

Course Unit	Electrical Power Systems	Field of study	Energy
Bachelor in	Renewable Energy Engineering	School	School of Technology and Management
Academic Year	2023/2024	Year of study	3
Type	Semestral	Semester	1
Level	1-3	ECTS credits	6.0
Code	9910-743-3102-00-23		
Workload (hours)	162	Contact hours	T - TP - PL 30 TC - S - E - OT - O -

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s) Susana Sofia Alves Freitas, Ângela Paula Barbosa da Silva Ferreira

### Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:

1. model the power system components under steady state conditions;
2. use the "per unit" system for power systems analysis;
3. formulate the load flow problem through Gauss-Seidel, Newton-Raphson and fast decoupled load flow methods;
4. solve load flow problems using computational tools;
5. use computational tools to simulate symmetrical and unsymmetrical faults;
6. understand the technological context related to the actual trends of DC-based energy systems and microgrids.

### Prerequisites

Before the course unit the learner is expected to be able to:

1. analyse linear circuits in direct current and alternate current (single-phase and three-phase);
2. understand numerical methods to solve nonlinear equations;
3. understand the fundamentals of electrical machines;
4. use programming languages.

### Course contents

Transmission and distribution systems. The "per unit" system. Power systems analysis: mathematical models, load flow formulation (Gauss-Seidel, Newton-Raphson, fast decoupled load flow methods and the linearized model). Symmetrical faults.

### Course contents (extended version)

1. Introduction to power systems
  - Historical evolution of electrical energy
  - Energy sources: classical generation and distributed generation
  - DC and AC energy transmission systems
  - Electrical energy grids and micro grids
  - The Portuguese utility
2. Basic concepts
  - Load diagrams
  - Balanced three-phase power analysis
  - Load characteristics
3. The per unit system
  - Definitions
  - Base quantities
  - Change of base
  - Fundamental laws of power systems in per unit system
4. Transmission and distribution lines
  - Series resistance and inductance
  - Capacitance and admittance
  - Equivalent circuit under steady state conditions
  - Thermal limit
  - Power transmission capability
5. Load flow analysis
  - Mathematical model
  - Bus classification
  - Solving load flow problems
  - The Gauss-Seidel method
  - The Newton-Raphson method
  - The fast decoupled load flow method
  - The linearized model
6. Symmetrical faults
  - Models of network components under fault conditions
  - Fault calculations

### Recommended reading

1. J. Paiva, Redes de Energia Eléctrica, uma Análise Sistemática, IST Press, 4th edition, 2015
2. J. Grainger, W. Stevenson, G. Chang, Power System Analysis, McGraw-Hill Education, 2nd edition, 2015
3. A. C. Zambroni de Souza, M. Castilla, Microgrids Design and Implementation, Springer, 2018
4. J. H. Chow; J. J. Sanchez-Gasca, Power System Modeling, Computation, and Control, John Wiley & Sons Ltd., 2019
5. L. Powell, Power System Load Flow Analysis, McGraw-Hill, 2005

### Teaching and learning methods

Theoretical classes: presentation of the course contents. Practical and laboratory classes: presentation of practical examples to support the expected learning outcomes; problem solving and critical analysis of the results. Non-presential hours: specific proposals on problem solving and accomplishment of evaluation work.

### Assessment methods

1. Distributed assessment - (Regular, Student Worker) (Final, Supplementary)

**Assessment methods**

- Practical Work - 15%
  - Intermediate Written Test - 15%
  - Final Written Exam - 70%
2. Global assessment - (Regular, Student Worker) (Final, Supplementary, Special)
- Final Written Exam - 100%

**Language of instruction**

Portuguese, with additional English support for foreign students.

**Electronic validation**

Ângela Paula Barbosa da Silva Ferreira, Susana Sofia Alves Freitas	José Luís Sousa de Magalhaes Lima	Ana Maria Alves Queiroz da Silva	José Carlos Rufino Amaro
29-09-2023	11-10-2023	14-10-2023	31-10-2023