



UWIG Technical Workshop

WIND INTEGRATION: FOCUS ON THE NORTHWEST

October 23-24, 2003
Sheraton Seattle Hotel and Towers
Seattle, Washington

Wind Turbine and Plant Modeling: Status and Needs

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Why Models?

- Computer models used in all phase of power system engineering:
 - Planning
 - Design
 - Maintenance and Operatios
 - Assessment and Forensic or Root Cause Analysis
 - Improvement and Enhancement
- Engineering recommendations are based on specific results for the system under consideration, not general rules

Primary Technical Tools

- Power Flow
 - Determines voltages, element loading for specified generation and demand
 - Most basic power system engineering tool
 - A variety of tools are used, but PSS/E and PSLF most common
- Dynamic Simulation
 - Used to show how large power system moves from state to state
 - Requires detailed models of dynamic elements
 - Suitable for simulations of very large power systems
 - PSS/E, PSLF are the standards from U.S. transmission entities
- Electromagnetic Transients
 - Detailed studies of electrical, mechanical, and control interactions
 - Very detailed models of all power system elements
 - Detailed nature of modeling prevents application to large power systems
 - Examples: EMTP, ATP, PSCAD

Important Studies for Wind Generation

- Power Flow
- Transfer Capability
- Transient Stability
- Dynamic Stability
- AGC/LFC/ED – Operations simulations
- Chronological Production Costing
- Specialized Studies (examples)
 - Switching operations (cap bank switching, false breaker tripping)
 - Sub-synchronous resonance
 - Short-Circuit

ERCOT Model Development Project - History

- Discussions of need for better wind plant models in system studies at least as far back as August, 2001
 - Ongoing issues with forced curtailment
 - Recognition that curtailments have linkage to models
- Project scope developed in early 2002
- RFP issued April, 2002
- Project awarded June, 2002
- Project kick off August 1, 2002
- Project completion September, 2003

