

COMPARING SINGLE AND MULTIPLE TURBINE REPRESENTATIONS IN A WIND FARM SIMULATION



Brian Parsons

**National Wind Technology Center
National Renewable Energy Laboratory
Golden, Colorado USA**

European Wind Energy Conference
Athens, Greece

February 27 – March 2, 2006

Disclaimer and Government License

This work has been authored by Midwest Research Institute (MRI) under Contract No. DE-AC36-99GO10337 with the U.S. Department of Energy (the “DOE”). The United States Government (the “Government”) retains and the publisher, by accepting the work for publication, acknowledges that the Government retains a non-exclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for Government purposes.

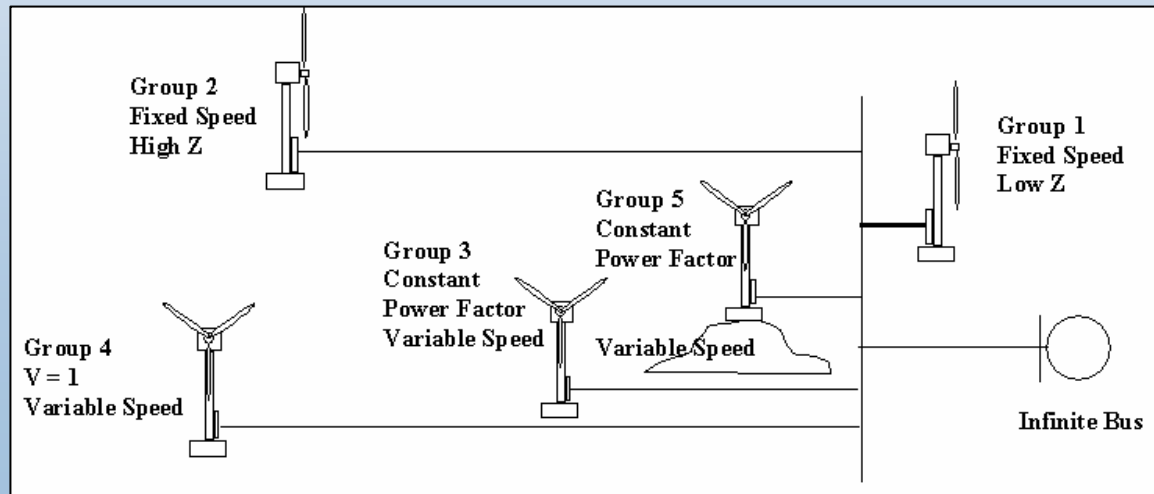
Neither MRI, the DOE, the Government, nor any other agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe any privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement, recommendation, or favoring by the Government or any agency thereof. The views and opinions of the authors and/or presenters expressed herein do not necessarily state or reflect those of MRI, the DOE, the Government, or any agency thereof.

OBJECTIVES

- Investigate different characteristics of wind turbines operating under normal and transient events.
- Understand the signature of each unique characteristic of the turbines.
- Represent the wind farm as a collection of unique groups of wind turbines.

