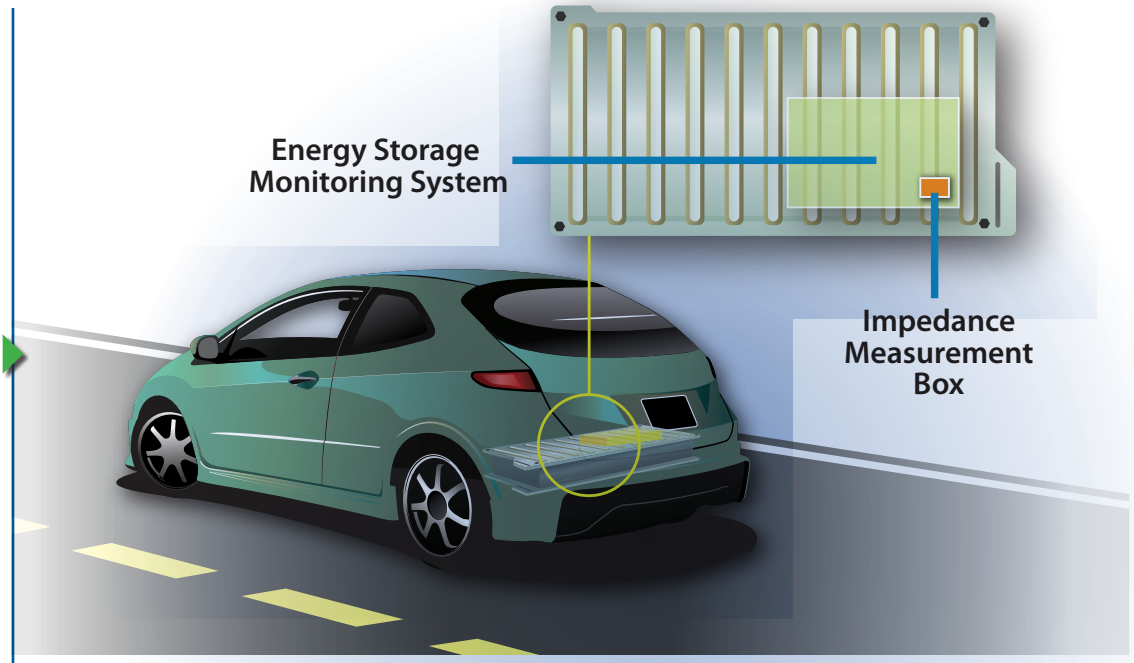
Accurately evaluating the health of a battery in operation is a crucial enabling technology, especially for electric vehicles. INL engineers and collaborators have invented the Impedance Measurement Box (IMB), which directly measures battery impedance and permits assessment of resistance and power degradation. Combining IMB with other capabilities will soon deliver a more accurate onboard battery status monitor.



Impedance Measurement Box

Working toward an Energy Storage Monitoring System

Energy storage devices, primarily batteries, are now more important to consumers, industries and the military. With increasing technical complexity and higher user expectations, there is also a demand for highly accurate state-of-health battery assessment techniques.

State of the Technology

The challenging nature of assessing the health of batteries has defied an industry standard. Presently, embedded monitoring techniques tend to rely upon passive monitoring of voltage and current, and often temperature. Monitoring strategies based on these techniques leave a vulnerable knowledge gap by ignoring key elements of battery health – pulse resistance and power capability – which would provide a much more accurate picture of health and remaining service life. This has been a very challenging and difficult problem to solve, until now.

Impedance Measurement Box

The Impedance Measurement Box (IMB) delivers a complete solution to this knowledge gap with a simple, sophisticated and well-engineered solution. It offers an innovative breakthrough in solving this complex problem by directly measuring impedance during battery operation, a never-before-accomplished electrical engineering feat. Impedance is the opposition to the flow of alternating electrical current and is a key performance measurement that correlates with more difficult parameters, such as resistance and power capability.

IMB incorporates patented, proprietary, and tested capabilities using control software and hardware that can be part of an embedded monitoring system. IMB directly measures the wideband impedance spectrum in seconds during battery operation with no significant impact on service life. It also can be applied to batteries prior to installation, confirming health before entering active service, as well as during regular maintenance.

The IMB diagnostic tool uses five key steps to obtain the vital impedance spectrum measurement results. First, an input signal is generated that consists of sinusoids, which are strategically separated by a known frequency spread and summed together. This combined signal is injected into the energy

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storage device (e.g., battery). Then, the response is captured by an appropriate data acquisition system for the final steps, data processing and analysis, and display.

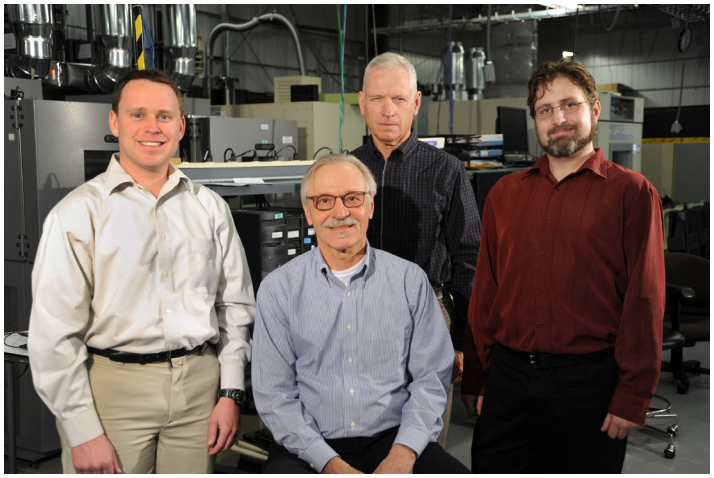
Up to this point, standardized impedance measurement techniques required expensive and delicate laboratory equipment, which precluded integrating evaluation of batteries in place. A progressive series of techniques were developed to rapidly measure the impedance using hardware that can be part of an embedded monitoring system. These capabilities include Impedance Noise Identification (U.S. Patent No. 7,675,293 B2), Compensated Synchronous Detection (U.S. Patent No. 7,395,163 B1) and Fast Summation Transformation (U.S. Patent Application No. 12/217,013). A combination of these advancements is undergoing long-term demonstration testing at the U.S. Department of Energy's Idaho National Laboratory (INL) Energy Storage Technology Laboratory in Idaho Falls, Idaho.

Developing an Energy Storage Monitoring System

Scientists and engineers from the INL, Montana Tech of the University of Montana and Connecticut-based Qualtech Systems, Inc. are collaborating on the development of an Energy Storage Monitoring System (ESMS). This new monitoring system will provide reliable and accurate state-of-health assessments for multiple industries, including automotive, military, space, medicine, electric utility applications and some consumer electronics. The ESMS will be an online, or in-situ, system that incorporates passive and active measurements combined with models and expert learning software tools to estimate health and remaining useful battery life. This new monitoring technology also will work with other energy storage devices, such as fuel cells and ultracapacitors.

Collaborative Effort

Each collaborator on the research team contributes an expertise unique to its proprietary technologies. When combined, their efforts make it possible for the monitoring device to reveal the qualitative data needed to understand battery health. INL adds its expertise with battery testing, data analysis and diagnostics, and prognostic modeling in support of electric vehicles. Montana Tech contributes its signal processing capabilities, and Qualtech offers expertise with diagnostic modeling software tools. In October 2010, IMB was demonstrated for major electric vehicle manufacturers, and they expressed interest in the technology.



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