# ICT design and informatics for Smart Grids

## ❖ Module Objectives

- Introducegeneral concepts, categories and challenges of the different communications technologies (wired and wireless) mainly for power systems students/trainees.
- Presents deeper knowledge on the different possible communications technologies that could be used on smart grid networks, at small scale (house, neighborhood) and large scale (nation scale), and depending on the considered communication and propagation channel.
- Learn how to design and simulate a communication system in the smart grids concept using Matlab/Simulink.
- Introduce SCADA systems and the smart Intelligent electronic devices, with their components and architectures.
- Presents the energy management systems (EMS) for control centers and their relationship with SCADA systems.
- Introduces the distribution automation and distribution management (DA/DMS) systems framework and its coordination with other management systems.

## ❖ *Learning Outcomes*

On successful completion of the module the student/trainee will be able to:

- Define and describe the different communications techniques wired and wireless ones with their advantages and weaknesses.
- Compare and choose the suitable technologiesto adopt and implement depending on the considered context, small- or large-scale grid.
- Simulate and evaluate communications scenarios on the Smart Grid context using Matlab/Simulink.
- Understand and build blocks of a SCADA Systems, including remote terminal and units intelligent electronic devices.
- Define and describe the energy management systems (EMS) for control centers, and distribution automation and distribution management (DA/DMS) systems.

## ❖ *Prerequisites*

Basic undergraduate mathematics and physics are assumed. It is expected that students/trainees have

Power or Communication Engineering as their background or/and have taken the Introduction to Signal and Systems course or any course related to communication networking, and wave propagation, and are familiar with its content. Students/trainees will, as a minimum requirement, be competent with units of measurement, engineering mathematics. Previous knowledge of Matlab/Simulink is advised.

## ❖ *Module Description*

The module introduces communications technologies to mainly power engineering students/trainees, and also, SCADA systems including its components and related energy management systems. It presents a background overview of the different communications techniques with their respective challenges related to the propagation channels and the deployment scale. Then, a more detailed presentation of the different communications tools and techniques that will be used in the smart grid context, such as power line communication (PLC), wireless sensor networks (WSN) and 4G/5G Mobile Networks. In addition, SCADA fundamentals are presentation with an overview of the energy management system for control centers. Finally, it presents distribution automation and distribution management (DA/DMS) systems including its framework and application functions. Some laboratory tasks will be done on Matlab in order to get in touch with the performance of the different techniques and challenges that can be faced on a real deployment scenario, where a large number of sensors and collected data will play a major role on the selected techniques.

## ❖ *Module Content*

**Chapter 1: Introduction to ICT Information System for Power System**

- Information architecture for the Smart Grid
  - Grid Equipment layer
  - Communication infrastructure layer
  - Data Storage layer
  - Data application layer
- Communication architecture for the Smart Grid
- Mapping ICTapplication in the Smart Grid
- Summary

- References

**Chapter 2: Introduction to the communication concepts**

- Definition of Information Data
    - Signals and Systems
    - Time and Frequency Domains
- Definition of Communication technologies
    - Transmission Chain
    - Propagation channels
        - Wired and Wireless
        - Constraints and Challenges
- Summary
- References

**Chapter 3: Smart Grid Communication System**

- Classification of power system communication accordingto their functional requirements
    - Real-time operational communication systems
    - Administrative operational communication systems
    - Administrative communication systems
- Existing electric power system communicationinfrastructure and its limitation
- Smart Grid communication system infrastructure
    - Home area network (HAN)
    - Neighbourhood area network (NAN)
    - Wireless Sensors Networks (WSN)
- Communication technologies
    - Power line communications (PLC)
    - Wireless Networks (IEEE 802 series)
        - WLAN, ZigBee, ...
        - Multi-protocol label switching (MPLS)
    - Mobile Communications
        - LTE, 5G

- Smart Grid Scenarios
    - Technologies challenges
- Cyber security of power systems
- Summary
- References

**Chapter 4: Design and sizing of a communication system for the Smart Grid**

- Design and sizing scenarios
    - HAN
    - NAN
- Introduction to Matlab/Simulink
    - Simulation of the different scenarios
    - Evaluation of the communications performances
- Summary
- References

**Chapter 5: SCADA fundamentals& Smart IED**

- Introduction
- Building blocks SCADA Systems
- Remote terminal units (RTU)
    - Components of RTU
    - Communication subsystem
    - Logic subsystem
    - Termination subsystem
- Intelligent electronic devices (IEDs)
    - IED functional block diagram
    - Hardware and software architecture of the IED
    - Simulation of the different scenarios
    - IED Communication subsystem
- References

**Chapter 5: Energy management systems (EMS) for control centers**

- Introduction
- Energy control centers
- Energy management systems (EMS) framework
- Data acquisition and communication (SCADA Systems)
- Transmission operations and management: Real time
- Smart transmission
    - Phasor measurement unit
    - Phasor quantity and time synchronization
    - Application of PMU
- References

**Chapter 6: Distribution automation and distribution management (DA/DMS) systems**

- Introduction
- Subsystems in a distribution control center
    - Distribution management systems (DMSs)
    - Outage management systems (OMSs)
    - GIS (geographical information system)
    - AMS (asset management system)
    - AMI (advanced metering infrastructure)
- DMS framework
- DMS application functions
- DMS coordination with other systems
    - Integration with OMS
    - Integration with AMI
- References

## ❖ *References*

1. Chen, L., Liu, X., Zhang, T. & Wang, Y.-f. (2013).*The Research on Information Architecture and Security Protection of Smart Grid*. Applied Mechanics and Materials, 421, 541-545.

2. M. A. Hammoudeh, F. Mancilla-David, J. D. Selman and P. Papantoni-Kazakos, *"Communication Architectures for Distribution Networks within the Smart Grid Initiative,"* 2013 IEEE Green Technologies Conference (GreenTech), Denver, CO, 2013, pp. 65-70.
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4. Ekanayake, Janaka B., Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, and Akihiko Yokoyama. *Smart grid: technology and applications*. John Wiley & Sons, 2012.
5. Proakis, John G., and MasoudSalehi. *Fundamentals of communication systems*. Pearson Education India, 2007.
6. Budka, Kenneth C., Jayant G. Deshpande, and Marina Thottan. *Communication Networks for Smart Grids: Making Smart Grid Real*. Springer Science & Business Media, 2014.