Introduction to Electrical Energy Storage Devices and Systems—Batteries, Supercapacitors, Chargers, and Applications

April 7–9, 2015
Madison, Wisconsin

- Gain a solid introduction to this emerging and rapidly growing field
- Acquire fundamental knowledge about batteries and supercapacitors and their application and integration into systems
- Learn with a building-block approach filled with application-specific examples

Develop comprehensive knowledge of electrical energy storage devices and system considerations to effectively utilize them in your applications and systems...

Essential information for:
- Electrical engineers
- Mechanical engineers
- System engineers
- Project engineers
- System integrators
- Electric power generation and utility engineers
- Technical leaders
- Program managers
- Program managers

Please share this brochure with colleagues who may benefit from attending this course.
Advance Your Knowledge
Energy storage is an emerging technology that is critical to developing competitive products for energy and power systems intended for applications with intermittent sources. The weight, volume, cost, life, reliability, safety, and system integration of batteries and supercapacitors are critical subjects to master in order to effectively use this key technology in new and existing energy applications.

This introductory course offers you a special opportunity to advance your knowledge in electrical energy storage with a focus on batteries and supercapacitors. Our experienced instructors will lecture on both the fundamentals and applications of these rapidly evolving components. Sound engineering knowledge with application examples will be our focus during three intensive days.

Join Us and Benefit
This course will be valuable to you if you are an engineer involved in the specification, integration, and application of electrical energy storage components and systems including batteries and supercapacitors.

A Fundamentals Course
Expect to apply your general engineering knowledge to master the fundamentals of electrical energy storage components and systems, focusing on batteries and supercapacitors.

Achieve Valuable Objectives
This course will make you more effective in your engineering work by helping you:

- Understand the basic chemistries of batteries and supercapacitors
- Identify the differences, advantages, and disadvantages of using alternative battery types
- Understand the figure of merits, energy, and power density limits of each electrical energy storage component type
- Examine battery testing standards
- Learn about battery charging systems and state of charge measurement techniques
- Learn about hybrid systems using batteries and supercapacitors and future hybrid technologies
- Understand safety and second-life use of batteries
- Learn about a variety of applications such as automotive and grid-energy storage systems
- Explore future research directions

Topics
- Battery and supercapacitors background and terminology
- Major battery chemistries (advanced lead acid, NiMH, li-ion, and others)
- Battery system integration
- Analysis and simulation of batteries
- Secondary use, recycling, disposal, and safety of batteries
- Battery chargers, protection, and SOC measurement
- Battery standards and testing
- Application examples (automotive and grid-tied systems)
- Current research directions
- Future technologies

Course Outline

Introduction to Electrical Energy Storage
- Scope of energy storage needs and opportunities
- Technology overview and key disciplines
- Example applications and projects

Battery Background
- What is a battery?
- Types of batteries
- Common units of measure and common figures of merit

Electrochemistry
- Electrochemical vs. thermal energy sources
- Voltage and potential energy
- Reduction and oxidation
- Reduction potentials and electrochemical couples
- Electrochemical cell

Battery Construction
- Major battery elements
- Cell mechanical structure
- Resistance and polarization
- Electrode design
- Discharging and charging

Major Battery Chemistries
- Common batteries (lead acid, NiMH, li-ion, and others)
- Common battery metrics—performance comparison, power, and energy
- Densities, specific power, and specific energy of batteries with different chemistries
- Relative comparison of electrical energy storage technologies

Lead Acid Batteries
- Types of lead acid batteries
- Lead acid battery charge/discharge characteristics
- Lead acid battery pros and cons

Nickel-Metal Hydride Batteries
- NiMH cell construction
- NiMH applications
- NiMH battery charge/discharge characteristics
- NiMH pros and cons

Li-Ion Batteries
- Lithium-ion cell reaction
- Li-ion cell construction
- Li-ion pouch cells
- Construction—can vs. flexible foil
- Typical charge characteristics
- Continuous discharge performance
- Typical discharge characteristics
- Li-ion pros and cons

Supercapacitors
- Fundamentals
- Construction and properties
- Types of supercapacitors
- Cycling and performance characteristics

ENROLL ONLINE TODAY! Or visit our website.
Battery System Integration
- Battery pack design considerations for performance
- Major battery sub-systems
- Typical battery schematic
- Smart battery control
- Cell balancing
- Balancing in action
- Safety considerations in batteries
- Safety and abuse
- Safety measures in cells
- Safety measures in battery systems
- Fault detection and management systems, battery protection systems

Analysis and Simulation of Batteries
- Equivalent circuit models
- Electrochemical models
- Thermal models
- Aging and life models
- Trends in simulation technology

Secondary Use, Recycling, and Disposal

Issues of Batteries
- USABC requirements
- Possible markets
- Economic analysis of deploying used batteries
- Individual and synergistic applications and benefits

Battery Chargers
- Introduction to charger configurations and features
- Charger classes and performance characteristics
- Electronics applications
- Automotive applications
- Industrial applications

Battery State Estimation
- State of charge (SOC)
- State of health (SOH)
- State of function (SOF)

Battery Standards and Testing
- Overview of major standards
- Test equipment survey
- Testing by application

Safety
- Fundamental failure modes
- Standards for testing
- Role of failure modes and effects (FMEA) tools
- Protection techniques

Future Electrical Energy Storage Technology
- Current challenges
- Promising high power and energy battery technologies
- Future battery electric vehicle performance requirements

