Wireless Battery Management System for Safe High-Capacity Li-Ion Energy Storage

Technology Development Team: LLNL: Joe Farmer, John Chang, J. Zumstein, J. Kotovsky, E. Zhang
EPT-Yardney: G. Moore, A. Dobley, F. Puglia,
Others: S. Osswald, K. Wolf, J. Kaschmitter, S. Eaves, T. Bandhauer
And we'd like to thank ARPA-E AMPED Management: Patrick McGrath, Russel Ross, Kevin Thompson and Ilan Guir

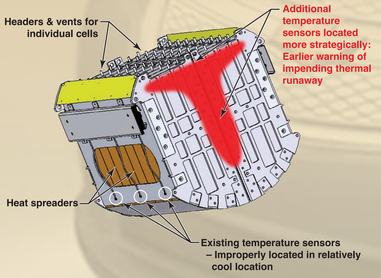
MISSION

Technology has been developed that enables monitoring of individual cells in high-capacity lithium-ion battery packs, with a distributed array of wireless Bluetooth 4.0 tags and sensors, and without proliferation of extensive wiring harnesses. Given the safety challenges facing lithium-ion batteries in electric vehicle, civilian aviation and defense applications, these wireless sensors may be particularly important to these emerging markets. These wireless sensors will enhance the performance, reliability and safety of such energy storage systems.

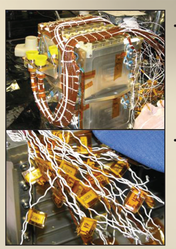
Why is new ARPA-e technology important

Enhanced saftey is crucial

Temperature sensors needed at more strategic locations



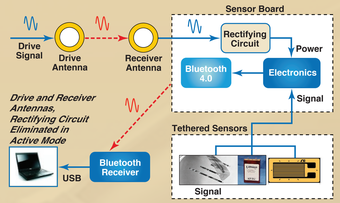
More sensors needed without proliferation of wiring harness



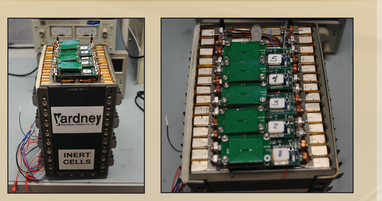
- Our visionary concept
  - Earlier detection
  - More sensors
  - Fewer wires
  - Remote monitoring
- Yardney Technical Product's 2.5 kWh Li-Ion battery pack for NASA's Mars Science Laboratory requires massive wiring harness

New wireless BMS technology

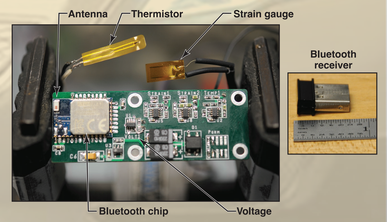
Bluetooth wireless BMS concept



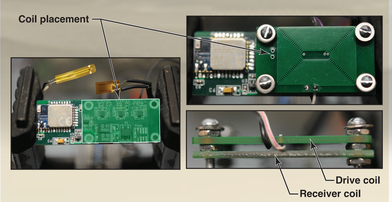
Both passive & active wireless sensors successfully demonstrated



LLNL's wireless BMS technology: Anatomy of prototypical sensor tag



LLNL's wireless BMS technology: Integration of tag & dual coils

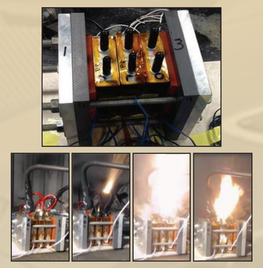


Testing wireless systems at Yardney

Sensitivity Testing

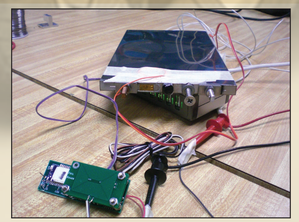
- Multiple Sell Packs
- Distance and Accuracy

Overcharge Test Monitoring with Wireless Sensors



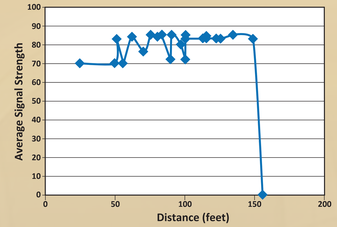
Interference tests with energized Battery Management System (BMS)

Testing strain gauges during pressurization & burst tests

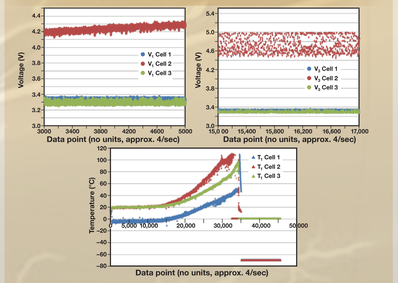


Sucessful demonstration of technology

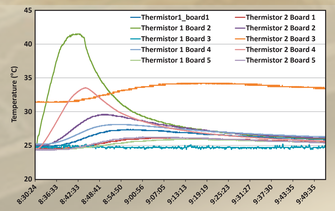
Wireless Sensors in Cell Packs Signal Strength by Distance



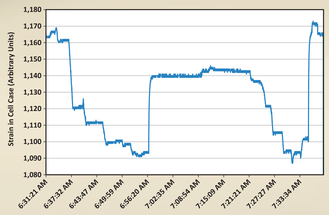
Overcharge Test Data from Wireless Sensors



Passive RFID temperature sensor localized heating test with Li-Ion battery simulator



Passive RFID strain sensor for Li-Ion cell case strain sensor 1 board 1

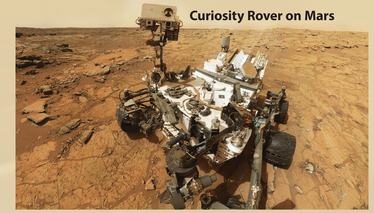


T2M plan involves early-adopter applications

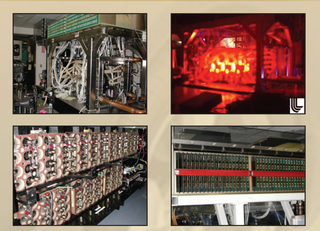
Wireless BMS tech-to-market plan: Possible early adopter applications

- Early adopters in Aerospace & Defense
- Advanced applications in civilian aviation
- UPS, grid & test equipment applications
- Automotive applications (EV, HEV & SLI)

Curiosity Rover on Mars



Early adopters in defense



Early adopters in transportation

EaglePicher/Yardney 6T Military Battery

eNow Technology Wireless Sensors on a Battery supporting a Refrigerated Truck

Our vision for Next-Generation

Today's Wireless Sensors

- Cell potential
  - Terminal
  - Internal reference electrode
- Cell temperature
  - External
  - Internal temperature sensor
- Cell strain
  - Infer internal pressure
- Emission sensors
  - Acoustic
  - Optical

Tomorrow's Wireless Control

- Enable high-fidelity balancing of individual cells
- Distributed wireless low-drain switches for control of current flow to each cell based upon sensed voltage
- Distributed wireless low-drain operational amplifier circuits to charge each cell with potential control

P1195464_pstr_Chang

LLNL-POST-645550

Lawrence Livermore National Laboratory · arpa·e
National Ignition Facility · Lawrence Livermore National Laboratory · Operated by the US Department of Energy
This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.
Yardney TECHNICAL PRODUCTS INC · EaglePicher Technologies, LLC An Oak-J Company Yardney Division · NIF