hybrid vehicle production for the US market will exceed 1.4 Million vehicles by 2015. Add to that the electric vehicles on resorts, in distribution centers, and under the city as well as devices like the Segway™ and you’re talking a lot of batteries to charge and move us!



**Electric Vehicle**

This paradigm shift in transportation technology calls for advances in power systems and the ATE systems that make sure it all works before you step on the accelerator. Fortunately for the Test Engineering community, PXI is up to the task. Let’s look at some of key electronic systems and the ways PXI is used in test in Electric vehicles.

### **Battery Charging Systems**

The auto industry has embraced the use of Lithium Ion Batteries for most future Hybrids and Plug-in Hybrids. This battery requires a carefully designed charging system to provide long life and safety; which means that one of the major challenges to be tackled in electric vehicles concerns the effective testing of the Battery Management System (BMS) – the electronics that manage the state of the batteries that store the high levels of energy required to propel the vehicle.

The BMS is a critical component of Hybrid-Electric Vehicle (HEV), Electric Vehicle (EV), and Plug-In Hybrid Electric Vehicle (PHEV) electric drive systems. A typical BMS controls all functions of the Energy Storage System (ESS), including battery pack voltage and current monitoring, individual cell voltage measurements, cell balancing routines, pack state of charge calculations, cell temperature and health monitoring, as well as ensuring overall pack safety and optimal performance.

The BMS modules and related sub-modules must read voltages from the cell stack and inputs from associated temperature, current and voltage sensors.

From there, the BMS must process the inputs, making logical decisions to control pack performance and safety, and reporting input status and operating state through a variety of analog, digital, and communication outputs.

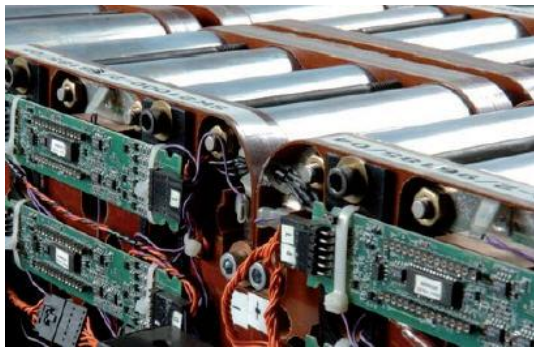
Effective testing of a BMS system involves two primary functions, (1) accurately simulating the required sensors and battery cell stack inputs to the BMS, and (2) measuring, collecting, and processing the digital and analog outputs produced by the BMS system as a result of those inputs.

Clearly, this is important technology, both for battery life and Vehicle/Passenger Safety. So where does PXI fit in? Let’s look at some areas.

## PXI Testing BMS Functions

Several PXISA members offer switch modules that have the performance needed for the high voltages – 300 volts plus – in the battery stacks. This switching would be used to verify isolation between critical components and load switching.

Of course, it is not practical to have a battery stack next to every test station. First there is the size and cost. Second, you cannot easily make a battery simulate a known bad situation. For those kinds of tests, you need to simulate certain conditions. Lithium-ion batteries have a nominal open-circuit voltage of 3.2 V and a typical charging voltage of 3.6 V. Lithium nickel manganese cobalt (NMC) oxide cathode with graphite anodes have a 3.7 V nominal voltage with a 4.2 V max charge. A typical battery stack in an automobile will use approximately 100 cells in series capable of generating voltages to over 350V.



**Typical Battery Stack**

High voltages allow energy to be transferred to the drive system with thinner wires and lower losses than would be the case with lower voltage systems. But high voltages need careful management if damage to electronic systems is to be avoided. Testing and validating new BMS systems on a real battery stack is not a practical solution because the consequences of an error are likely to result in significant damage to either the BMS or the battery stack, and could hurt the test operator as well. For obvious reasons, the test cannot be repeatedly run with this configuration. Only when confidence is high can the BMS be connected to a real battery stack. The second problem is that faults and the characteristics of a real battery stack cells cannot be varied to simulate all of the conditions the BMS is designed to handle. Injecting faults, especially in development and NPI can be crucial to successfully validating hardware and firmware designs.

Fortunately, one of the PXISA Members has developed a battery simulator that could be used to simulate a low power battery stack for the purpose of validating the BMS design. The battery stack had to be fully programmable for output voltage for each cell, and the stack had to be capable of both sourcing current and sinking current (the charging state).

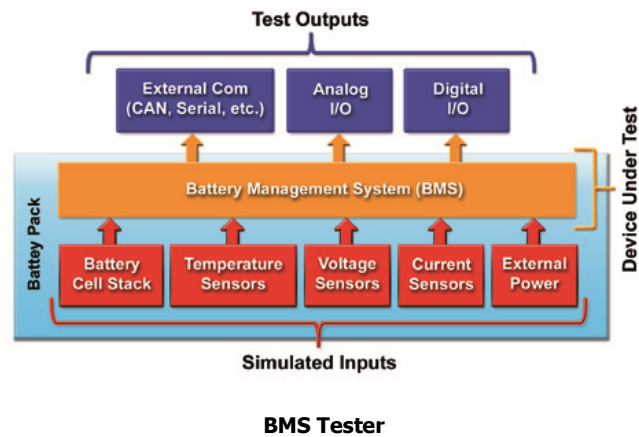


### Battery Simulator Chassis

Each channel has to be capable of providing up to 300mA and generate voltages in excess of 4.2V for each cell, which was a significant challenge for the chassis backplane to provide enough power for each slot and for the system as a whole – keep in mind we also need fast transient response to simulate a battery response to a load.

Safety and isolation also presents significant design challenges. In a battery stack, the 100 cells are connected in series. If each cell is set to its nominal 4.2V output voltage, the result is a potentially lethal output voltage. The isolation barrier has to be designed to withstand up to more than double of the common voltage on each cell and yet still have programmatic control of the battery cell. The module design used digital isolators to provide the control interface to the PXI backplane. And, a safety interlock system was defined that allows the user to connect the modules in such a way that if that user disconnects the cable assembly from the front of the PXI module, either that module or all the modules in the system would close down.

So that solves the Battery test functions. For other areas of test, sensor emulation modules can help simulate the BMS monitoring of the temperatures of the many battery cells that make up a stack. These sensor emulation modules simulate temperature monitors in the stack and high density switch matrices are used to inject signals, faults, and monitor the UUT's response. Add to that CAN communication modules to query the BMS and run diagnostics as well as DMMs for voltage checks, and you have a complete test system in PXI! In addition, the small size of PXI test systems makes it more convenient to use them in areas such as environmental chambers, that require the systems to be as close as possible to the UUT during development and HALT/ HASS testing.



## **Conclusion**

As emerging technologies call for new test techniques, the PXISA community will clearly be ready with solutions. Just as PXI has been used for Automotive Applications in the Internal Combustion Engine arena for over 10 years, PXI will be addressing the testing needs of the Electric Transportation Industry for years to come.