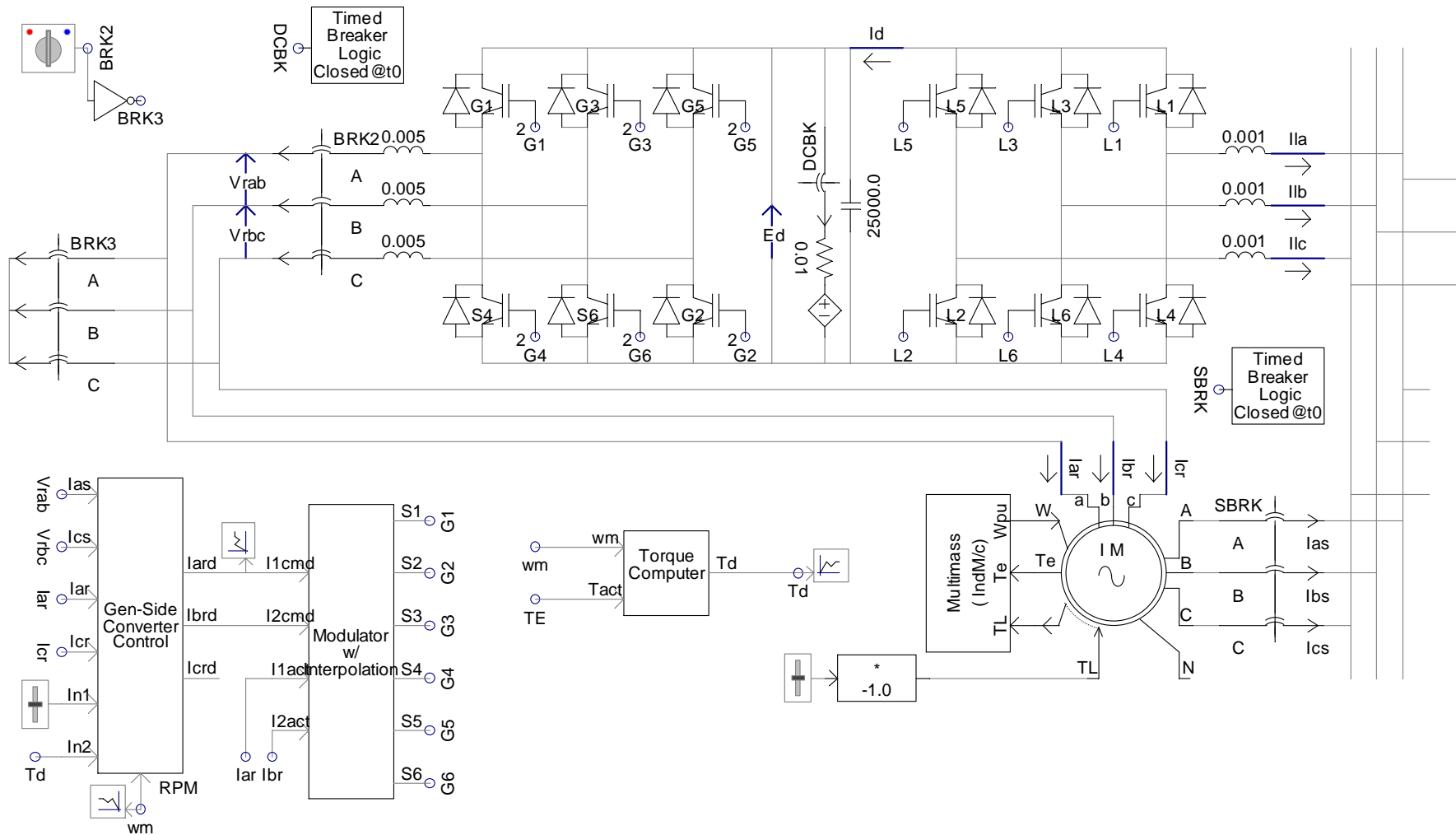
Project Objectives

- Develop models for four categories of commercial wind turbines appropriate for:
 - Steady state analysis (power flow)
 - Transient stability
 - Small signal stability
 - Stabilities studies including long and short-term dynamics
- Validate models with available event data from field measurements
- Document and deliver as “User Models” for PSS/E