APPROACH

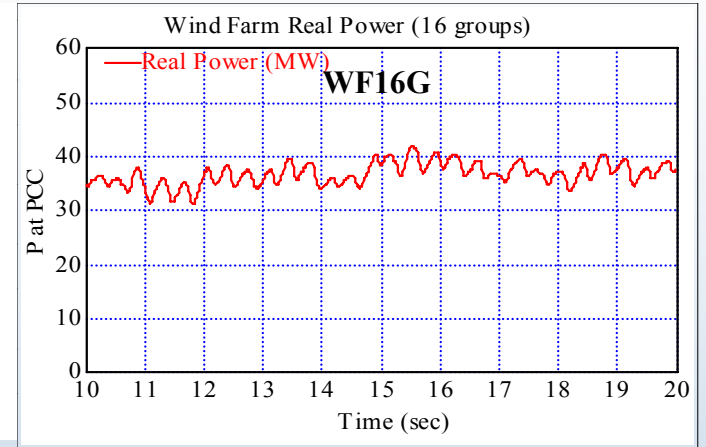
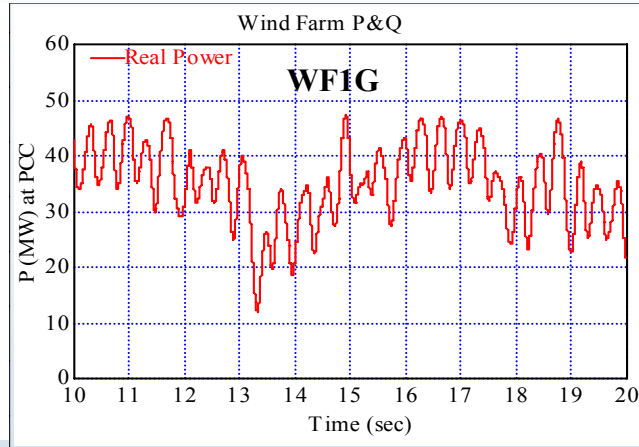
- Simulate a single turbine with different attributes (line impedance, wind speeds, etc.) represented.
- Compare the signature of each unique attribute of each turbine to show the differences in dynamic responses.
- Represent a multi-turbine system on the power system network using a group of turbines with unique attributes.



