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

Battery Management System with Distributed Wireless Sensors
ARPA-e AMPED Program Review
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- Naval Post Graduate School
- Naval Facilities Engineering & Expeditionary Warfare Center
- McClellan Nuclear Research Center
- Polystor Energy Corporation
- Eaves Devices
- Colorado State University

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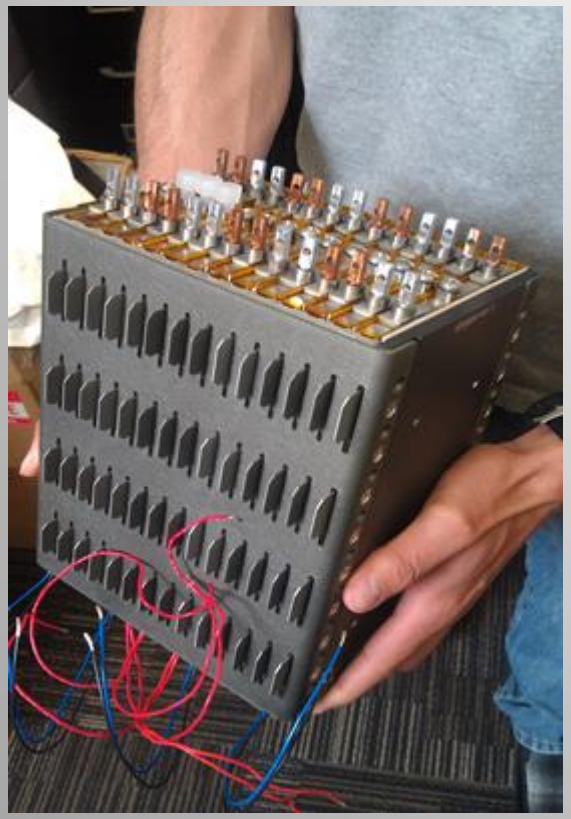
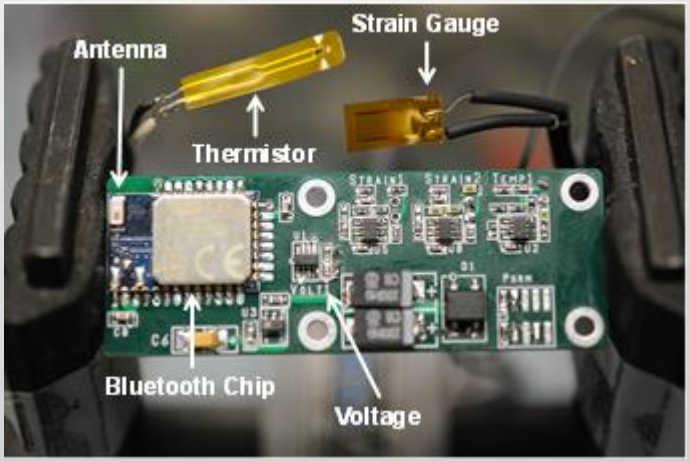
Technology Summary & Value Proposition
Description of Technology

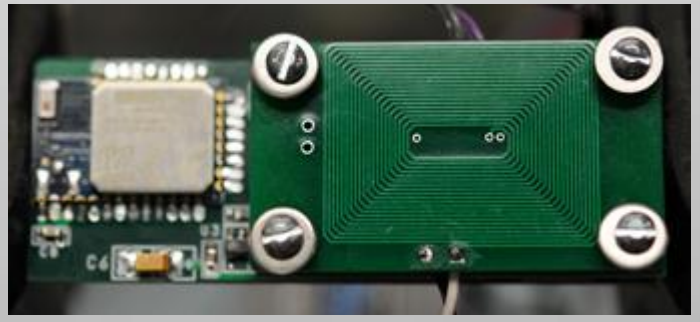


Safe development expedited with realistic and controllable YTP 7S2P battery simulator



Active operation with power from battery posts … single pair of wires used to monitor cell voltage & provide power to tag and sensor suite