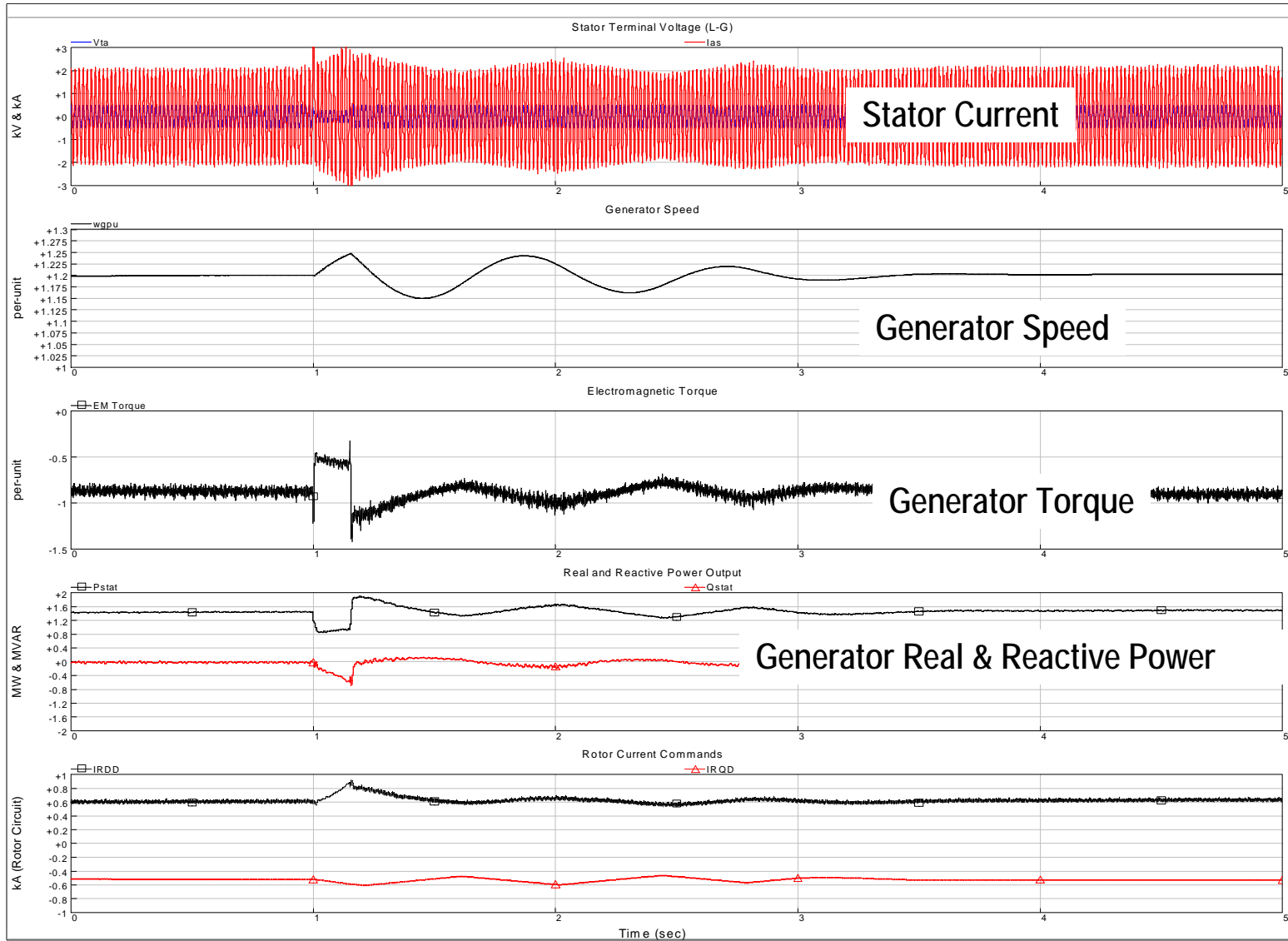
General Approach

1. Develop detailed models for individual wind turbines in PSCAD/EMTDC
2. Execute cases with detailed models and analyze results
3. Use simulation results to reduce the order of the turbine models for the types of events to be studied
4. Construct reduced-order models in PSS/E
5. Compare PSS/E and PSCAD/EMTDC results; refine models if necessary
6. Validate PSS/E models against field measurements

