# Regulation of Wind Power Plants

## Lab 4

### EEEN40550 - Power System Dynamics & Control

### Learning and Program Outcomes

The main objective of this lab activity is to study the transient response of a simple system with inclusion of a wind turbine. Specific goals are:

- To compare the transient behavior of a constant-speed wind turbine (CSWT, Type A) with a doubly-fed induction generator wind turbine (DFIG, Type C).

- To determine the effect of control parameters of the DFIG wind turbine on its small-signal stability and transient behavior.

- To define the transient response of the CSWT and DFIG with different wind speed inputs.

The program outcome of the lab is to familiarize with a software tool for time domain simulation of electric power systems.

### Exercises

Download from the webpage of the module the data file `wind.dm` and sketch a single-line diagram that represents the system defined in the data file. Using the on-line Dome help, identify the wind turbine device elements and parameters. Details on controller schemes are given in the slides of the module and explained during the lectures.

1. Study the effect of varying machine (e.g., inertia, stator and rotor reactances and resistances) and control parameters (e.g., gains and time constants) of both the CSWT and the DFIG on the small signal stability of the system. With this aim, vary one parameter at a time and draw relevant conclusions. The goal of this exercise is to understand the sensitivity of the models to both machine and control parameters.

2. Using the DFIG and the CSWT models, simulate and compare the transient response of the system with respect of different non-deterministic wind speed models:

   (a) Mexican hat model (`Wind_mexican`)

(b) Composite model (`Wind_compost`)

The purpose of this exercise is to understand the sensitivity of the models to machine, wind and control parameters. Based on the analysis carried out for Exercise 1, use appropriate machine and controller parameters for the wind turbines.

## Data File

Use the file `wind.dm` that can be found in the collection of data files on the module website.

## Hints

- The data file includes two wind turbine models, one CSWT (i.e., Type A turbine) and one DFIG (i.e., Type C turbine), respectively.

- The turbine models and control schemes are those explained in the lectures.

- To run the simulations, always use only one wind turbine model at a time.

- Make sure that the wind turbine model is properly connected to the active wind turbine model.

- For exercise 1, use the Mexican hat model of the wind (`Wind_mexican`). This model is deterministic and it is more appropriate to define the transient response of the wind power plant over a large variation of the wind speed.

- The time domain integration can be solved using the command:

      >> dome -r TDS wind.dm

  Help on available options can be obtained using the command:

      >> dome -A TDS

- Time domain simulation results can be plotted using the `domeplot` command.

- 20 s of simulated time should be sufficient to fully define the behaviour of the system.

- It can be useful to run an eigenvalue analysis to determine whether varied parameters lead to an acceptable (e.g., stable) operating point.

- It can be convenient to set a fixed time step for the time domain integration: `TDS.fixt = True` and a reasonably small time step, e.g., `TDS.tstep = 0.1`.