Tutorial 1

Smart Grid Distribution Automation

The mass deployment of distributed energy resources (DERs) is creating a paradigm shift of the way energy is produced, traded, distributed, and utilized. Although such shift is unparalleled, it is accompanied with serious accommodation challenges in existing outdating/aging power distribution systems infrastructure. Thanks to Distribution Automation, one of the smart grid pillars, that offers new digital technologies to be integrated within existing utility grids to substantially improve the overall efficiency, reliability, and interoperability of the network as well as facilitating seamless accommodation of DERs.

This 3-hour instructor-led tutorial focuses on the transformation of existing power distribution systems from their conventional structure with unidirectional power flow towards automated distribution grids integrated with distributed energy resources (DERs). The tutorial provides participants with a practical understanding of the technical challenges that power utilities currently face to accommodate DERs in their distribution networks, and the most recent interconnection requirement standards of DERs. The tutorial also provides participants with the required knowledge to understand, assess, and analyze the technical needs of adopting Distribution Automation technologies to mitigate such technical challenges and enhance the operation and reliability of power distribution systems.

Participants Receive

After participating in this Smart Grid Distribution Automation tutorial, participants will be able to:

- Identify several technical integration challenges for DERs in existing power distribution systems
- Being familiarized with the most recent IEEE 1547 standard for interconnection requirements of DERs
- Assess the key features of power conversion systems (PCS) offered by industry to meet the interconnection standards for DERs
- Understand the need for compatibility of automation devices with IEC 61850 standard
- Being familiarized with applications of smart grid distribution automations such as volt/var control, demand response, outage management, and fault detection, isolation, and load restoration (FDIR).

Course Schedule: 12th March 2022 | 8:30 AM – 12:00 PM

Session # 1	8:30AM–10:00AM

S1.1 Legacy of Smart Distribution Networks

- Distribution Substations
- Distribution Feeders
- Evolution in Distribution Systems
    - Distributed Renewable Generation
    - Electric Vehicles
    - Energy Storage Systems
- What is Smart Grid Distribution Automation

S1.2 Integration Challenges of DERs with Power Distribution Grids

- Impacts of DG Integration on The Protection Coordination
- Impacts of DG Integration on Voltage Regulation and System Losses

S1.3 Utilities Technical Interconnection Requirements of DERs: IEEE 1547 std.

- Performance Requirements (Power Quality, Disturbances, Resonance)
- Protection Requirements
- Operating Requirements
- Telecommunication Requirements

Session # 2	10:30AM–12:00PM

S2.1 Framework of Distribution Automation

- Traditional Substation Automation
- Intelligent Electronic Devices (IEDs)
- Remote Terminal Units (RTUs)
- Advanced Metering and Information Technologies (AMI)
- Interoperable Communication Networks (IEC 61850)

S2.2 DA Application Applications

- Integrated Voltage and Var Control (IVVC)
- Outage Management
- Fault Detection, Isolation, and Load Restoration (FDIR)
- Demand Response and Demand Side Management

About the Instructor:

Dr. Hany Farag,

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HANY E. Z. FARAG (PhD, P.Eng, SMIEEE)–received the B.Sc. (Hons.) and M.Sc. degrees in electrical engineering from Assiut University, Assiut, Egypt, in 2004 and 2007, respectively, and the Ph.D. degree in electrical and computer engineering from the University of Waterloo, in 2013.

Dr. Farag is an associate professor and York Research Chair (YRC) in Integrated Smart Energy Grids at York University. He is a Registered Professional Engineer in Ontario and a recipient of the prestigious Early Researcher Award (ERA) from the government of Ontario.

His current research interests include the integration of distributed and renewable energy resources, electric mobility, hydrogen generation and storage, modeling, analysis, and design of microgrids, and applications of multi-agent, IoT, and blockchain technologies in smart grids.

