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## 2EL6140 – Electric machinery, power electronics and grids.

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**Instructors:** Herve Gueguen  
**Department:** CAMPUS DE RENNES  
**Language of instruction:** ANGLAIS  
**Campus:** CAMPUS DE RENNES  
**Workload (HEE):** 60  
**On-site hours (HPE):** 35,00  
**Elective Category :** Engineering Sciences  
**Advanced level :** Yes

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### Description

The supply of electricity to isolated sites such as islands has some specific characteristics due to the small size of their power grid. This leads to a high risk of instability and therefore the control of a microgrid, including all its electrical components, is crucial for its proper operation.

This elective proposes to study this issue from two perspectives:

- **Electrical engineering:** presentation of the key electrical components of an alternating microgrid
- **Automatic control:** implementation of control techniques on these components and introduction to the control of large-scale systems (i.e. how to go beyond the “classical” control theory which only deals with 2–3 variables).

Note: the electrical engineering program of this elective is close to the “Energy Conversion” elective offered in Paris-Saclay. The automatic control part is unique to this elective.

### Quarter number

SG8

### Prerequisites (in terms of CS courses)

Power systems concepts you need to know (e.g. by having taken the first-year elective “Electrical Energy (ENE)”):

- Power in AC regime:  $P$  (active),  $Q$  (reactive) and  $S$  (apparent)
- **Three-phase** electric power system: phase-to-neutral and phase-to-phase voltages



Control theory concepts you need to know (e.g. by having followed the ST5 common course on automatic control):

- Modeling a system by a transfer function
- Regulation of a linear system by a PID controller

Having taken the ST7 “Smart grids and energy challenge: energy management in isolated sites” would be a plus, but is not a prerequisite, as the topics addressed are very different:

- ST7 “Renewable energies and microgrids” course: high level modeling (energy flows), with economic optimization.
- this elective: voltage/current modeling and more detailed analysis of electrical components and their low-level regulation.

### Syllabus

This elective belongs to both *electrical engineering* and *automatic control*, with extra *transversal and practical* skills on the analysis and control of systems thanks to the intensive use of a modeling and simulation software.

For the electrical part, the aim is to understand the operation and modeling of the *energy conversion components* of a microgrid:

- power electronics converters (choppers and inverters)
- AC electric machines (synchronous and asynchronous)

This knowledge is presented through lectures and exercise sessions.

For the automatic control part, the aim is to understand the *control and regulation* strategies of microgrid components, in particular the power electronics converters. In addition, this part includes an introduction to the control of large-scale systems (the microgrid with its many components).

This automatic control part is mainly conducted as hands-on sessions on computers. These sessions are an opportunity to *intensively practice* a modeling and simulation tool (Simulink/Simscape). One of the issues addressed is the choice of a level of details in the model adapted to the objective (compromise between simplicity, speed, fidelity...). This transversal skill is meant to be transposable to other engineering fields.

Note: the optimization of power flows (power dispatch) to ensure the economically optimal operation of a microgrid is not addressed. Indeed, this issue is part of the ST7 optimization project. “Smart grids and the energy challenge: energy management in isolated sites”.



### **Class components (lecture, labs, etc.)**

Lecture sessions aim at acquiring basic knowledge in the field of power systems. These sessions include exercises on paper.

The practical sessions are done on computers (Matlab/Simulink). Computer work can be done in pairs. The time devoted to these sessions is substantial to allow the students to become fully comfortable with the simulation tool.

Lectures: 9 hours, Tutorials: 9 hours, Laboratories: 15 hours, Evaluation (written exam): 2 hours.

### **Grading**

The evaluation of the lecture sessions is one final written exam.

The evaluation of the computer lab sessions is done by checking the progress along the sessions and by a final synthesis report.

The weighting between the lecture part and the practical part is 50%, 50%.

### **Course support, bibliography**

Course site on Edunao:

<https://centralesupelec.edunao.com/course/view.php?id=1494>

### **Resources**

Course staff:

- Pierre Haessig: course supervisor
- Alexandros Charalampidis: computer lab sessions
- Loïc Matel: electric machines & power electronics lectures

Required software: Matlab, with Simulink and the [Simscape Electrical](#) toolbox. Academic licenses for those products are free for all CentraleSupélec students.

### **Learning outcomes covered on the course**

At the end of the lectures, students will be able to:

- *Describe the operation and perform simple theoretical analyses of the electrical machines and power electronic converters covered in the course*



At the end of the practical part, students will be able to:

- *Implement* models of electronic converters in a simulator (Simulink) with a complexity adapted to the phenomena to be studied.
- *Describe* the control structure of an electronic converter and *adjust* some control loops of this structure.
- *Evaluate/analyze* the proper operation of the regulation through well-selected simulations

### **Description of the skills acquired at the end of the course**

The learning outcomes of this course allow validating the following CentraleSupélec engineer core skills:

- C1.2 Use and develop appropriate models, select the appropriate modeling scale and relevant simplifying assumptions to tackle a problem
- C1.3 Apply problem-solving through approximation, simulation and experimentation
- C1.4 Specify, design, build and validate all or part of a complex system