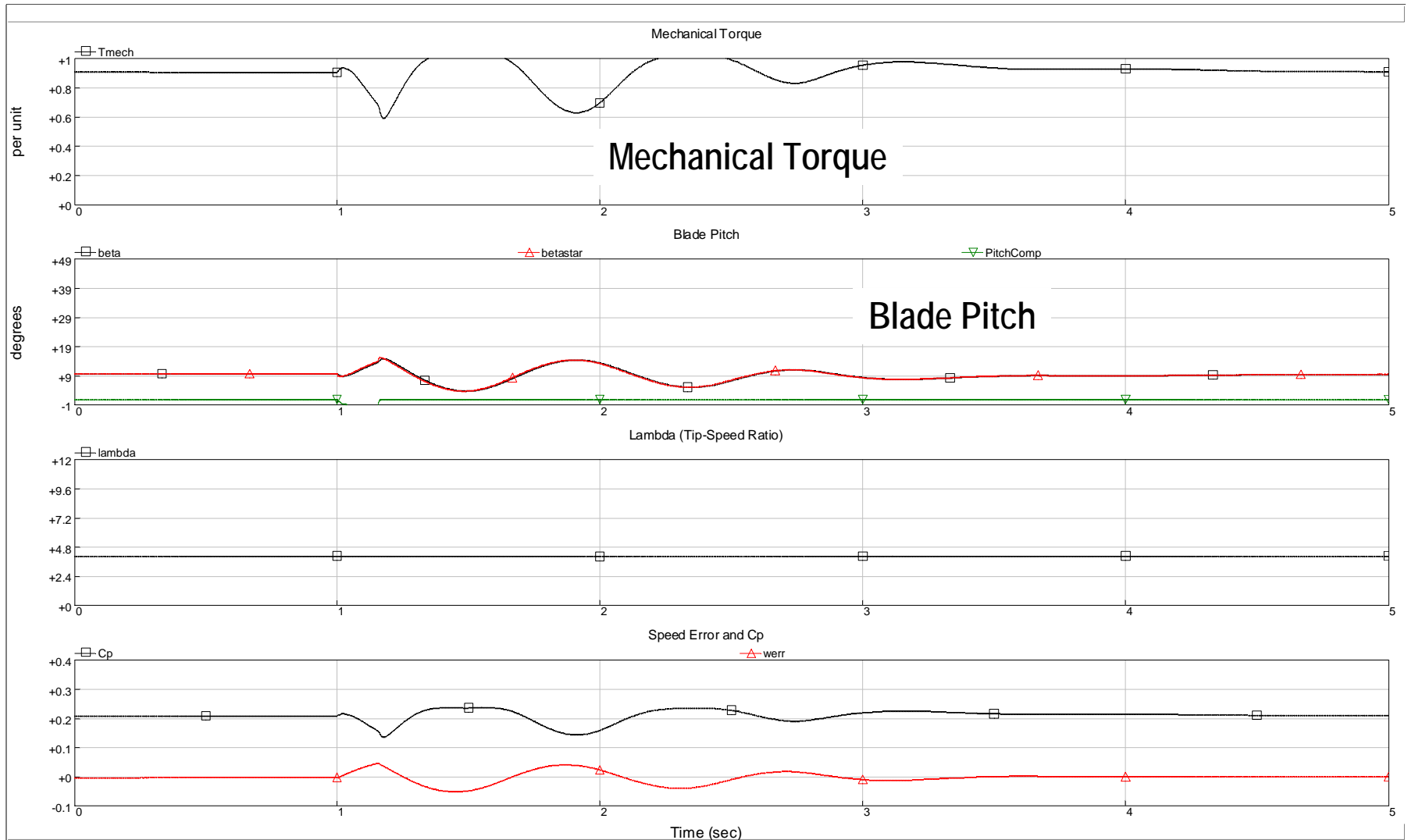
GE Wind 1.5 MW – PSCAD/EMTDC