EPRI | ELECTRIC POWER RESEARCH INSTITUTE

GEARED

GRIDED

The Center for Grid Engineering Education

Application of Smart Inverters

Course Description

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, limiting active power generation 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, real/reactive power control, maximum power point tracking techniques, 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. Laboratory testing and field demonstration results will be presented to highlight the impact of smart inverters on the power system. Communication and control requirements to manage smart inverters will be discussed. Students will be introduced to relevant standards, grid codes and certifications, including the latest developments in IEEE1547, grid codes, and UL 1741.

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

PDH Available: 12 hours

Registration Fee:

- $1,200 per person
- 20% discount for organizations with three or more attendees
- 25% discount for government employees (non-utility)
- 25% discount for university professors*
- 75% discount for graduate students*

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

Students 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.

For More Information:

Amy Feser, afeser@epri.com, (865) 218-5909

Course Instructors:

Aminul Huque, mhuque@epri.com (865) 218-8051

Ben York, byork@epri.com (865) 218-8187

Meet the Instructors

Dr. Aminul Huque, is a Principal 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 SHINES 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 a senior engineer in EPRI's Integration of Distributed Energy Resources program area, focusing on systems integration and interconnection issues. Having helped develop EPRI's Integrated Grid concept, Ben continues to lead several related demonstration projects. Ben also guides ongoing research and technical discussion around inverter behavior, power quality, and distribution system grounding. Before joining EPRI in 2013, Ben was a Research Assistant at Virginia Tech's Future Energy Electronics Center. 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)

- **DER Technologies and Power Electronics Interface**
  - DER technologies and topologies
  - Inverter types
  - Commercial examples
  - Maximum power point tracking
- **Inverter Fundamentals**
  - Basic switching circuits
  - Modern inverter topologies
  - Real and reactive power control
  - Anti-Islanding
  - Load rejection and ground fault over voltage
- **Advanced Grid Support Functionalities**
  - Voltage regulation
  - Ride through
  - Max generation limiting
  - Frequency-watt
  - Maximum generation limit

Day 2 (Half Day)

- **Benefits of Smart Inverters**
  - Impact on distribution voltage
  - Impact on PV hosting capacity
- **Communication and Control**
  - Architecture
  - Protocols
  - DMS/DERMS integration
- **Interconnection Standards**
  - Update on IEEE P1547 Revision
  - State Grid Codes (CA Rule 21, HI Rule 14H)
  - Update on UL1741SA

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