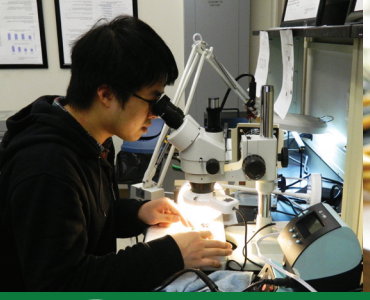
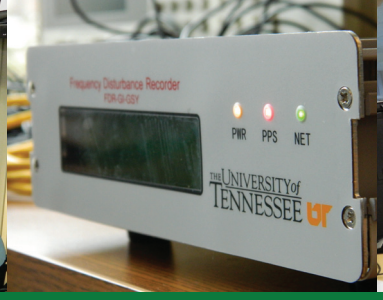


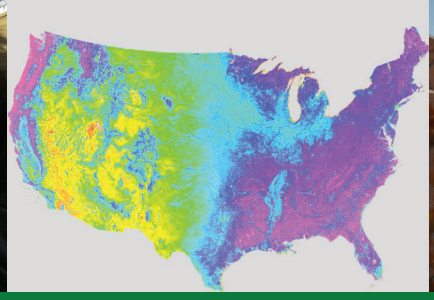


CURENT

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RESEARCH

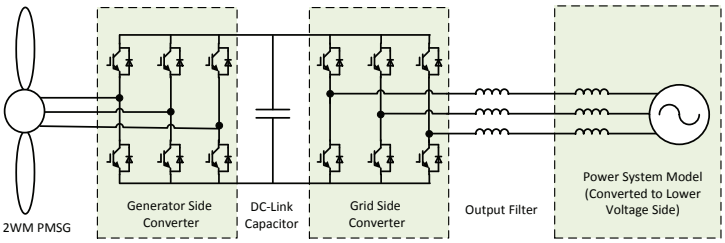
Frequency Regulation and Control with Large Renewable Penetration and Inverter Control

Overview

CURENT foresees renewable systems playing a much more active role in frequency and voltage regulation in grids of the future. To ensure that the electric system of the future can fully utilize these resources, CURENT is developing converter based control systems that can provide advanced voltage and frequency regulation capability.

Technology Pathway

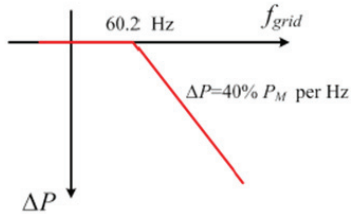
In the U.S., renewable systems today have very limited participation in the voltage and frequency regulation of the grid. However, as the renewable penetration increases, this presents a unique opportunity for renewable systems to participate more actively in regulating voltage and frequency.



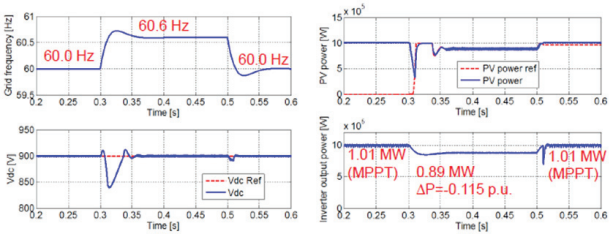
The center is developing the power electronics interfaces and controls needed for active voltage and frequency regulation, including:

- Develop methodology and characterization for using wind and PV solar energy for dynamic grid frequency and voltage support over wide areas
- Explore the effects of inverter-connected sources and loads on electromechanical system stability
- Quantify contributions of distributed, local control policies to system-wide robust stabilization
- Three-phase wind turbine and solar PV models and control systems for interface studies and detailed analysis
- Positive-sequence wind turbine models and control systems for larger grid studies and analysis

P-F Droop



detailed model and simulation of 2-stage grid connected solar PV



Impact

- Control methods that demonstrate how renewable energy sources can provide voltage and frequency support
- Show how large penetrations of renewables can work in the system by using wide area situational awareness and control