Model



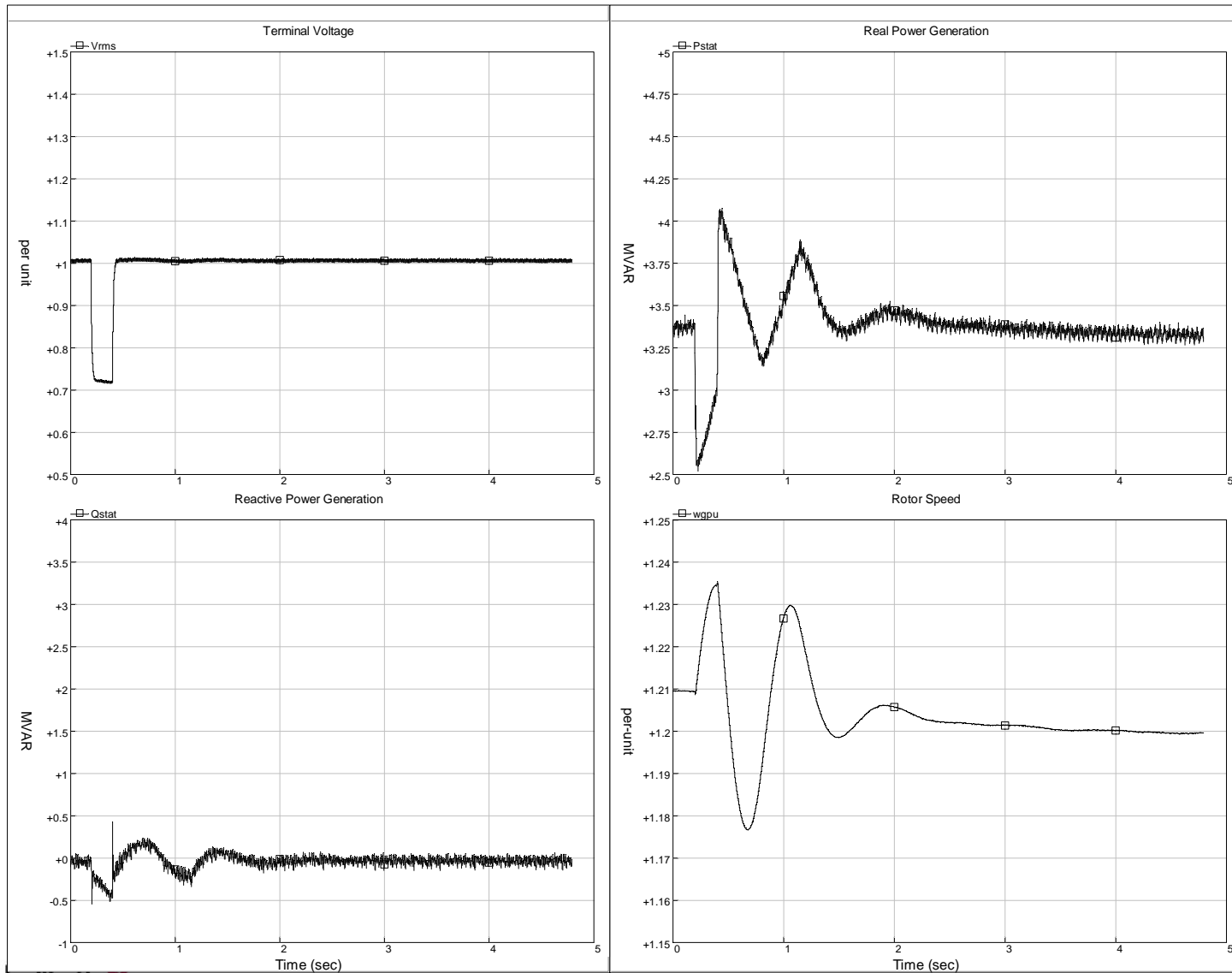
GE Wind 1.5 MW



