



S&C ELECTRIC COMPANY
Excellence Through Innovation

EnerNex
CORPORATION

2008 T&D Conference

Modeling of Large Wind Farm Systems for Dynamic and Harmonics Analysis

Part 1 - Dynamics

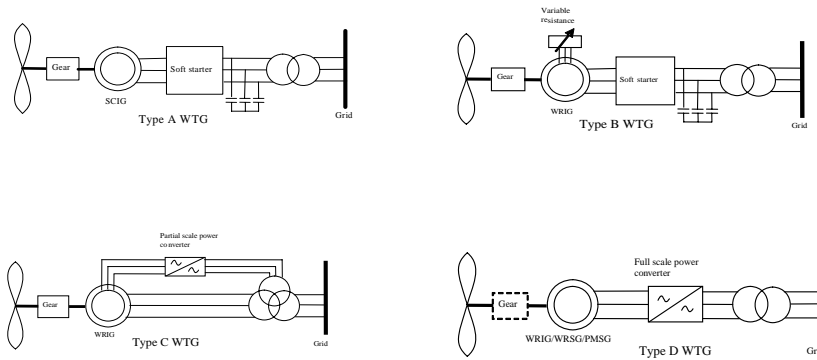
Jun Li, Nader Samaan, Stephen Williams

Chicago, IL
April 23, 2008

Why Do We Do Wind Turbine Modeling?

- Large wind plants (>100 MW) being developed
- Grid impacts must be assessed in the interconnection study
 - Steady state
 - Dynamic
- Computer models of plants required for the study
 - Vendors must provide dynamic models

Types of Wind Turbines



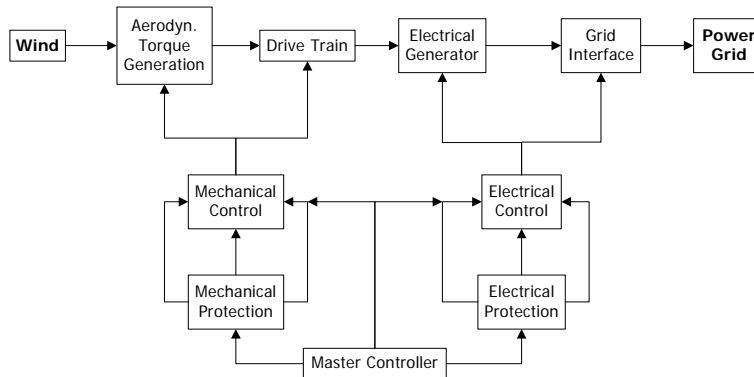
3

Power Control of Wind Turbines

- Fixed-speed turbines
 - Stall control : lose power when the wind speed is over a certain limit
 - Active control : achieve maximal power at lower wind speeds; like stall control at high wind speeds
- Variable-speed turbines
 - Active control: achieve maximal power at lower wind speeds; achieve rated power at high wind speeds

4

Wind Turbine Model – Components and Subsystems



5

Dynamic Models of Wind Turbines

- Pitch controller
 - achieve the optimal power output (wind speed is low)
 - regulate the generator to output the rated power to avoid violating the design limits of the turbine (wind speed is high)
- Aerodynamic model
 - convert the total power in the wind to the mechanical power of the wind turbine
- Drive train model
 - A two-mass model is commonly used. One mass is for the inertia of the turbine rotor; the other is for the inertia of the generator rotor and the gearbox
- Power controller
 - guarantee the generator to follow the predefined power speed curve
- Electric Machine
 - Manufacturer parameters used in standard model

6

Modeling Tools

- Dynamic
 - Phasor solutions
 - Limited control bandwidth
 - Includes discrete protection
 - e.g. PSLF, PSS/E

- Solution time step, 4 ms typical

7

Modeling Tools

- Transient
 - Full RLC components (3 – phase)
 - Full controls bandwidth
 - e.g. PSCAD/EMTDC, EMTP, Matlab/Simulink

- Solution time step 1 – 100 μ s

8

End of Part 1

Questions ?