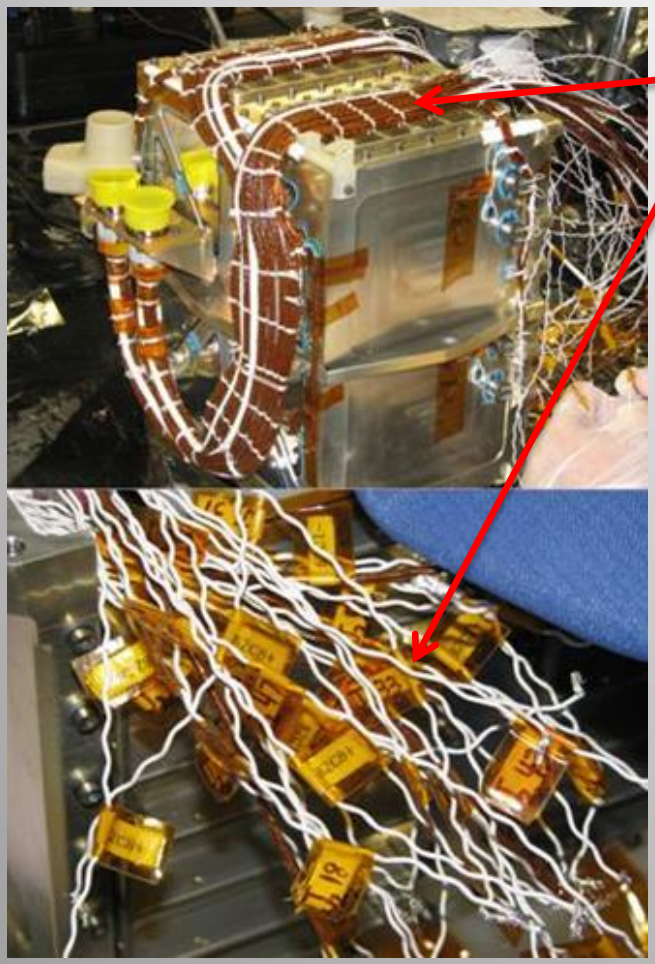
Bluetooth 4.0 USB Receiver



Passive operation with power from RF drive coil … tag & sensor suite continue to operate even if battery disabled

World's first demonstration of wireless BMS technology by ARPA-e AMPED LLNL-YTP Team

Technology Summary & Value Proposition Advantage Over State-of-the-Art



Yardney Technical Product's 2.5 kWh Li-Ion battery pack for NASA's Mars Science Laboratory requires massive wiring harness

Our new vision for wireless BMS technology

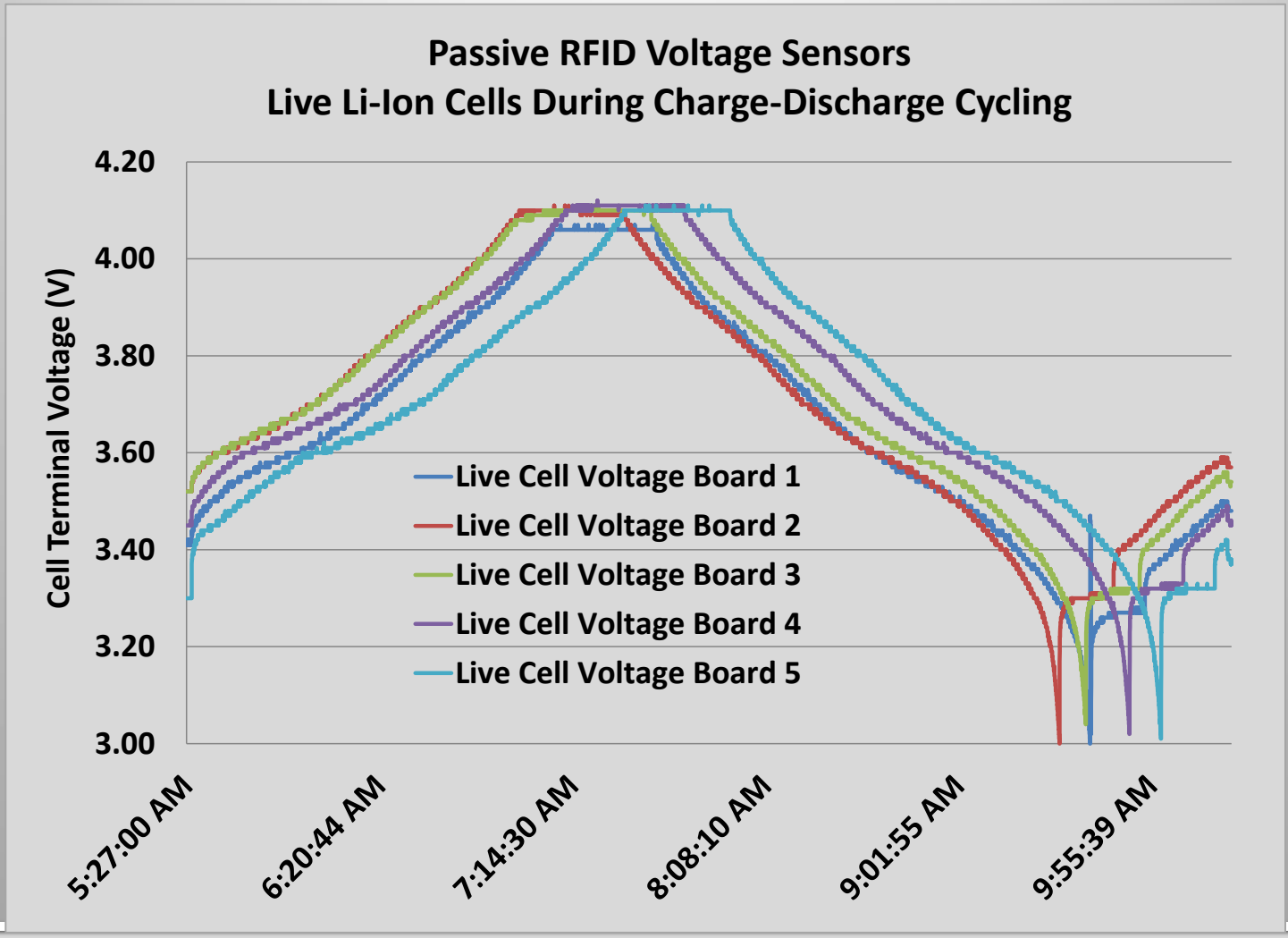
- **Cell-level monitoring and communication, from the factory, to incorporation into multi-cell pack, to reclamation and recycle**
- **Improved control for longer cell life and better battery pack performance**
- **Early warning of catastrophic thermal event in cell responsible for initiation … provide sufficient reaction time for intervention**
- **More sensors with fewer wires**
- **Increased reliability and safety**