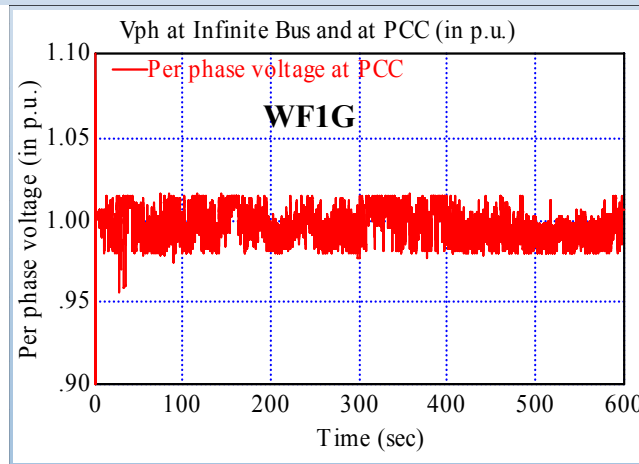
DYNAMIC – NORMAL OPERATION

Tower Shadow Effect

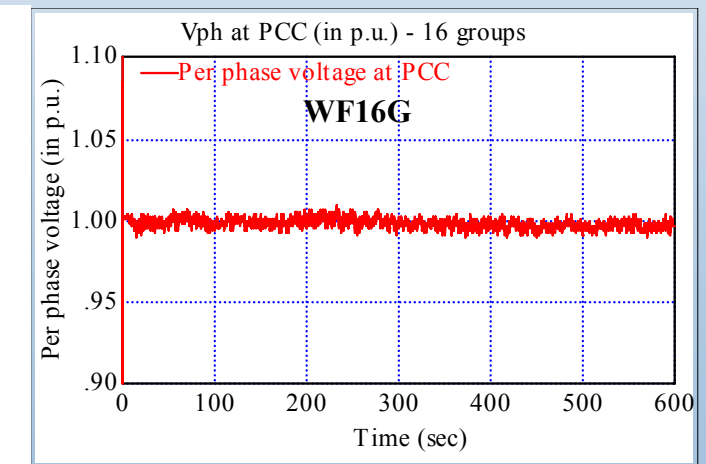
Power



Voltage

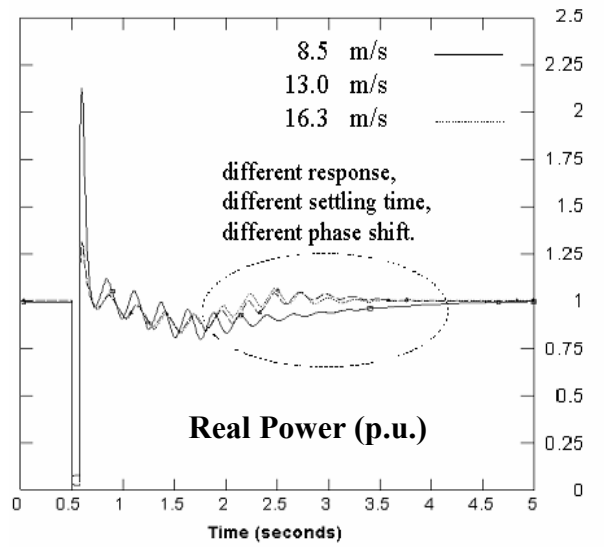
