Course guide
240290 - 240EN13 - Introduction to Electric Power System

Last modified: 21/06/2024

Unit in charge: Barcelona School of Industrial Engineering
Teaching unit: 709 - DEE - Department of Electrical Engineering.

Degree: MASTER'S DEGREE IN ENERGY ENGINEERING (Syllabus 2022). (Optional subject).

Academic year: 2024 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: VINÍCIUS ALBERNAZ LACERDA FREITAS

Others:

PRIOR SKILLS

- Basic knowledge of engineering calculus is necessary.
- Basic knowledge of operations with complex numbers is necessary
- All simulation activities will be performed using Matlab/Simulink, thus it is adivisable that the student acquire before or during the course a basic knowledge of Matlab/Simulink, especially Simscape Electrical or SimPowerSystems library.

REQUIREMENTS

All simulation activities will be performed using Matlab/Simulink.

TEACHING METHODOLOGY

Hybrid classes for main concepts, combining theoretical concepts, exercises and problems.

LEARNING OBJECTIVES OF THE SUBJECT

The main course objectives are
• Provide students with the essential background in electrical engineering, electrical machines, power converters and power systems to prepare them for future courses in the field of electrical engineering and power generation.
• Balance the knowledge between students with electrical and non-electrical engineering background.
• Provide an applied view of conventional electrical engineering concepts that are typically taught in a purely theoretical manner

The objective is that, after sucessfully completing this course, the student will be able to:
- Explain the structure of a power system.
- Describe power system components and explain their functions.
- Selecting appropriate models for power system components.
- Perform calculations on AC and DC circuits.
- Understand the energy conversion process into electrical power.
- Calculate power system quantities based on the per unit (p.u.) system.
- Identify differences between a simple electrical circuit and a three-phase power system.
- Summarize operating principles of a power system in terms of control of voltage, active and reactive power.

CONTENTS

Part I – Introduction to electric power systems

Description:
• Conventional power system
• Generation, transmission network and distribution network
• Power system operation
• Network examples

Specific objectives:
Objectives:
• Introduce the main elements of the power system and its essential components
• Describe the basic operation of the power system

Full-or-part-time: 6h
Theory classes: 3h
Self study : 3h

Part II – Basic electrical engineering concepts

Description:
• AC and DC currents
• Circuit elements and basic circuit laws
• AC voltage generation
• Phasors for AC systems
• Impedance and admittance
• Power in AC systems (active, reactive, apparent)
• Three-phase systems essentials
• Activity with Matlab Simulink model to understand AC and DC systems

Specific objectives:
• Explain the basic concepts of electrical engineering to understand and perform basic calculations with AC circuits
• Introduce three-phase AC systems (fundamental to understanding the power system and power generation)

Full-or-part-time: 21h
Theory classes: 9h
Guided activities: 3h
Self study : 9h

Part III – Synchronous generators

Description:
• Basic principles of electromagnetism applied to electrical machines
• Power plants
• Main concepts of electrical machines
• Operating principle of synchronous generators
• Motor/generator operation
• Rotor and stator main parts
• Excitation systems
• Voltage generation in a synchronous generator
• Synchronous generator when operating in load conditions
• Equivalent scheme of the synchronous generator
• Phasor diagram of the synchronous machine
• Excitation control (voltage control)
• Power/torque expressions and motor/generator operation
• Single machine: voltage regulation

Specific objectives:
• Understand the fundamental operation principles of synchronous generators
• Understand how voltage and frequency are controlled in synchronous generators

Full-or-part-time: 8h
Theory classes: 4h
Self study : 4h

Part IV – Power converters

Description:
• Basic principles of power electronics
• Converter circuits
• Voltage-source converters
• Pulse-width Modulation
• Basic control methods of voltage-source converters
• Applications to PV plants
• Applications to Wind plants
• High-Voltage Direct Current systems

Specific objectives:
• Understand the fundamental operation principles of power converters used in renewable generation

Full-or-part-time: 8h
Theory classes: 3h
Guided activities: 2h
Self study : 3h

Part V – Fundamentals of power system control

Description:
• Frequency and power control basics
• Demand-generation equilibrium
• Frequency regulation: primary, secondary and tertiary regulation
• Primary frequency regulation
• Curve Power-frequency of a generator
• Droop frequency characteristic constants
• Power reference for generators
• Generators Q-V curve
• Generator connected to the main network
• Generators connected in parallel
• Secondary regulation
• Frequency response services from renewables

Specific objectives:
• Understand the fundamentals of control of electric power systems

Full-or-part-time: 7h
Theory classes: 3h
Guided activities: 1h
Self study : 3h

GRADING SYSTEM

Mid-term exam = 40%
Final exam = 60%
Assignment = (pass or fail)

BIBLIOGRAPHY

Basic:
- Glover, J. Duncan [et al.]. Power system analysis and design. 5th ed. Stamford: Cengage Learning, cop. 2021. ISBN 9781111425791.
- Kundur, Prabha S.; Malik, Om. Power System Stability and Control [on line]. 2nd. New York: McGraw Hill, 2022 [Consultation: 05/07/2024]. Available on: https://www-accessengineeringlibrary-com.recursos.biblioteca.upc.edu/content/book/9781260473544?implicit-login=true. ISBN 9781260473544.
- Boylestad, Robert L. Introductory Circuit Analysis. 12th. Prentice Hall, 2010. ISBN 978-0137146666.
- Robbins, Allan H. ; Miller, Wilhelm C. Circuit Analysis: Theory and Practice. 5th ed.. Dehli: Delmar Cengage Learning, 2013. ISBN 9788131519028.
- Ceraolo, Massimo; Poli, Davide. Fundamentals of Electric Power Engineering: From Electromagnetics to Power Systems. 1st. Wiley-IEEE Press, 2014. ISBN 9781118679692.
- Chapman, Stephen. Electric Machinery Fundamentals. 5th ed. New York: McGraw-Hill, 2012. ISBN 9780071086172.