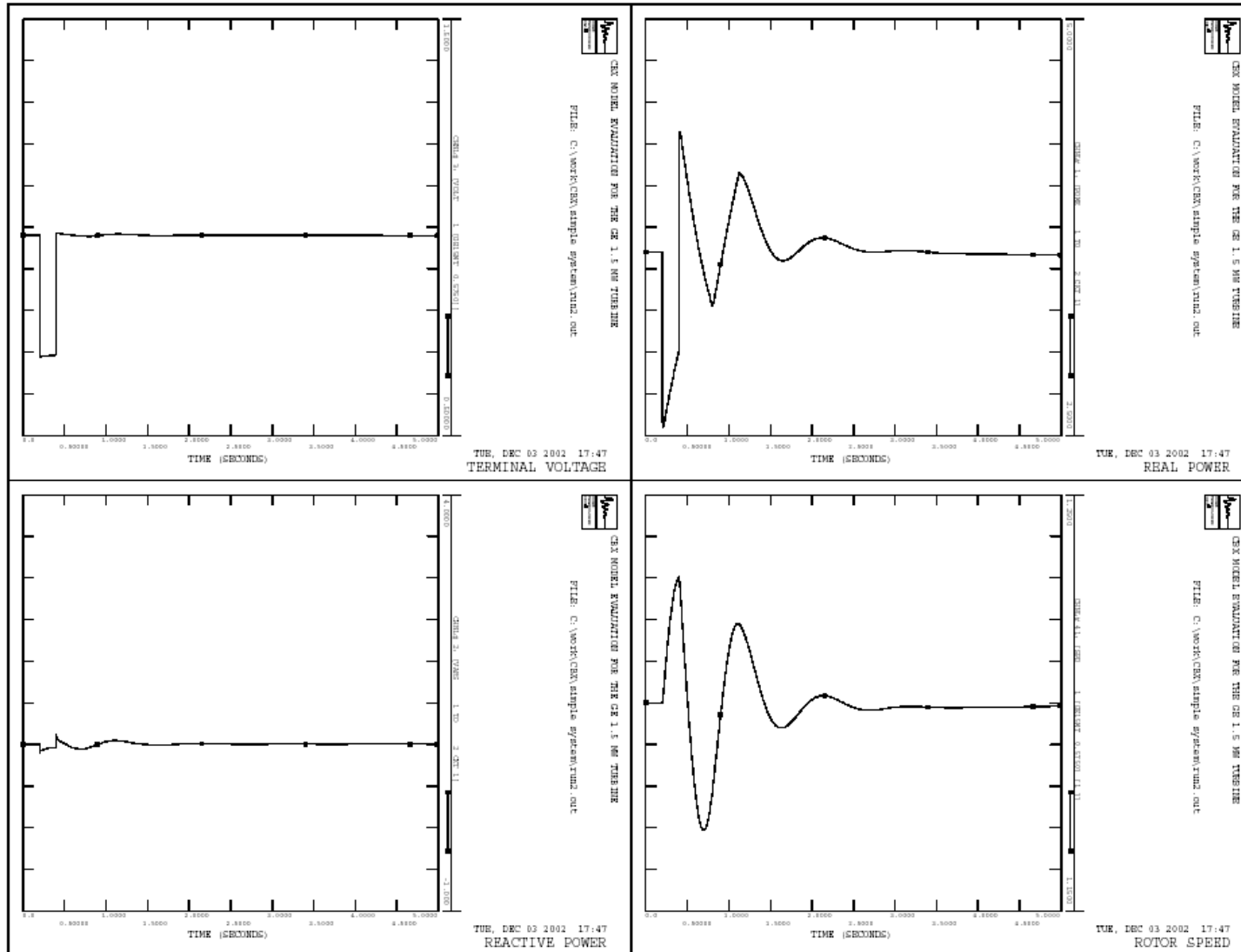
GE Wind 1.5 MW (cont.)



