Aalto University
School of Engineering

Distributed Generation Technologies

ELEC-E8424 - 5 ECTS

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Fall 2021

Outline

1. Introduction & Course Description
2. Distributed Energy Sources
3. Distributed Generation Technology and it's Application in Power System (i.e., Microgrids and Smart Grids)
4. Control and Operation of Grid-Connected DC/AC Converter
5. Role of Power Electronic Converters in Power System: Presentation by Dr. Mikko Routimo
6. Operation and Control of Converter-Based Synchronous Generators

Course Objectives

At the end of this course, students will be able to:

- Model a general structure for integration of distributed energy sources into the power grid
- Apply some control techniques for control of grid-connected power converters
- Find a solution for problems related to the power grid
- Use the Matlab for simulation of grid-connected converters supplied by DG sources
- Carry out a detailed study for a specific project and do a report.

Course Material

- **Teaching Materials** will be available as pdf form in Mycourse
- **Optional Textbook:** Remus Teodorescu, Marco Liserre, and Pedro Rodriguez, “Grid Converters for Photovoltaic and Wind Power Systems,” Published by John Wiley & Sons, Ltd., Publication.
- Exercises and their solutions (MyCourses)

Complementary References

I. E. Pouresmaeil, C. Miguel-Espinar, M. Massot-Campos, D. Montesinos-Miracle, and O. Gomis-Bellmunt, "A Control Technique for Integration of DG Units to the Electrical Networks," IEEE Trans. on Ind. Electron., vol. 60, no. 7, pp. 2881-2893, Jul. 2013.

II. S. Naderi, E. Pouresmaeil, and David W. Gao, "The Frequency- Independent Control Method for Distributed Generation Systems," Applied Energy, vol. 96, pp. 272-280, Aug. 2012.

III. E. Pouresmaeil, M. Mehrasa, and J. P. S. Catalao, "A Multifunction Control Strategy for the Stable Operation of DG Units in Smart Grids," IEEE Trans. on Smart Grid, vol. 6, no. 2, pp. 598-607, Mar. 2015.

Course Introduction

Prerequisites:

- Power electronics (e.g., basic circuits: rectifiers, converters. Basic concepts for analysis of power electronic circuits, general definition of power factor, harmonic content, power factor correction (PFC), active power filter (APF)).
- Power systems (e.g. single and 3-phase circuit analysis, power calculations, active and reactive power concepts, displacement power factor.
- Control theory (e.g., when an equilibrium point of a system is stable and when it is not, modeling, feedback systems, etc.).
- Familiarity with at least one computer simulation software e.g., Matlab, Pscad, Psim,….
- Knowledge on how to browse through professional publications.

Course Description:

- Graduate level course.
  - Goal #1: To discuss topics related with distributed generation sources and technologies.
  - Goal #2: To prepare the students to conduct research or help them to improve their existing research skills.
- This latter goal implies that students are expected to have a proactive approach to their course work, which in some cases will require finding on their own proper ways to find unknown solutions to a given problem.

Course Format

Schedule is Available in the MyCourses Portal

- Lectures 12x2 h, Tuesday 10:15 -12:00, TUAS-building, via Zoom
- Exams will be online via Zoom.

  E1: Dec. 21, 2021, Tue. 10:00-13:00
  E2: 31 Jan. 2022
  E3: 28 Mar. 2022

- I will be available in my office or via Zoom, if you need to talk with me about the course contents.

Final Exam

- The course will be concluded with a 3-hour written exam with 5 problems.
- An erroneous answer, incomplete or badly motivated solutions give point reductions.
- As a general rule, bad motivation or errors that relate to fundamental principles of the course will lead to large point deductions.
- Computational errors that do not lead to unreasonable answers generally give smaller point deductions.
- The purpose of all exam problems is to test to what degree the students have reached the aims and objectives.
- The course is about understanding, not remembering formulae and/or imitating the solution of the exercise problems.
- You are not allowed to bring with you the databook or teaching materials.

Assignments

- 2 assignments, totally **20% of the course grade**
- Simulations with MATLAB simulator and short problems
- Reports are written **in groups of two (or alone)**
- Submit your answer to MyCourses no later than assigned deadline, late reports will not be accepted!
- Problems will be given (at least) one week before deadline
- Students are encouraged to discuss with other students but copying solutions from other groups is not allowed!

Simulation Topics

- Three phase grid-connected voltage-source converter

Project

- The class includes a project that will require successful students to survey current literature.
- The project consists of carrying out a short research project throughout the course.
- The students need to identify some topic related with the application of distributed generation technologies in power and energy networks.
- The project is divided in two phases:

  Preliminary phase. Due date: **Oct. 19**. Submission of references, application, description, and problem formulation (1 to 2 pages long).

  Final phase. Due date: **Nov. 29**. Submission of a short paper (the report), at most 10 pages long, single column.

Final Presentation:

- Every student is expected to do a presentation discussing their project to the rest of the class as if it were a conference presentation of a paper.
- The format and dates of the presentations will be announced during the semester .

Prospect for working in teams:

- Depending on the course enrollment, I may allow to do both the project and the final exam in groups of 2. I will announce my decision within the first week of classes.

Grading

Grading, Total Points

Terms	Points
Exam	50
Assignment 1	10
Assignment 2	10
Project Abstract	5
Project File	10
Project Presentation	15
Total	100

Grading, Course Grade

Grade	Total Points
Fail	0 -<50%
1	50 -<60%
2	60 -<70%
3	70 -<80%
4	80 -<90%
5	90 -100%

- Without simulation assignments, the maximum achievable course grade is 4. Preparing and returning the assignments is highly encouraged!

Estimated Student Workload

	Contact (h)	Individual (h)	Total (h)
Lectures (á 2h)	24	24	48
Simulation	4	8	12
Preparing for exam		24	24
Taking the exam		3	3
Project Preparation		40	40
Total	28	101	129

- Weekly individual working is necessary for learning!
  - Reading the textbook
  - Going through exercises
  - Preparing homework
  - Discussing with other students, etc.

Questions and comments are most welcome!