

## Course guides

### 300027 - CESA - Electronic Circuits and Power Supply Systems

**Last modified:** 12/05/2017

**Unit in charge:** Castelldefels School of Telecommunications and Aerospace Engineering  
**Teaching unit:** 710 - EEL - Department of Electronic Engineering.

**Degree:** BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2009). (Compulsory subject).  
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2015). (Compulsory subject).  
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2015). (Compulsory subject).  
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERINGS/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING - NETWORK ENGINEERING (AGRUPACIÓ DE SIMULTANÈITAT) (Syllabus 2015). (Compulsory subject).

**Academic year:** 2017    **ECTS Credits:** 6.0    **Languages:** Catalan, Spanish

#### LECTURER

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**Coordinating lecturer:** Definit a la infoweb de l'assignatura.

**Others:** Definit a la infoweb de l'assignatura.

#### PRIOR SKILLS

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- Know the voltage-current relationships in resistors, capacitors, coils and ideal transformers.
- Analysis of linear circuits, with both resistive and reactive elements.
- Analysis of circuits with operational amplifiers applying the virtual short circuit.
- Know the basic circuits with operational amplifiers.
- Solve linear differential equations of first and second order.
- Know the representation of Bode by identifying the poles and zeros of the transfer function.
- Know the basic concepts of harmonic distortion, active and reactive power.
- Know the Maxwell equations about electromagnetism.

#### REQUIREMENTS

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You must already pass the following subjects:

- Física
- Cálculo y Matemáticas de la Telecomunicación
- Electrónica de las Telecomunicaciones

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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**Specific:**

1. CE 16 TELECOM. Capacidad de utilizar distintas fuentes de energía y en especial la solar fotovoltaica y térmica, así como los fundamentos de la electrotecnia y de la electrónica de potencia. (CIN/352/2009, BOE 20.2.2009.)

**Generical:**

5. EFFICIENT USE OF EQUIPMENT AND INSTRUMENTS - Level 1: Using instruments, equipment and software from the laboratories of general or basic use. Realising experiments and proposed practices and analyzing obtained results.

#### Transversal:

2. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.
3. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
4. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.
6. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.

## TEACHING METHODOLOGY

The teaching methodology for the theory group is based on participatory lectures that include "Activities in the classroom". For the laboratory group 7 guided practices are proposed, where students, in groups of 2 to 3 people, must do a previous study outside the classroom and a later experimental execution in the scheduled laboratory sessions. In each session, the teacher tracks the progress of each group.

## LEARNING OBJECTIVES OF THE SUBJECT

At the end of the subject of Electronic Circuits and Power Systems, the student must be able to:

- . Identify the basic blocks that form a power system.
- . Know the topology of the electrical network, both its structure, the conversion form from three-phase to single-phase, and the different schemes of distribution at low voltage.
- . Identify the problems of safety of the electrical network, both for the circuits as for the users. As well as identifying and describing the respective protection devices, and analyzing the basic circuits where these devices appear.
- . Know the physical principle of operation, electrical model and characteristics  $I / V$  and  $P / V$  of the cells and photovoltaic panels.
- . Calculate the power supplied by a photovoltaic panel based on its geographic location, slope, and system topology, as well as size it for a given load.
- . Know the different electrochemical storage devices such as batteries, fuel cells and supercapacitors.
- . Know different ways of measuring current in order to monitor power systems, as well as to know, analyze and design appropriate conditioning circuits using differential amplifiers and to a lesser extent isolation.
- . Analyze and design conditioning circuits based on operational (voltage feedback) amplifiers including the effects of offset voltages, bias currents, CMRR, Slew Rate, and bandwidth.
- . Know the different types of circuits for energy conditioning, as well as the concepts of energy efficiency and power density.
- . Know the operation of DC / DC converters, in particular linear regulators, load pumps and switched converters, interpreting commercial specifications, and analyzing and designing circuits based on them.
- . Know the basic operation of diodes and MOSFET transistors in switching, their use as switches.
- . Know and analyze the basic topologies of single phase rectifiers and inverters in semipunto and complete bridge.
- . Know basic block diagrams and specifications of some common power systems such as linear and switched power supplies, uninterruptible power supplies, and power systems from the Ethernet network and the USB bus.