Tutorial 2

Dynamics of Emerging Inverter-Rich Power Systems

Fundamentals, challenges, and mitigation solutions

Emerging renewable-rich power systems are facing a technological shift due to the massive integration of inverter-based technologies and its consequent phase-out of synchronous machines, which could potentially threaten system frequency stability/resilience, associated with varying low-inertia conditions and inadequate frequency control ancillary services, and voltage stability/control, associated with low system strength and weak grid areas. This tutorial aims to fundamentally discuss how the mention technological revolution is changing the dynamics and characteristics of power systems and brings some new dynamic phenomena and stability challenges in system operation. We will discuss the root causes and manifestations of potential system instability phenomena under weak and low-inertia conditions as well as the associated system dynamic assessments required to capture these new class of system instabilities. We will then discuss how inverter-based technologies, in particular battery energy storage systems and hydrogen electrolysers, could contribute to secure and resilient system operation, as well as the potential challenges and requirements. The modelling foundations for these inverter-based technologies will be presented. In this context, we will also discuss several real-life examples and events to highlight the potential capabilities of inverter-based technologies in system stability and resilience support.

Target audience:

Graduate students, PhD students, relevant industry professionals

Prerequisites:

Power system analysis and control

Learning objectives:

Having completed this tutorial the participant is expected to:

- Develop ability for in-depth technical competence in the dynamics of emerging renewable-rich power systems, in particular the underlying physics of system strength, its contributing factors, and the relevant system-level and device-level issues,
- Develop the dynamic models of inverter-based technologies, including battery energy storage systems and hydrogen electrolysers, for system-level studies,
- Simulate and study the dynamic behaviour of utility-scale battery storage systems and their capabilities in providing system support services, including virtual inertia response, fast frequency response, frequency regulation, grid-forming services, reactive power support, and voltage control,
- Simulate and study the dynamic behaviour of electrolysis plants and their capabilities in providing system support services, including virtual inertia response, fast frequency response, frequency regulation, grid-forming services, reactive power support, and voltage control,
- Learn more about the recent real-life developments in utility-scale battery energy storage systems and hydrogen electrolysers.

Course Schedule: 12th March 2022 | 1:00 PM – 5:00 PM

1. Dynamics of low-carbon grids: Fundamentals and challenges (30 minutes)
    a. System inertia and frequency stability
    b. System strength and weak grid area challenges
    c. Mitigation solutions

2. Battery energy storage systems: fundamentals, modelling, benefits, and challenges (1 hour)
    a. Battery storage dynamic modelling, including battery storage stack model and its power-electronics interface/control
    b. System support services from battery storage
    c. Simulation case studies and exercises

    15 minutes Q&A followed by 5 minutes break

3. Hydrogen electrolysers: modelling, benefits, and challenges (1.15 hour)
    a. Modelling foundations of electrolysis plants for power system studies
    b. Frequency support services, including virtual inertia, fast frequency response, and frequency regulation
    c. Voltage control and reactive power support
    d. Grid-forming services

    5 minutes Q&A followed by 5 minutes break

4. System dynamic support from inverter-based technologies: real-life examples (1 hour)
5. Concluding remarks (15 minutes)

About the Instructors:

Mehdi Ghazavi Dozein received M.Sc. degree from University of Tehran and Ph.D. degree from The University of Melbourne. He is currently an Associate Lecturer in Power Systems at The University of Melbourne. His research interests include power system dynamics and stability, and modelling and control of inverter-based technologies such as battery storage systems, hydrogen electrolysers, wind units, and photovoltaics.

Saman Dadjo Tavakoli received his M.Sc. degree in electrical engineering from Shahid Beheshti University, Tehran, Iran, in 2015. He joined Technical University of Catalonia (UPC), Barcelona, Spain, in 2018 to pursue a Ph.D. degree in electrical engineering. Since 2022, he has been with Siemens Energy as HVDC control and protection expert. His research interests include modern power system dynamics, advanced control system design for power converters, and hydrogen electrolyzers.