New wireless BMS technology has been realized, with the intellectual property protected for DOE and now available for licensing

Validation Plan & Performance Targets
Major Interim/End Milestones

- Milestone 1: Develop Individual Wireless Sensors & Tags Capable of Being Operated in Either Passive or Active Mode
  - *Wireless Sensors Developed with Active & Passive Modes Demonstrated*
- Milestone 2: Integrate Distributed Array of Wireless Tags & Sensors with Multi-Cell Li-Ion Battery Pack; Develop BMS Capability to Communicate with Distributed Array
  - *Integrated Sensors Into Battery Simulator & Live Battery Pack*
  - *Integration of Wireless Communications Into YTP BMS During 2014*
- Milestone 3: Demonstrate Wireless Tags & Sensors & Conduct Comparative Studies; Create First International Standard for Wireless BMS Systems
  - *Demonstration of Wireless Tags & Sensors & Initial Studies Completed*
  - *Initial Work on Preparation of Standard for Wireless BMS*
- Milestone 4: Technology-to-Market (T2M) Plan & Analysis & Evaluate Cost Reduction Strategies Involving ASIC
  - *Comprehensive T2M Plan Developed*
  - *Protection of Intellectual Property & Initial Licensing Discussions*

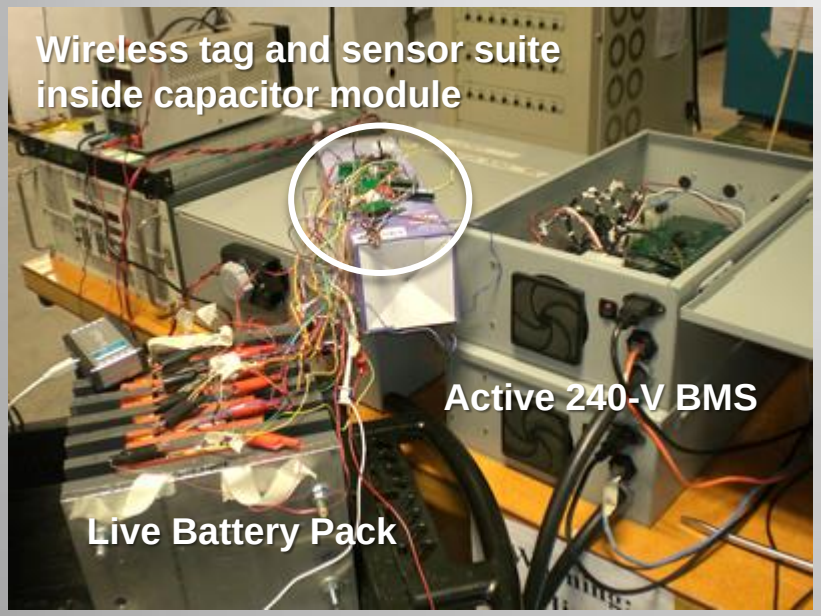
Key Interim Learning & Results
Compelling Data & Performance



Key Interim Learning & Results Compelling Data & Performance

Pulsed power system with 192 capacitor modules, each consisting of twenty 22-kV capacitors. Energy is stored for 60 seconds and then released in 400-microsecond burst, with a peak current in excess of 100 million amperes, and a peak power in excess of one terawatt — more power than the entire United States uses in that same fraction of a second. Current pulses are delivered via more than 150 kilometers of high-voltage cable.

Wireless transmission of secure encrypted data, immune to noise in harsh EM environments



Successful testing of wireless tags and sensors with active 240-volt BMS demonstrating no significant interference

Successful testing of wireless tags and sensors inside active 22-kV capacitor module successfully transmitting data to monitoring station during charge and discharge

Uniqueness: How Technology Differs From & Represents Enhancement Over State-of-the-Art

Attribute	Wired Sensors	Wired Multiplex	Wireless Sensors
Number of Sensors Practical	Low	Increased	**High**
Number of Wires Required for Sensors	High	Reduced	**None**
Immunity to Single-Point Sensor Failure	No	No	**Yes**
Continuous Cell Monitoring Over Entire Life Cycle	No	No	**Yes**
Wireless Inventory Control Enabled	No	No	**Yes**
Reliability Enhancement	No	Yes	Yes
Safety Enhancement During Pack Assembly	No	No	**Yes**
Safety Enhancement During Pack Operation	No	Yes	Yes
Useful for Controlling Cell-Level Cooling	No	Yes	Yes
QA Records Travel with Individual Cell	No	No	**Yes**
Cost	Low	Modest	Modest

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