## STUDY LOAD

Type	Hours	Percentage
Hours large group	36,0	24.00
Guided activities	6,0	4.00
Hours small group	24,0	16.00
Self study	84,0	56.00

**Total learning time:** 150 h

## CONTENTS

### Evolution and general characteristics of power supply systems

#### Description:

In the theory section, the student is given a brief overview of the historical evolution of power supply systems. Also, briefly enumerate some technical specifications that define these system and the different blocks that comprise them. In the laboratory part, it is shown how to use the basic instruments of the laboratory by expanding the basic knowledge that was given in previous subjects.

#### Related activities:

Activity 1: Lectures.

Activity 2: Experimental and application sessions.

Activity 3: Controls.

#### Full-or-part-time: 14 h

Theory classes: 1h 30m

Laboratory classes: 6h

Guided activities: 1h 15m

Self study : 6h

### Energy sources

#### Description:

The theory part is dedicated to the different sources of energy used by power supply systems. In particular:

- The electrical distribution network.

The topology of the electrical network, both its structure (generation, transport and distribution) and low voltage distribution schemes (TT, TN and IT), is presented. The following describes electrical safety problems, both for circuits (overcurrents and overvoltages) and for users (electric shocks). It is also described how to avoid these problems by means of appropriate protective devices.

- Solar power.

It describes the physical operation, electrical model and characteristics current / voltage and power / voltage of the cells and photovoltaic panels. The electrical parameters of interest are presented and how to use them to calculate the energy generated as a function of the irradiation, the temperature and the topology of the system. It explains how to associate several cells in parallel or in series forming photovoltaic panels and what problems it supposes. Different types of silicon photovoltaic cells (amorphous, polycrystalline and monocrystalline) and their characteristics are introduced. Finally, it is explained how to calculate the energy supplied by a photovoltaic panel according to its geographical location, inclination and atmospheric conditions, as well as its dimensioning to feed a determined load.

- Energy storage devices.

The basic characteristics of electrochemical storage devices are described: primary and secondary batteries, supercapacitors and fuel cells, highlighting their differences. For secondary batteries, their characteristics are described in more detail: load and discharge curves, nominal voltage, capacity, internal resistance and type. It also introduces load, safety and supervision circuits. Finally, it explains how to size a storage system with secondary batteries for a given application, and in particular for autonomous photovoltaic systems.

In the laboratory part, we work from a more applied and experimental point of view electrical safety issues, including devices such as PPTC or MOV. The operation of a photovoltaic panel and the design of a protection circuit of secondary batteries are shown experimentally to avoid overcharging and overdischarging.

#### Related activities:

Activity 1: Lectures.

Activity 2: Experimental and application sessions.

Activity 3: Controls.

#### Full-or-part-time: 42 h

Theory classes: 10h 30m

Laboratory classes: 8h

Guided activities: 2h

Self study : 22h

### (ENG) Títol contingut 3: Circuits per a la supervisió dels sistemes d'alimentació

#### Description:

The theory section describes functions and variables of interest in the supervision of a power system and shows how to determine them by means of current and voltage measurements. The signal chain is analyzed to digitize the information, presenting some examples. Subsequently, different types of current sensors (shunt resistance, current and Hall effect transformers) and appropriate conditioning circuits are described in more detail. The design of amplifiers is then introduced using operational amplifiers, considering the effects of offset voltage, bias currents, CMRR, Slew Rate and bandwidth.

In the laboratory part, the design of a conditioning circuit for a resistive shunt current sensor is performed from a more applied and experimental point of view. It is formed by a differential amplifier where the effects caused by the non-ideal characteristics of the operational amplifier are analyzed.

#### Related activities:

Activity 1: Lectures.

Activity 2: Experimental and application sessions.

Activity 3: Controls.

