Hybrid electric power systems

Academic Year: (2019 / 2020) **Review date: 13-03-2019**

Department assigned to the subject: Electrical Engineering Department

Coordinating teacher: CASTRONUOVO , EDGARDO DANIEL

Type: Electives ECTS Credits : 6.0

Year : Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

For a correct understanding of this subject it is of utmost importace to have passed the 2nd year subject "Fundamentals of Electrical Engineering".

Also, it is highly recommended to be skilled enough with numerical software applications such as Matlab/Simulink programming environment.

OBJECTIVES

After taking this course, the student should be enabled to describe the behaviour, analyze, design and size a variety of hybrid electric energy systems for stationary and vehicular applications. The description of these simple systems, which will include different technologies for energy storage and conversion, will be based on their electrical parameters (voltages, currents, power), but also on the energy efficiency or their economic costs. The student should be able to solve a practical, low complexity, real problem including all of the above mentioned issues.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction
The actual energy scenery. Limits for current generation systems, and potential of energy storage. The load curve.
2. General aspects of energy storage
Conventional (classical) electrical energy storage: pump hydro power plants. Classification of energy storage technologies: flywheels, superconducting coils, CAES, batteries, ultracapacitors. Ragone Diagramms. Historic evolution of energy storage systems.
3. Batteries
Constitutive parts of a battery. Different battery technologies: Ni, Li, Pb, flow batteries. Operation principle. Characteristic curves. Main parameters: capacity, state-of-charge, state-of-health. Equivalent circuits. Sizing a battery system. Series/parallel connection. Discharge times.
4. Fuel cells
Hydrogen economy: hydrogen as energy vector: suitability of hydrogen infraestructures, safety related issues, hydrogen storage. Constitutive parts of a fuel cell: stack, auxiliary systems (cooling, draining, etc). Avalaible fuel cell technologies: PEM, SOFC, AFC. Characteristic curves. Main parameters. Equivalent circuits. Sizing of a fuel cell system.
5. Ultracapacitors
Constitutive parts and operation principle: load separation. Characteristic curves and equivalent circuit electrical parameters. Sizing of a ultracapacitor application: series/parallel connection. Calculation of discharge times.
6. Hybrid energy systems
Stationary applications: interface to main energy source or electrical network. Energy management for peak shaving, load shifting and load levelling. Transport applications: electric, and hybrid electric vehicles, Power flows and power share among different energy sources (ICE, FC, battery, UC). Suitability of each energy storage technology. base power, regenerative braking.

LEARNING ACTIVITIES AND METHODOLOGY

The course will include:
- Lecture sessions, where the theoretical aspects of the subject will be presented and debate sessinos where the students will make on oral presentation of their assigned homework, followed by a debate.
- Practical sessions where practical cases and numerical problems will be presented, solved and

discussed, and
- Laboratory sessions, where the students will have the opportunity of a hands.on experience with this energy systems, make measurements and experience their behaviour.
The students should develop a short assignment over a particular topic of this subject, that will require the search of additional information by themselves.
the students are assumed to consult periodically web page in AulaGlobal2, carefully read the informations posted on it, accurately follow the instructions and deliver the assignments on time.

ASSESSMENT SYSTEM

The course can be passed by one of the two options, to be chosen by the student:

Ordinary call:

1. Continuous evaluation 100%
2. Continuous evaluation 40% and final exam 60%

Extraordinary call:

1. Continuous evaluation 40% and final exam 60%
2. Final exam 100%

Continuous evaluation:
Laboratory activities
Oral presentations in classroom
Personal assignments

% end-of-term-examination:	40
% of continuous assessment (assigments, laboratory, practicals…):	60

BASIC BIBLIOGRAPHY

- C. A. Vincent. Modern batteries: an introduction to electrochemical power sources, Edward Arnold.
- J. Larminie. Electric vehicle technology explained, John Wiley & Sons.
- J. Larminie. Fuel cells systems explained, John Wiley & Sons.
- R. Baxter. Energy storage: a non technical guide, PenWell.

ADDITIONAL BIBLIOGRAPHY

- I. Husain. Electric and hybrid vehicles: design fundamentals, CRC.
- R. Dell. Undestanding batteries, RS C.
- R. J. Press. Introduction to hydrogen technology, John Wiley & Sons.

BASIC ELECTRONIC RESOURCES

- . Wikipedia - Battery: http://en.wikipedia.org/wiki/Battery_%28electricity%29
- . Battery University: http://www.batteryuniversity.com
- . The Electropaedia - Battery and Energy Technologies: http://www.mpoweruk.com/index.htm
- . How stuff works - Batteries: http://electronics.howstuffworks.com/battery.htm