

# A Signal Processing Perspective to Smart Grids Analysis, Optimization, and Management

## Attività didattica: contenuti

Power grids have recently changed their perspective from a conventional highly centralized system where the power is generated at the centre of a star using limited renewable resources to a distributed and highly integrated one, where the nodes are basically microgrids that support smart meters, smart appliances and often work as microgenerators through rooftop solar electric systems, small wind turbines or fuel cells.

Smart meters deliver signals that can help to reduce consumption at the different levels of the systems in order to cut costs. Also the exchange of relevant information is bidirectional. Smart grids can be studied as complex systems and the signals there generated can be analyzed with modern signal processing methodologies, like time-frequency analysis or adaptive frequency estimations and optimization. Among the advantages of smart grids there are a more efficient transmission of electricity, an improved security and reduced management costs.

The aim of this course is to give to some selected students of the “Regioni Convergenza” of Southern Italy, in particular of the University Mediterranea of Reggio Calabria, the opportunity to integrate their curriculum with updated, innovative and advanced topics that can be then of more general importance to the development of energy policy in their regions.

Lectures are intended to give a bird’s eye view on the major engineering aspects of the signal processing to the study of “smart grids” in order to yield to the students most practical insights on the design of relevant systems paying special attention to the efficiency of the developed solutions.

The first part of the course will yield the theoretical foundations needed to manage the problems and test-cases presented in the second part of the program, where the main emphasis will be on practical considerations and laboratory applications.

The use of duly developed software codes will be of great help to complete the preparation of the students.

The course will be developed in two parts, each corresponding to ten hours of both frontal lessons (lectures) and laboratory experiments. The main part of the course will be based on the textbooks of the applicant.

Part 1 (10 hours) : Introduction to the study and analysis of Smart Grids; History of the Grids; Introduction to the numerical modelling of engineering energy problems, Foundations of Signal Processing; Smart Meters and Home EMS; Smart Home and Smart Appliances; Power Generation and Microgrids; Non-stationary time-series analysis; Forecasting techniques for Electricity Loads and Prices; Laboratory: Practical Test Cases; Benchmark Problems.

Part 2 (10 hours) : Smart Grids Applications; Widely Linear Adaptive Estimators; Complex Valued nonlinear adaptive filters; Non-circularity; Neural Models (see textbook of the same author); Event Detection; Synchronization; Renewable Resources; Grid Components; Complex Networks; Laboratory: Signal processing methodologies for energy problem solution.

A third module of about ten (10) hours will be devoted to practical work from students that will be involved in the preparation of a small thesis based on the topics of the course.

## Attività didattica: metodi

The course is divided in three parts that are strictly related with the aim of learning not only theoretical aspects of the topic but mainly to focus on abilities to do. Two parts will include a both a theoretical and a practical section. A third section will involve directly the students in small project-works.

The students will be asked to actively attend the lectures, motivated to posing questions and to improve judgment abilities. The description of what is presently done at the Imperial college of London on the subject will give the opportunity to share international experiences and to know the way how others face the same environmental and energy problems.

The content of the lectures will be made available in the form of power point slides. The suitable didactic aids will be suggested, with particular reference on the textbooks of the applicant that focus on the above described topics.

### **Periodo di svolgimento:**

Da: 23/09/2013 a: 2/10/2013

### **Attività didattica:**

Numero ore di lezione: 20 (in English)

Numero ore di laboratorio/esercitazione: 10

### **Attività pratiche:**

During the course period, various exercises and laboratory experiments will be proposed to the students. The practical experience will be graduated on the different levels reached by the students by also making any correction may appear needed on the basis of the students' response. Some experience will be done by guiding the students on the implemented codes on PCs.

### **Attività di valutazione:**

To check the level of competencies if the students in relation to the developed topics, the teacher will pose questions and questionnaires during the lectures. The final test will be in the form of questions with multiple choice to evaluate the final level of comprehension of the proposed topics or through a colloquium.

### **Modalità e criteri di selezione:**

By also exploiting the results of the test, there will be a final stage of selection of the two students (at the graduate level) that will do the experience of visiting the College. The selected students need to possess an adequate knowledge of English language measured at least by a B1 European level. The selection will also be carried out on the basis of the proficiency and the votes reported in the University exams.

### **Attività all'estero:**

The didactic activity abroad will mainly focus on the same subjects proposed to the students during the course in Italy, with special emphasis on the way how the activities are carried out at the College. The students will visit the Department at the College and will interact with other international students to gain a not only scholastic experience. They will also meet researchers and professors of the Department.

### **Periodo attività all'estero**

Da: 01/04/2014 a: 31/05/2014

Durata della permanenza all'estero: 2 mesi

### **Diffusione dell'esperienza:**

At the end of the visiting period, the students will prepare a technical report in the form of a thesis on a selected subject. The report will also highlight notes on the different aspects of the didactic project thus including the social activities and the way how the activities are organized at the College. This is also because, coming back in Italy, they will act as "Knowledge Messengers" not only in terms of technical abilities but also on reporting the life experience they have carried out. The students will give some seminars to the other students in order to communicate their experience abroad.