PSCAD Results for Comparison w/ PSS/E



Prototype PSS/E Model Results

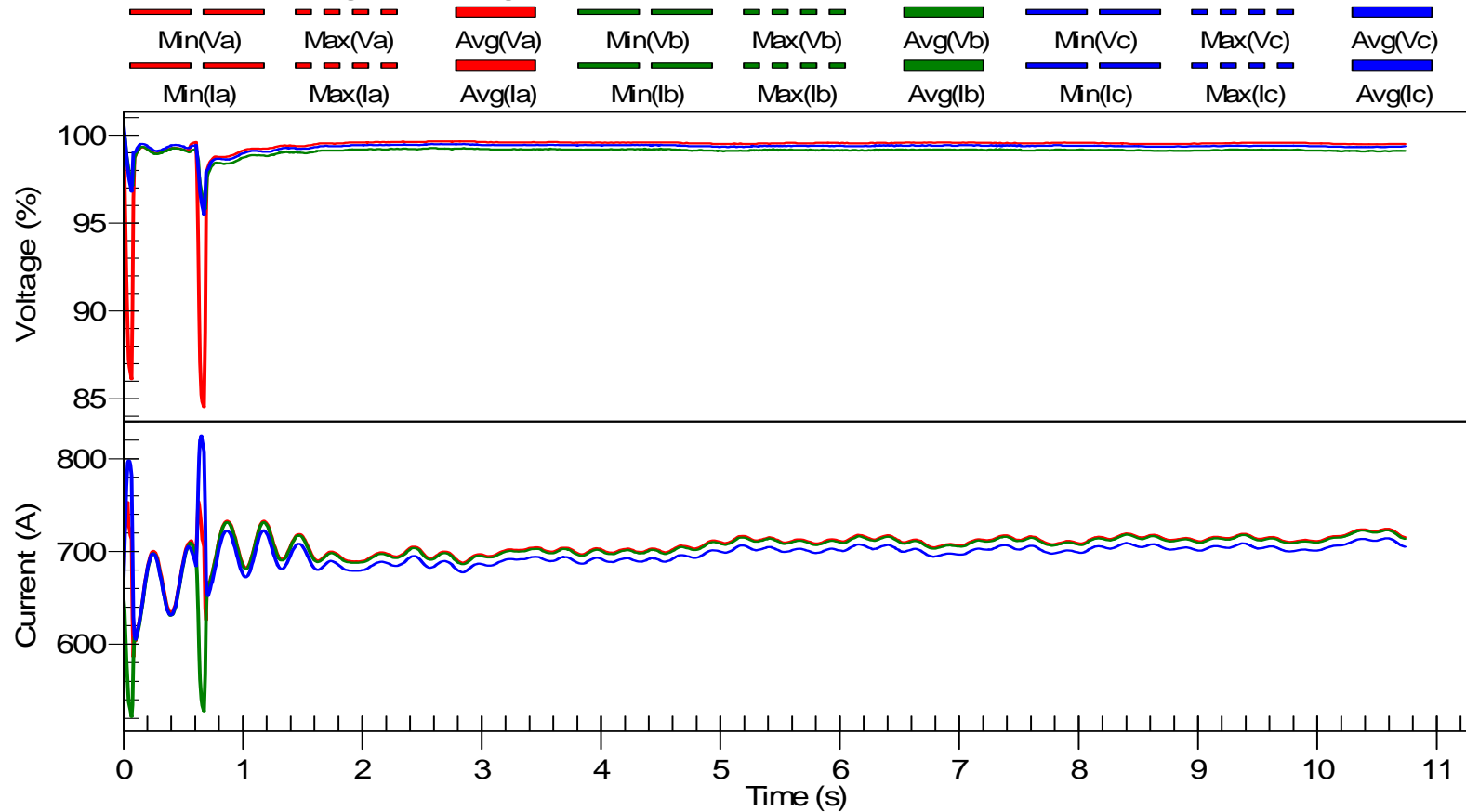


Validation of ERCOT Dynamic Models

- Actual measurements are ultimate measure of model validity
- Quantities of interest
 - Terminal characteristics – voltage current, P, Q
 - Mechanical – speed, pitch
 - Wind speed
- Challenges
 - Both individual turbine and plant level measurements desirable for computer model validation
 - Not feasible to collect both here due to budget and logistical constraints
 - Individual turbine measurement data hard to come by, even from vendors
- Electrical data from interconnect bus best compromise in terms of value and cost

Example Disturbance Data

king42 King Mountain - 5/10/2003 10:03:06.524



Project Status

- 8 months of monitoring completed
- Detailed PSCAD and reduced-order PSS/E single turbine models completed for all 4 turbine types
- Analytical validation of PSS/E turbine models against detailed models completed for all 4 turbine types
- ERCOT wind plant models completed with finalization of TWPP remaining
- Plant model validation against measurements completed
- Presentation

Ongoing Needs

- Model application expertise
- Continuing model validation
- Keeping up with new wind energy technology developments
- Addressing related issues
 - Short-circuit behavior
 - Advanced wind turbine technologies
 - Advanced wind plant designs

Looking ahead...

- Enlisting others in the process
 - Other transmission providers, operators
 - Turbine vendors / customers
 - Industry working groups (e.g. IEEE PES)
- Addressing other power system engineering needs related to wind energy
 - Short-circuit models
 - Operations models
 - Wind plant design
 - Turbine and wind plant requirements/ standards
- UWIG Role?