

Syllabus: Smart Grids: The Basics

1. Course overview

The smart grid of the future is a complex electrical power system. Its study, design, and management requires the integration of knowledge from various disciplines including sustainability, technology and mathematics. In this first course, you will be introduced to the definition of a smart grid, its heterogeneity, dynamics, control, security and assessment strategies. The challenge of modeling such a system is also discussed. A group of researchers will offer their expertise on these topics and will introduce the modeling method which will be used in the second course of this program. The course enables the learner to describe and assess a Smart Grid by adding controls, communication, and other digital elements to make it more flexible, robust, and efficient, as is required from an electrical power grid of the future.

The course follows a module structure, divided over six modules. Each module contains, video lectures, reading material and quizzes. Further, some modules also have peer graded analysis and practice activities.

2. Learning objectives

So, what will you actually learn in this course? At the end of this course, you will be able to:

1. Identify different tools and approaches to modelling a Smart Grid
2. Apply Optimal Power Flow (OPF) solutions to evaluate the performance of a power system with renewable energy sources
3. Analyze power system dynamics (frequency stability) to achieve active power balance, and
4. Identify control-room technologies for system-wide remote monitoring, protection, and risk management of smart grid cyber security

3. Course structure

The course is organized into 6 modules, with an estimated workload of 4 hours per week. A brief summary of each module is presented below. Detailed instructions and resources will be provided over the duration of the course.

0. Getting Started (21-01-20, Module 0)

In the Getting Started section you will get to know the course structure, familiarize yourselves with the virtual learning environment, complete your profile, meet your fellow students and the moderator.

1. Modeling Smart Grids (21-01-2020, Module 1)

In this module, we will introduce the concept of a **Smart Grid** and the key role it will play in the transition to a sustainable energy future. We will also discuss its trans-disciplinary, complex nature and how one can model such a heterogeneous system. This module consists of video lectures and reading material.

2. Optimal Power Flow (OPF) (28-01-2020, Module 2)

In the second module, we will focus on the application of Optimal Power Flow (OPF) solutions to evaluate the performance of a power system with renewable energy sources. In this module, we attempt to answer questions such as :

- What is an optimization problem and how can it be applied to power systems?
- How can uncertainties be modeled?

In this module, the following terms may be used extensively: OPF and PPF. They refer to Optimal Power Flow and Probabilistic Power Flow respectively.

This module consists of video lectures, reading material.

3. Power System Dynamics (PSD) (04-02-2020, Module 3)

In module 2, we looked at the structure and information needed to solve optimal power flow problems. We also learnt the application of these OPF solutions to evaluate the performance of systems with renewable energy sources. This module delves into the area of power system dynamics, which is crucial to ensure system operation. Broadly, we will deal with the following themes in this module:

- Understand and classify types of power system stability phenomena
- Analyze two major types of stability: voltage and frequency stability
- Understand active power balance and frequency control

Similar to module two, this module consists of video lectures, reading material.

4. Automation networks (11-02-2020, Module 4)

In this module we will offer a brief introduction to Automation Networks, as communication is an integral part of a smart grid. Specifically, you will learn about the following topics:

- Types of networks and their attributes
- Different network protocols
- ISO-OSI reference model
- Industrial automation networks with LonWorks as a case study
- Automation network security

This module consists of video lectures and reading material.

5. Wide Area Monitoring Protection and Control (WAMPAC) (18-02-2020, Module 5)

In this module we will deal with the latest technologies that can enable an automatic and resilient electrical power grid. We will cover several topics such as:

- Energy Management System (EMS)
- Digital substations
- Synchronized Measurement Technology
- Cyber Security in an EMS

This module consists of video lectures and reading material.

6. Smart Grid Cyber Security (25-02-2020, Module 6)

In the final module, we will learn further about cyber security in smart grids. We will study several topics such as:

- Cyber security risk assessment
- Security index computation
- Use of RTDS and simulation tools for analyzing the impact of an attack

7. Conclusion and Final Exam (03-03-2020, Module 7)

To conclude the course, a summary of all the topics covered over the past six modules is provided.

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