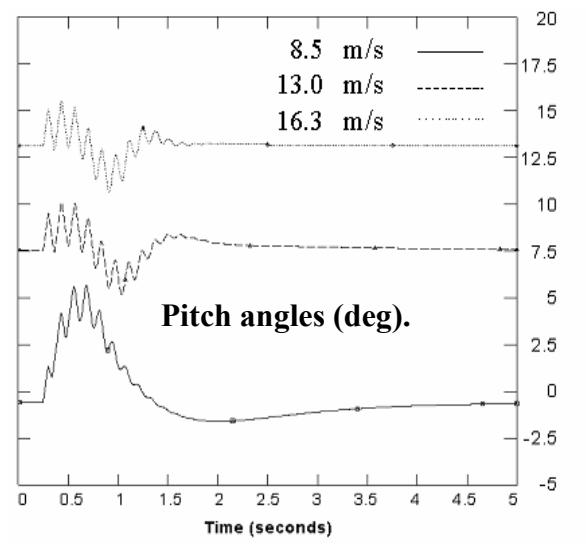
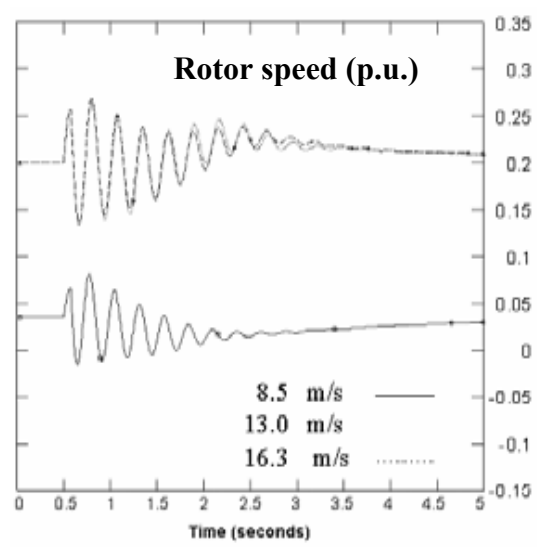
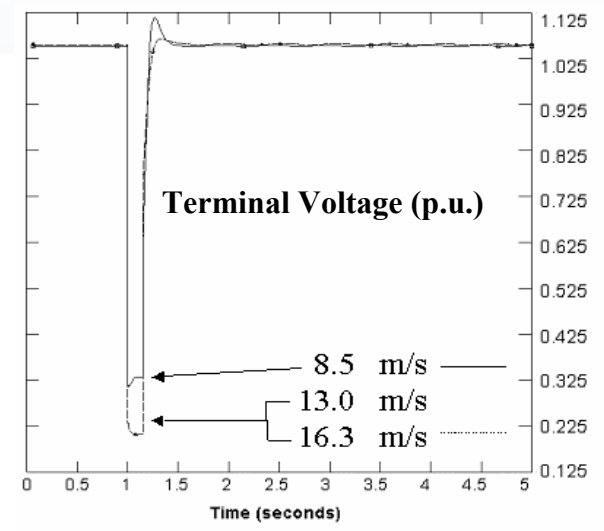
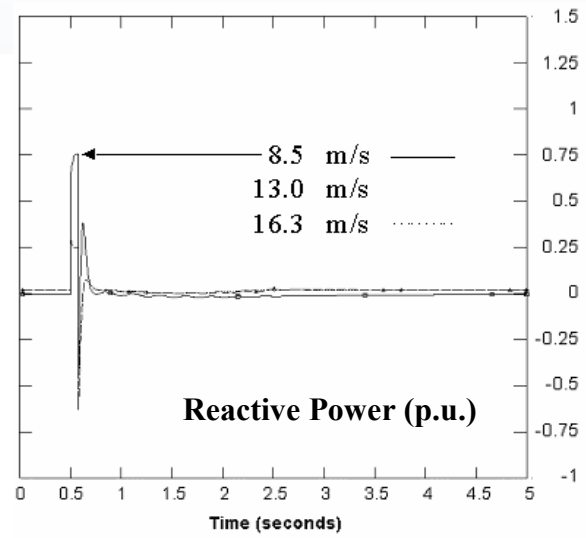
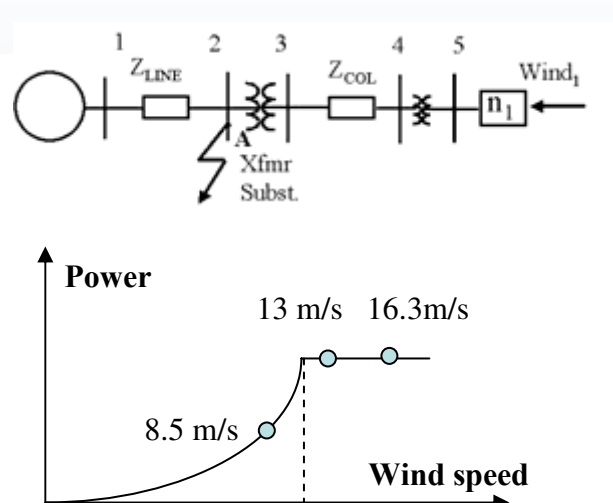