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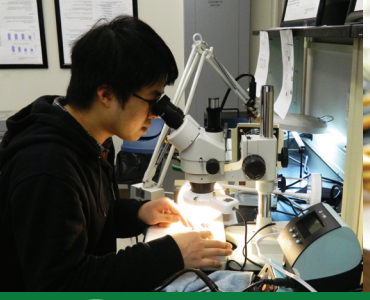
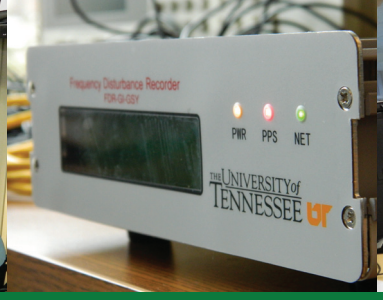


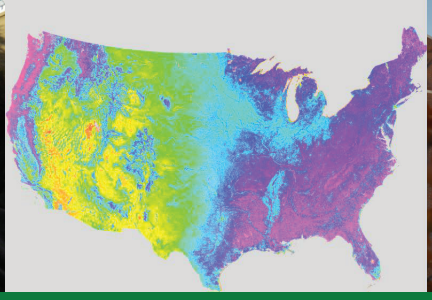


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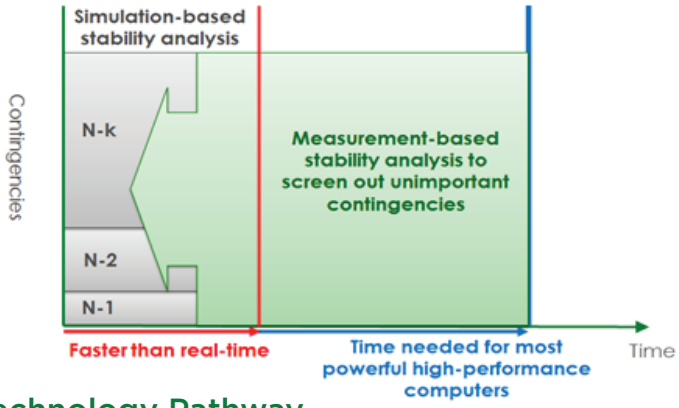
RESEARCH

Hybrid Voltage Stability Assessment

Overview

Voltage stability is a major concern in daily power system operations and a leading factor to limit power transfers in a prevailing open access environment. CURENT is developing a new hybrid voltage stability assessment method combining the traditional simulation-based approach and a new measurement-based approach. The hybrid method aims at calculating voltage stability margin directly from real-time measurements to identify vulnerable areas, and then identifying post-contingency voltage instability and remedial actions by simulations on those areas.

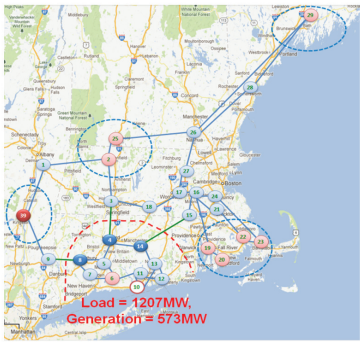
A hybrid scheme: *measurement-based + simulation-based*



Technology Pathway

Presently, model- or simulation-based voltage stability assessment (VSA) programs are widely applied to study voltage stability following given contingencies. If applied in the online environment, such a simulation-based approach helps operators foresee the next most critical contingencies that may cause voltage problems based on the current system state estimate. However, its performance may be influenced by inaccurate models of generation, load, and transmission facilities, or divergence in state estimation under, e.g., stressed conditions. An alternative measurement-based approach is to directly use real-time measurement data to assess voltage stability. To integrate the two approaches, comprehensive voltage stability assessment would be achieved by the following tasks:

- Identify locations (e.g. load buses, transmission corridors, load centers, or grid interfaces), which are more vulnerable to voltage insecurity.
- Develop an accurate measurement-based algorithm to estimate real-time voltage stability margins at those locations. Low margins indicate that additional contingencies may cause voltage problems at those locations.
- Perform simulation-based VSA by high-performance computers (HPCs) focusing on the contingencies related to the locations with low margins based on the most recent state estimate. Identify potential post-contingency voltage insecurity and determine remedial actions.



IEEE 39-bus New England System

Time(s)

Impact

- System operators would be aware of real-time voltage stability issues and be provided with decision support.
- For such a hybrid scheme, the more accurate the measurement-based approach is, the fewer burdens the simulation-based approach will have.

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