Current Research Update
- Overview of major research areas and highlights
- Electrochemistry research
- Advanced materials research
- Battery systems and management research

Automotive Battery Applications
- Degrees of vehicle electrification
- Battery size vs. application
- Battery performance and sizing—USABC
- DOE targets for vehicular energy storage systems
- Battery sizing factor (BSF)
- Static capacity and energy

Automotive Battery Application Performance
- Static capacity test
- Temperature performance
- Power performance
- Life and durability
- Battery cycling
- Factors affecting cycle life
- Drive profiles
- Calendar life

Grid-Tied Energy Storage System Applications
- Sodium sulfur and redox flow battery based energy storage systems
- Fundamentals of sodium sulfur and redox flow battery systems
- Construction
- Properties and characteristics
- Grid interconnection and control topologies

Course Schedule
Registration and course will be held at Engineering Hall, Room 1610
1415 Engineering Drive
Madison, WI

Day 1
8:00 a.m. to 8:30 a.m. Registration
8:30 a.m. to 5:00 p.m. Class

Day 2
8:00 a.m. to 5:00 p.m. Class

Day 3
8:00 a.m. to 3:30 p.m. Class
Midmorning and midafternoon refreshment breaks and noon lunch will be provided all three days.

Course Faculty

Thomas M. Jahns, PhD, is a professor with the Department of Electrical and Computer Engineering at the University of Wisconsin–Madison. Previously with GE Corporate R&D and Massachusetts Institute of Technology, Jahns has research interests in electric machines, drive system analysis and control, and power electronic modules.

Marc A. Anderson, PhD, is a professor in and Chair of the Environmental Chemistry and Technology Program, University of Wisconsin–Madison. Anderson has research interests in fabrication and application of chemistries for catalysts, photocatalysts, ultracapacitors, batteries, fuel cells, gas, and liquid filters.

Oliver Gross is an energy storage systems specialist for High Voltage Energy Storage Solutions, at Chrysler Group, LLC, where he is responsible for the battery systems technology roadmap for Chrysler and the Fiat Group. He holds both a BS and a master’s degree in materials science from the University of Toronto. Gross has 20 years of experience in the advanced energy storage industry. Prior to Chrysler, he worked at Cobasys, Valence Technology, and Ultralife on various battery technologies. He currently holds more than ten patents and has authored more than 20 publications.

Omer C. Onar, PhD, is an Alvin M. Weinberg Fellow and on the R&D staff at the Energy and Transportation Science Division at the US Department of Energy’s Oak Ridge National Laboratory. His research interests cover power electronics, energy storage systems, and both hybrid- and battery-electric vehicles, including plug-in hybrid vehicles. He received his PhD in electrical engineering from Illinois Institute of Technology (IIT).

Theodore Bohn is a principal investigator for Grid Connected Vehicle (Smart Grid/Advanced Charging) research in the Vehicle Systems Group with the Center for Transportation Research at Argonne National Laboratory. He has been working on advanced technology and alternative energy fueled vehicle research for over 25 years. He is the current Advanced Battery Technology Chair for the SAE Congress. Bohn received his BS and MS degree in electrical engineering at the University of Wisconsin–Madison.

Bulent Sarlioglu, PhD, is an assistant professor at the UW–Madison and the associate director of the Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC). He previously worked at Honeywell International Inc.’s aerospace division for 11 years, most recently as a staff systems engineer, earning Honeywell’s technical achievement award in 2003 and an outstanding engineer award in 2011. Sarlioglu’s expertise includes electrical machines, drives, and power electronics and he is the inventor or co-inventor of 15 US patents as well as many international patents. He received his PhD from UW–Madison, MS from University of Missouri–Columbia, and BS from Istanbul Technical University, all in electrical engineering.
For information about these courses or to make a suggestion for a course we do not presently offer, call Bulent Sarlioglu, PhD, at 800-462-0876 or email bulent@engr.wisc.edu.

Need to Know More?
Call toll free 800-462-0876 and ask for

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General Information
Fee Covers Notebook, course materials, break refreshments, lunches, certificate, and continuing education credits (CEU/PDH).

Cancellation Policy If you cannot attend please notify us seven days prior to the course start, and we will refund your fee. Cancellations received after that date and no-shows are subject to a $150 administrative fee per course. You may enroll a substitute at any time before the course starts.

Location This course will be held at Engineering Hall (Room 1610), 1415 Engineering Drive, Madison, WI. Phone messages: 608-263-3163.

Accommodations We have reserved a block of guest rooms (rates starting at $130, including parking) at Wisconsin Union Hotel, 1308 West Dayton Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingP726 or call 608-263-2600 and indicate that you will be attending this course under group code STORE. Room requests after March 7 will be subject to availability. Other fees and restrictions may apply.

We have reserved a second block of guest rooms (rates starting at $139) at HotelRED, 1501 Monroe Street, Madison, WI. Reserve a room (rates starting at $130, including parking) at Wisconsin Union Hotel, 1308 West Dayton Street, Madison, WI. Reserve a room online at epd.engr.wisc.edu/lodgingP726 or call 608-263-2600 and indicate that you will be attending this course under group code STORE. Room requests after March 7 will be subject to availability. Other fees and restrictions may apply.

Earn Continuing Education Credit
By participating in this course, you will earn 20 Professional Development Hours (PDH) or 2.0 Continuing Education Units (CEU).