single turbine



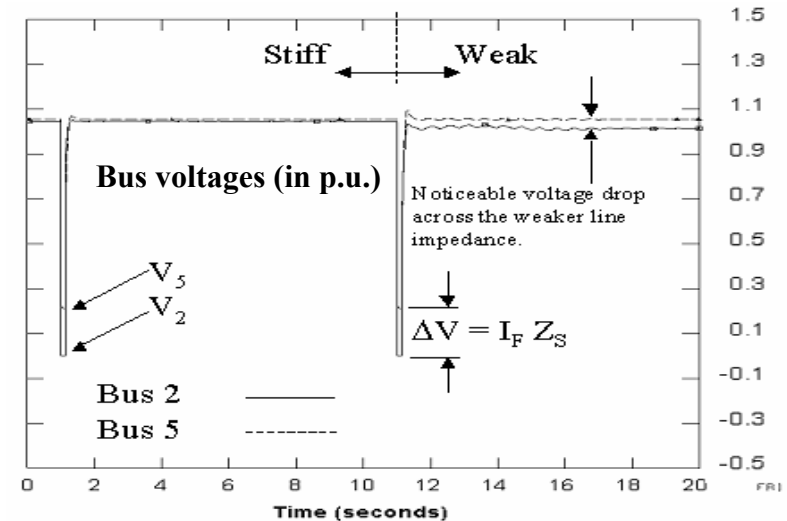
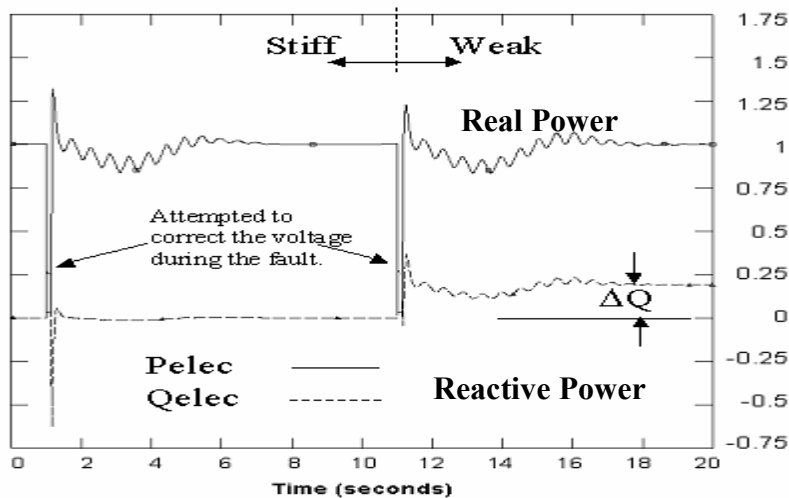
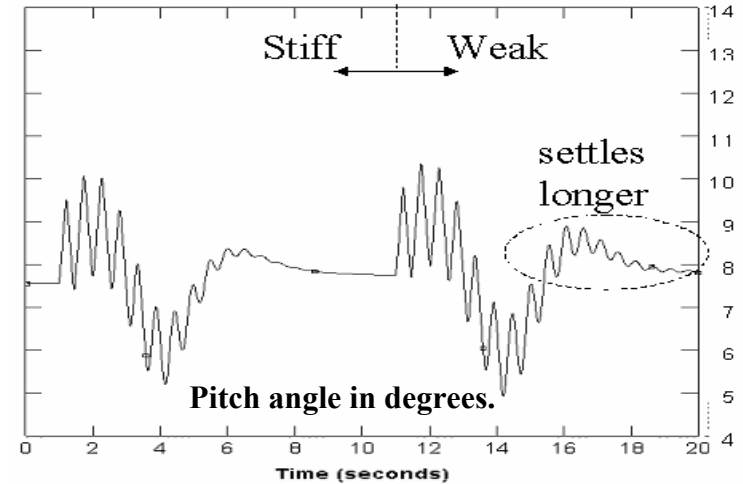
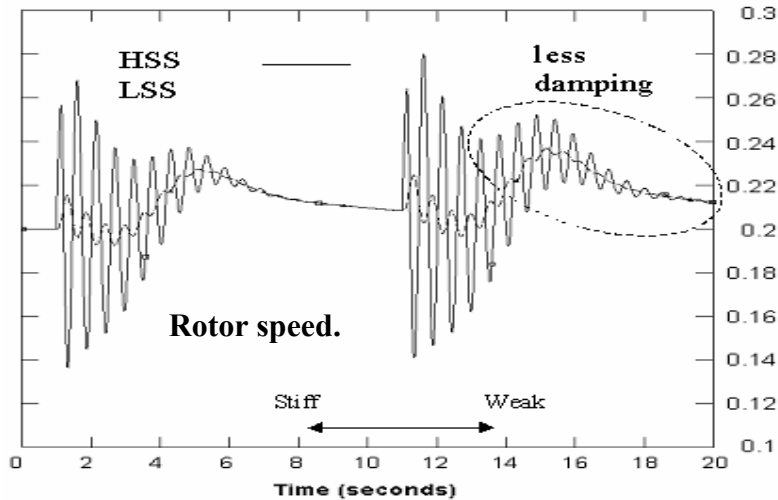
multiple turbines

