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The Center for Grid Engineering Education

# Application of Smart Inverters

Greater adoption of distributed energy resources (DER), especially solar photovoltaic (PV) systems, interconnected on distribution feeders can create grid management challenges. However, PV and energy storage inverters are also capable of being "smart," delivering timely support for grid voltage and frequency, curtailing active power when necessary, and maintaining operation during transient events. This course focuses on these smart inverter functionalities, from their fundamentals through applications to the growing number of distributed resources being integrated into the power system.

Beginning with the basics of grid-tied inverter operation, the course will introduce participants to modern inverter topologies, modulation schemes, real/reactive power control, maximum power point tracking techniques, grounding practices, and islanding detection methods. From this foundational understanding, the concept of "smart" functionality will be developed that harnesses these fundamental features to support the grid. Students will learn the methods behind advanced control such as frequency-watt or volt-var, available configuration options, as well as the implications for distribution and bulk electricity system performance. Results of laboratory evaluation tests, distribution circuit simulation, and field demonstration will be presented to highlight the impact of smart inverters on distribution system planning and operation. Students will be introduced to relevant standards, grid codes and certifications, including the latest developments in IEEE1547, CA Rule 21 and UL1741.

## Who Should Attend

Utility engineers handling new DER interconnection applications, performing distribution circuit impact studies, and commissioning new plants will benefit from this course. Individuals involved in the DER policy and planning activities will learn about smart inverter functionalities, which are becoming increasingly important for reliable integration of higher penetration of solar PV in the electric network.

## Registration Information

**Class Dates:** October 8 and 9, 2015
Day 1: 8:00 am – 5:00 pm
Day 2: 8:00 am – 12:00 pm

**Course Length:** 1.5 Days

**PDH Available:** 12-Hours

**Registration Fee:**
- $1,200 per person
- 20% discount for organizations with three or more attendees
- 25% discount for university professors*
- 75% discount for graduate students*

*University IDs required to qualify for professor or graduate student discounts.

**Location:** Baltimore Marriott Waterfront
700 Aliceanna Street, Baltimore, MD 21202

**Registration:** http://grided.epri.com/courses.html

***Students will need to bring:*** *laptops or tablets to access online resources and to follow class notes. Wi-Fi access is provided. Lecture slides will be provided electronically in PDF format.*

**NOTE: This course follows the EPRI PDU Advisory Meeting to be held October 5-7 at the Baltimore Marriott Waterfront**

## EPRI Contact

Aminul Huque, mhuque@epri.com or 865.218.8051
Lori Warneke, lwarneke@epri.com or 865.218.8174

*Professional Development Hours

## Meet the Instructors

**Dr. Aminul Huque** is a Technical Leader in the Integration of Distributed Energy Resources (DER) research area at the Electric Power Research Institute (EPRI). His research at EPRI focuses on power converters for DER which includes smart-inverters, interconnection standards, grid codes, energy storage integration with solar PV, energy resiliency, and microgrid. Aminul is currently managing several smart-inverter projects including a DOE funded smart inverter demonstration project. He is serving as EPRI representative at the IEEE 1547 working group and facilitating a subgroup working on the voltage regulation section for the ongoing full revision activity. He is also a standards technical panel (STP) member of Underwriters Laboratories. Aminul received a PhD from the University of Tennessee at Knoxville (Tennessee, USA), and an MSc from the Imperial College London (London, UK) in 2010 and 2003 respectively.

**Dr. Ben York** is an engineer in EPRI's Distributed Energy Resource program area, focusing on both technical and economic integration. Under this effort, Ben currently contributes to several focus areas, including power electronics, photovoltaic balance-of-systems, and microgrids. He is a published author in multiple industry journals on power electronics design and control. Before joining EPRI in 2013, Ben was a Research Assistant at Virginia Tech's Future Energy Electronics Center. Ben was responsible for research, development, and demonstration of several products directly related to photovoltaic energy conversion. Ben received a B.S. (2008) degree in electrical engineering from the University of Alabama, as well as M.S. (2010) and Ph.D. (2013) degrees in electrical engineering from Virginia Tech.

## Course Outline

### Day 1 (Full-Day)

- Introduction to DER Technologies and Power Electronics Interface
  - DER technologies and topologies
  - Inverter types
  - Commercial examples
- Inverter Fundamentals
  - Basic switching circuits
  - Modern inverter topologies
  - Modulation schemes
  - Control architectures
  - Maximum power point tracking
  - Real and reactive power control
- Advanced Grid Support Functionalities
  - Voltage regulation
  - Ride through
  - Max generation limiting
  - Frequency-watt
- Testing of Smart Inverter
  - Laboratory testing
  - Field commissioning & demonstration
- Contemporary Issues in Inverter Design
  - Islanding detection
  - DC and AC grounding
  - GFCI and AFCI
  - Load rejection and ground fault over voltage

### Day 2 (Half-Day)

- Application of Smart Inverters
  - Modeling and simulation
  - Impact on distribution circuits
  - PV hosting capacity
- Interconnection Standards and Protocols
  - IEEE 1547
  - CA Rule 21
  - UL1741
  - Communication Protocols
- Deployment challenges
  - Communication
  - Certification
  - Utility interface

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**Electric Power Research Institute**
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com