Designing with Lithium-ion Batteries: An Engineering Perspective

Abstract:

The Lithium-ion chemistry is being adopted rapidly by new sectors of the electronics and electrical industry with the automotive sectors being the latest markets to move towards using Lithium-ion as a power source. Low cost, high energy density, high reliability and low weight are all features commonly listed as reasons that have made various industries move away from Nickel based chemistries (NiCad and NiMH) towards Lithium-ion over the past decade. However, the speed of adaptation of this technology has varied by industries. While the consumer electronics industry has been quick to transition almost completely to using Lithium-ion as an energy storage medium, other industries such as the medical electronics industry has been a slower adapter. Part of the reason for the reluctance by certain industries may be that although Lithium-ion batteries are highly reliable, they do have some unique failure modes. Under rare circumstances, Lithium-ion batteries can go into thermal runaway. For this reason various design topologies and comprehensive battery management systems are implemented to manage the battery and ensure its operation within the lithium-ion cell's reliable range. The control topologies are application specific and generally utilize safety circuits with multiple levels of safety redundancy to ensure that the cells operate within their rated specification. As such, the designer of the energy storage system in an application utilizing lithium-ion batteries usually takes a system level approach to the design. With device form factors and size requirements varying by industries, a system level approach to the design ensures that all required safety features work as intended providing adequate levels of protection to the Lithium-ion cells in the battery pack.

During this four hour tutorial, the following topics will be covered:

- Introduction of the lithium-ion technology and an insight into how the chemistry functions
- Comparison of the lithium-ion technology with other battery technologies
- Discussion of the typical steps involved in the manufacturing of lithium-ion cells and the quality checks performed during the manufacturing process
- Discussion of the safety concerns typically associated with the lithium-ion technology and steps taken to mitigate these concerns in battery and system designs
- Discussion of the typical techniques used to evaluate and characterize the performance of these batteries in the field
- Examples of the ongoing reliability test (ORT) procedures typically needed once the battery system is in the field in actual applications
- Introduction of the typical design topologies and battery management architectures employed for small and large format lithium-ion batteries. This will include examples of typical architectures used in the consumer electronics, telecommunications and automotive industries.
- Discussion of the various industry standards that have been developed for evaluating both the safety and reliability of lithium-ion batteries. This will include a description of the approaches taken by the various industry standards.

It is expected that the attendee through this tutorial will gain an understanding of lithium-ion batteries and understand not only how the chemistry functions, but also gain insight into techniques used and things to consider when adapting this technology for real-world applications.

Lead Instructors:

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Instructor Bios

Mr. Ashish Arora is a Senior Managing Engineer in Exponent's Electrical and Semiconductors practice. Mr. Arora specializes in electrical and electronic systems particularly in power converter and rechargeable battery technology design and safety evaluation.

At Exponent, Mr. Arora has investigated the safety of consumer products and performed design reviews, safety evaluations and failure analysis in the field of power storage and conversion systems including power electronics, energy storage systems, battery charging and management systems, power supplies, UPS systems etc. He has developed test and safety evaluation procedures for energy storage and control systems, as well as complex control system designs, utilizing his failure analysis experience. Mr. Arora has also worked on failure analysis of both passive and active electronic components. In addition, he has assisted in investigations related to potential product recalls.

Relevant Publications

Book Chapter

1. Arora A, Medora NK, Livernois T, Swart J. Safety of lithium-ion batteries for hybrid electric vehicles. In: Electric and Hybrid Vehicles, Power Sources, Models, Sustainability, Infrastructure and the Market, Chapter 18, pp. 463–491, Elsevier B.V., 2010.

Papers & Presentations

1. Pinnangudi B, Arora A, et al. Thermal shutdown characteristics of separator materials used in lithium-ion batteries. Presentation, 2010 IEEE Symposium on Product Compliance Engineering, IEEE Product Safety Engineering Society (PSES), Boston MA, October 18–20, 2010.
2. Arora A, Medora NK, Swart J. Failures of electrical/electronic components: Selected case studies. Presentation, 2007 IEEE Symposium on Product Compliance Engineering, IEEE Product Safety Engineering Society (PSES), Longmont, CO, October 22–23, 2007. Also approved for publication in the IEEE PSES 2007 Conference Proceedings.
3. Arora A, Swart J, Megerle M, Nilsson S. Methods for measuring the mechanical safety vent pressure of lithium ion cells. IEEE Symposium on Product Safety and Compliance Engineering, Irvine, CA, 2006.
4. Swart J, Arora A, Nilsson S. Characterizing the performance of battery chemistries used to power a single person vehicle. 6th International Advanced Automotive Battery (and Ultracapacitor) Conference, Baltimore, MD, 2006.
5. Swart J, Arora A, Nilsson S, Xu Y. Going beyond industry standards in critically evaluating lithium-ion batteries. Advancements in Battery Charging, Monitoring and Testing, Vancouver, Canada, 2005.
6. Arora A, Swart J, Nilsson S, Xu Y. Characterizing the vent operation of lithium-ion cells and battery packs. 5th International Advanced Automotive Battery (and Ultracapacitor) Conference, Hawaii, 2005.
7. Arora A, Swart J, Nilsson S, Xu Y. Lithium-ion batteries for hybrid electric vehicles: A safety perspective. 5th International Advanced Automotive Battery (and Ultracapacitor) Conference, Hawaii, 2005.
8. Arora A, Swart J. Design review of a lithium-ion battery powered product. IEEE Symposium on Product Compliance Engineering, Longmont, CO, 2007.
9. Swart J, Arora A. Is lithium ion chemistry viable as a renewable energy storage medium in a micro photovoltaic power system? Advancements in Battery Charging, Monitoring and Testing, Chicago, IL, 2006.