DYNAMIC – FAULT TRANSIENT Various Wind Speeds



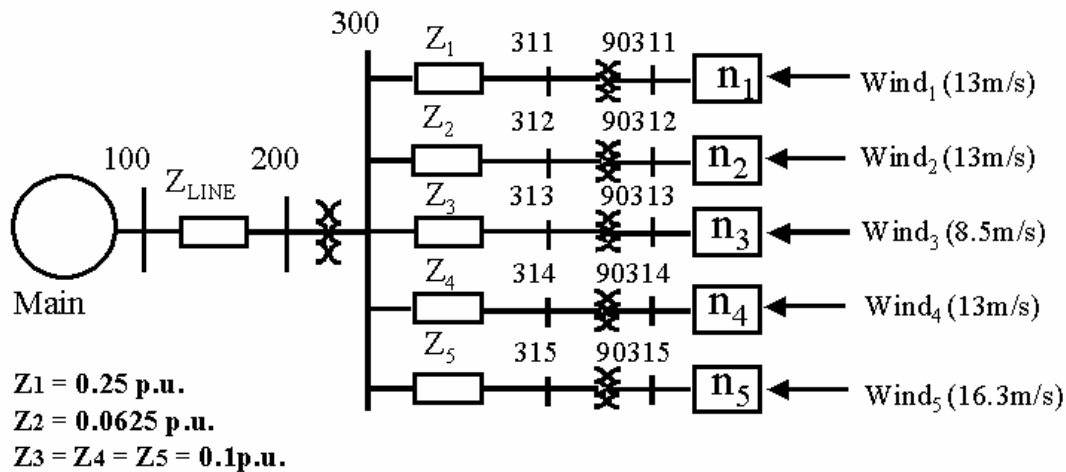
DYNAMIC – FAULT TRANSIENT

Weak Grid vs Stiff Grid

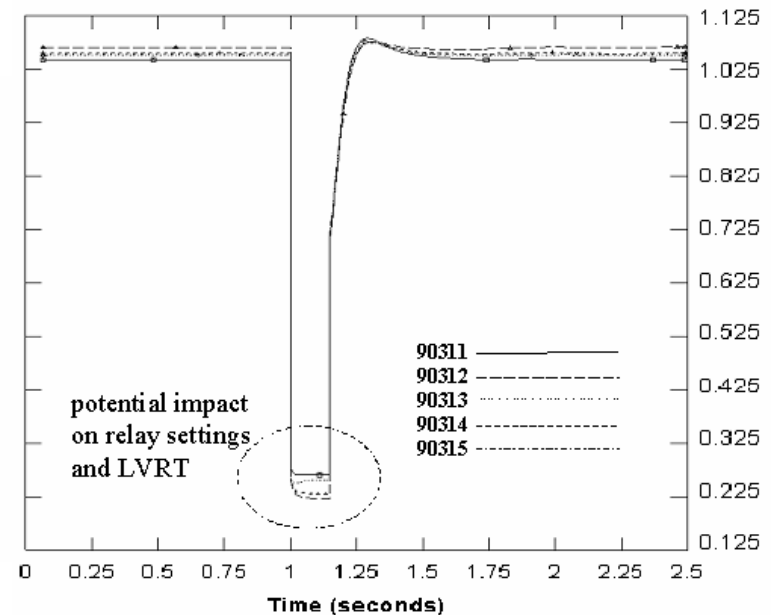


DYNAMIC – FAULT TRANSIENT

Multiple Turbine Representation



Single line diagram of a wind farm with 5 groups of turbines (20 MW/group).



Voltage at the terminals of wind turbines.

CONCLUSIONS

- Diversities characterizing wind turbines such as line impedances, wind speed differences, turbine types, relay protection settings, control strategies, and reactive power compensation etc. may affect the LVRT of each wind turbine.
- Wind turbines are electrically connected but mechanically independent with respect to each other. Mechanical-electrical interaction is less likely to be found in a large wind farm than in a single large conventional synchronous generator.
- In the event of a fault:
 - single turbine representation leads to the worst-case scenario (a single fault event may disconnect the entire wind farm).
 - multiple groups of wind turbines better represent a wind farm and lead to a best-case scenario (a single fault event may disconnect only a few turbines within the wind farm).