Syllabus
2023 - 2024

GENERAL INFORMATION

Data of the subject	
Subject name	Electric Power Systems Control
Subject code	DIE-MII-531
Mainprogram	Official Master´s Degree in Industrial Engineering
Involved programs	Máster Universitario en Ingeniería Industrial [First year]
Level	Intercambio
Quarter	Semestral
Credits	4,5 ECTS
Type	Obligatoria
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Office hours	By appoinment

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DESCRIPTION OF THE SUBJECT

Contextualization of the subject

Prerequisites

Knowledge of electric power systems

Course contents

Contents

Theory

1. Introduction

   1. Power flows in AC systems. Series and shunt compensation
   2. DC transmission versus AC transmission

2. An overview on power semiconductor switches

   1. Line-commutated devices vs self-commutated devices: Thyristors and IGBTs.
   2. Limitations of Si-based semiconductors.
   3. New alternatives

3. Line-commutated FACTS (the first generation)

   1. Thyristor Controlled Reactor (TCR).
   2. Thyristor Switched Capacitor (TSC).
   3. Static Var Compensator (SVC).
   4. Thyristor Controlled Series Capacitor (TCSC).

4. Self-commutated FACTS (the second generation)

   1. Voltage Source Converters: voltage and current control, power-flow control and beyond.
   2. STATic -synchronous- COMpensator (STATCOM).
   3. STATCOM vs SVC.
   4. Static Series Synchronous Compensator (SSSC).
   5. Series + shunt compensator: the Unified Power Flow Controller (UPFC).

5. Power flow with control elements

   1. Power flow with on load tap changing transformers.
   2. Power flow with phase shifter transformers.

6. Optimal power flow

   1. Problem formulation.

2. Objective funcions.
3. Euqality and inequality constraints.
4. Solution methods.

7. Security analysis

1. Contingency analysis.
2. Corrective actions.

8. Power flows with FACTS devices

1. Shunt device control in the power flow solution.
2. Series device control in the power flow solution.
3. Hybrid device control in the power flow solution.

9. Stability

1. Large-disturbance stability of a synchronous machine connected to an infinite bus.
2. Small -disturbance stability of a synchronous machine connected to an infinite bus.

10. Stability enhancement with FACTS devices

1. Large-disturbance stability enhancement of a synchronous machine connected to an infinite bus by shunt and series compensation.
2. Small-disturbance stability enhancement of a synchronous machine connected to an infinite bus by shunt and series compensation.

11. High Voltage DC (HVDC) transmission based on line-commutated converters

1. Components of an LCC-HVDC link.
2. AC/DC conversion with thyristors.
3. Control of a HVDC link.
4. Current harmonics.
5. Reactive power requirements.

12. High Voltage DC (HVDC) transmission based on self-commutated converters

1. Components of an LCC-HVDC link.
2. AC/DC conversion with self-conmutated converters.
3. Control of a HVDC link.
4. Multi-terminal HVDC links.
5. Comparison brtween LCC-HVDC and VSC-HVDC.

13. Power flows with HVDC links

1. LCC-HVDC control in the power flow solution..
2. VSC-HVDC control in the power flow solution.

14. Stability enhancement with HVDC links

1. Large-disturbance stability enhancement by a parallel LCC-HVDC link.
2. Small-disturbance stability enhancement by a parallel LCC-HVDC link.
3. Large-disturbance stability enhancement by a parallel VSC-HVDC link.
4. Small-disturbance stability enhancement by a parallel VSC-HVDC link.

Laboratory

Session 1: Dynamic simulation of a STATCOM using Simulink

Modeling and simulation of a STACOM Matlab-Simulink. Control loops. Performance analysis of a STACOM.

Session 2: Power flow solution with control elements using PSS/E

Power flow with a STACOM. Power flow with a phase shifter transformer. Power flow with a SSSS.

Session 3: Dynamic simulation using PSS/E

Steps of dynamic simulation with PSS/E. Dynamic simulation with PSS/E using Python scripts.

Session 4: Dynamic simulation with shunt FACTS devices using PSS/E

EVALUATION AND CRITERIA

Evaluation activities	Evaluation criteria	Weight
Exams	• 30% Mid-term exam • 70% Final exam	75
Laboratory	• 70%: Laboratory sessions • 30%: Laboratory exam	25

Grading

Ordinary call

Theory: 75%

–30% Mid-term exam

–70% Final exam

Laboratory: 25%

–70%: Laboratory sessions

–30%: Laboratory exam

Grades of both theory and laboratory must be greater than 5 out of 10

Class attendance is mandatory according to Article 93 of the General Regulations (Reglamento General) of Comillas Pontifical University and Article 6 of the Academic Rules (Normas Académicas) of the ICAI School of Engineering. Not complying with this requirement may have the following consequences: students who fail to attend more than 15% of the lectures may be denied the right to do the final exam (and even the retake exam)

Extraordinary call

Theory: 75%

–30% Mid-term exam

–70% Final exam

Laboratory: 25%

–70%: Laboratory sessions

–30%: Laboratory exam

Grades of both theory and laboratory must be greater than 5 out of 10

If the grade of the laboratory is greater than 5 in the ordinary call, laboratory has not to be retaken

BIBLIOGRAPHY AND RESOURCES

Basic References

P. Kundur, Power System Stability and Control. Mc Graw Hill, 1993.

Advanced References

- N.G. Hingorani and L. Gyugui. Understanding FACTS. Concepts and technology of flexible AC transmission sytems, IEEE Press. 1999
- P. García Gonzalez and A. García Cerrada. Transporte flexible de la energía eléctrica en corriente alterna. Anales de Mecánica y Electricidad, Nov-Dic. 2004. pp 59-66.
- A. Yazdani and R. Iravani. Voltage-Sourced Converters in Power Systems. Wiley-IEEE Press, 2010.
- N.R.Chaudhuri, B. Chaudhuri, R. Majumder and A. Yazdani. Multi-terminal Direct-Current Grids: modelling, analysis and Control. Wiley-IEEE Press, 2014.
- Cigre Study Committee B4, “HVDC and Power Electronics”, http://b4.cigre.org/