**Full-or-part-time:** 46 h

Theory classes: 12h

Laboratory classes: 4h

Guided activities: 0h 30m

Self study : 30h

### Power conditioning circuits

#### Description:

In the theory section, energy conditioning circuits (DC / DC converters, AC / DC, DC / AC and AC / AC) are described and the concepts of energy efficiency and energy density are defined. DC / DC converters are first introduced, describing three types: linear regulators, switching converters and charge pumps. Emphasis is placed on the first two. The internal structure of the linear regulators (series) is described, including the passage element (transistor in its linear zone) and the control loop. Parameters of interest are described such as line and load regulation, dropout voltage and leakage currents. In addition, we work on the topic of thermal dissipation and the use of heat sinks. As for the switching converters, emphasis is placed on bilinear analysis from the state variables. Some basic converters such as buck, boost and flyback are analyzed and tools are given to analyze others. The control circuit based on PWM modulation is described. The AC / DC conversion describes the basic structures of single-phase rectifiers: half wave and full wave. Finally a brief description of the basic operation of the inverters (DC / AC) is made.

In the laboratory part, the linear regulators are used from a more applied and experimental point of view, and by means of a circuit simulation program (Proteus) the switching converters.

#### Related activities:

Activity 1: Lectures.

Activity 2: Experimental and application sessions.

Activity 3: Controls.

**Full-or-part-time:** 42 h

Theory classes: 10h 30m

Laboratory classes: 6h

Guided activities: 1h 45m

Self study : 25h

## Power supply systems

### Description:

This last part has a desire to summarize and integrate the concepts seen throughout the course. The basic characteristics and block diagram level performance of some power systems are shown very briefly. Specifically, it describes the operation of power supplies, uninterruptible power supplies (UPS), photovoltaic systems and power from the Ethernet network and USB bus.

### Related activities:

Activity 1: Lectures.

### Full-or-part-time: 2 h

Theory classes: 1h 30m

Guided activities: 0h 30m

Self study : 1h

## GRADING SYSTEM

The evaluation criteria defined in the subject's infoweb will be applied

## EXAMINATION RULES.

Attendance at laboratory practices will be mandatory, as will be the delivery of previous studies at the beginning of laboratory classes. In any case, attendance at a practice or delivery of a previous study outside the established terms should be duly justified.

## BIBLIOGRAPHY

### Basic:

- Franco, Sergio. Design with operational amplifiers and analog integrated circuits. 3rd, international ed. Boston [etc.]: McGraw-Hill, 2002. ISBN 0071121730.
- Guirado Torres, Rafael. Tecnología eléctrica. Madrid: McGraw-Hill, 2006. ISBN 844814807X.
- Roberts, Simon. Solar electricity : a practical guide to designing and installing small photovoltaic systems. New York [etc.]: Prentice Hall, 1991. ISBN 0138263140.
- Stanley, William D. Operational amplifiers with linear integrated circuits. 4th ed. Upper Saddle River: Prentice Hall, 2002. ISBN 0130320137.
- Buchmann, Isidor. Batteries in a portable world : a handbook on rechargeable batteries for non-engineers. 3rd ed. British Columbia: Cadex Electronics, 2011. ISBN 9780968211830.
- Erickson, Robert W.; Maksimovic, Dragan. Fundamentals of power electronics. 2nd ed. Dordrecht: Kluwer Academic Publishers, 2001. ISBN 0792372700.

### Complementary:

- Linden, David; Reddy, Thomas B. Handbook of batteries. 3rd ed. New York: McGraw-Hill, 2002. ISBN 0071359788.
- Castañer Muñoz, Luis. Energía solar fotovoltaica. Barcelona: Edicions UPC, 1994. ISBN 8476533756.
- Mohan, Ned; Undeland, Tore M.; Robbins, William P. Power electronics : converters, applications, and design. 3rd ed. New York [etc.]: John Wiley & Sons, 2003. ISBN 0471226939.
- Pérez García, Miguel Ángel. Instrumentación electrónica. 2ª ed. Madrid: Thomson, 2004. ISBN 8497321669.

## RESOURCES

### Other resources:

- Software: MPLAB, Proteus i LabView.
- Class notes, slides and problem collections that will be available to the ATENEA digital campus.