PSERC

On-Line Transient Stability Assessment Scoping Study

Vijay Vittal – ASU/ISU
Peter Sauer – UIUC
Sakis Meliopoulos – GA Tech
George K. Stefopoulos, Graduate Student – GA Tech

PSERC Tele-Seminar, May 3, 2005

Project Objectives

PSERC

- Review the state of art in on-line transient stability assessment
- Evaluate promising new technologies
- Identify technical and computational requirements for calculating transient stability limits and corrective and preventive control strategies for operating situations that are transiently insecure.

Primary Components

PSERC

- On-line transient stability analysis vendor survey and analysis
- Member survey and analysis
- Technical survey of the state of the art and suggested new developments in modeling and analytical approach

Vendor Survey – On-Line Transient Stability Tools

PSERC

- A literature survey was conducted to determine vendors who currently deliver on-line transient stability packages.

- Six vendors were identified with products that were advertised and demonstrated at various forums.

Vendor Survey – On-Line Transient Stability Tools

PSERC

- The vendors included
  - Areva T&D Corporation
  - Bigwood Systems
  - Powertech Labs Inc.
  - Siemens EMIS
  - University of Liege, Belgium
  - V&R Energy System Research Inc.

Vendor Survey – On-Line Transient Stability Tools

PSERC

- The vendor survey included 23 questions.
- The questions include a wide range of queries which probed the vendor about the capabilities of their tools.
- The questions are listed in the next few slides.

Vendor Survey – On-Line Transient Stability Tools

PSERC

Name of Vendor

_____

_____

1.Please circle the most appropriate answer

The basis for the DSA Tool is

Full Scale Time Domain Simulation

Extended Equal Area Criterion

Transient Energy Function Method

Other_____ (Please Specify)

2. The DSA tool has a pre-filter to determine critical contingencies given a selected list of contingencies to analyze using a full blow time domain simulation program.

Yes

No

Vendor Survey – On-Line Transient Stability Tools

PSERC

3. The DSA tool interfaces with network data obtained from the real time system using a state estimator

Yes
No

4. The DSA tool has the ability to be automatically triggered following a network topology change
Yes
No

5. The DSA tool can be triggered manually by the operator for a specified condition and list of contingencies
Yes
No

Vendor Survey – On-Line Transient Stability Tools

PSERC

6. The DSA tool is triggered on a regularly scheduled cycle
Yes
No

7. The DSA tool has capabilities to represent the dynamics of the external equivalent
Yes
No

8. The DSA tool has all modeling capabilities available in a conventional time domain simulation package
Yes
No
If No Please Specify what is not available.

Vendor Survey – On-Line Transient Stability Tools

PSERC

9. The DSA tool uses a database structure to facilitate performance
Yes
No

10. The DSA tool converts the traditional EMS bus name – breaker format to a bus number format for analysis
Yes
No

11. The DSA tool uses a multiprocessor architecture to analyze multiple contingencies at the same operating condition
Yes
No

Vendor Survey – On-Line Transient Stability Tools

PSERC

12. The DSA tool has capabilities to stop the simulation if the case is considered to be either stable or unstable
Yes
No

13. The DSA tool has capabilities to analyze faults other than three phase faults
Yes
No

14. The DSA tool has capabilities to represent relay operations and hence subsequent switching following an initiating disturbance
Yes
No

Vendor Survey – On-Line Transient Stability Tools

PSERC

15. The DSA tool has capabilities to calculate critical operating limits in terms of plant generation or critical interface flows
Yes
No

16. The DSA tool has capabilities to represent preventive control and corrective control strategies
Yes
No

17. Please specify the preventive control strategies that can be represented

18. Please specify the corrective control strategies that can be represented

Vendor Survey – On-Line Transient Stability Tools

PSERC

19. The DSA tool has capabilities to represent special protection systems
Yes
No
If Yes please specify the capabilities

20. The DSA tool has sensitivity based or similar analytical tools to account for change in parameters and operating conditions
Yes
No

21. The DSA tool has the capability to detect voltage problems during transient swings
Yes
No
Sort of (explain):

Vendor Survey – On-Line Transient Stability Tools

PSERC

22. The DSA tool can analyze systems of the following size in the following amount of computation time for one run:

System size (buses): _____

System size (generators): _____

Typical computation time for one run: _____

23. The following companies are using our DSA tool:

Analysis of Vendor Survey

PSERC

- Most vendors use a full-scale, time domain simulation computational engine together with either an extended equal area criterion approach or a transient energy function approach to perform transient stability assessment. One vendor uses a specialized approach called the Single Machine Equivalent method.
- All but one tool provide the ability to pre-filter critical contingencies from a given list of contingencies.
- All the tools provide an interface to real time data using a state estimator.
- All the tools except one provide the ability to be automatically triggered following a network topology change.

Analysis of Vendor Survey

PSERC

- All the tools can be triggered manually by the operator for a specified condition and list of contingencies.
- All the tools are triggered on a regularly scheduled cycle.
- All the tools except one have the capabilities to represent the dynamics of the external equivalent.
- All the tools provide the complete set of modeling capabilities available in a conventional time domain simulation package.
- Three of the tools utilize a database structure to facilitate performance.

Analysis of Vendor Survey

PSERC

- All the tools except one convert the traditional EMS bus name-breaker format to a bus number format for analysis.
- All the tools except two use a multiprocessor architecture to analyze multiple contingencies at the same operating condition.
- All the tools have the ability to stop the simulation for cases that are clearly stable or clearly unstable.

Analysis of Vendor Survey

PSERC

- All the tools except one have the ability to analyze faults other than three phase faults.
- All the tools except one have the ability to represent relay operations and hence analyze subsequent switching following an initiating disturbance.
- All the tools have the capability to calculate critical operating limits.

Analysis of Vendor Survey

PSERC

- Three of the tools have the capability to represent preventive control and corrective control strategies.
- Three of the tools have the capability to represent special protection systems.
- Five of the tools use sensitivity-based techniques to account for change in parameters and system operating conditions.

Analysis of Vendor Survey

PSERC

- Five of the tools have the capability to detect voltage problems during transient swings.
- The tools provided by the six vendors vary in their capabilities with regard to system size and performance. The range of system sizes that can be handled by the various tools are from 1500 buses to 100,000 buses, and 300 generators to 15,000 generators. The time performance provided by all vendors for a complete cycle of analysis ranged from 5 - 15 minutes.
- All but one tool have been implemented at a utility company.

Member Company Survey

PSERC

- A survey was also sent to all PSERC member companies.
- Ten member companies responded to the survey.
- The survey questions are not shown here because of a lack of space.
- They are given in detail in the final report.

Member Company Survey

PSERC

- The member companies who responded to the survey included:
  - ABB
  - Arizona Public Service Company
  - IREQ
  - MidAmerican Energy Company
  - NYISO
  - PJM
  - Southern Company
  - TVA
  - TXU Electric Delivery
  - WAPA

Member Company Survey

PSERC

- An on-line transient stability tool that uses both off line data either planning or operations planning, and real time EMS data is preferred.
- A pre-filter to determine critical contingencies is essential.
- Interfacing with the real time data using a state estimator is essential.
- Different modes of triggering the on-line transient stability analysis tool are preferred.

Member Company Survey

PSERC

- The representation of the dynamics of the external equivalent is preferred by most members. Some of the members have provided a detailed description of their needs.
- The members prefer detailed modeling capabilities available in a conventional time simulation package.
- The data base to enhance performance is preferred by most members.
- The conversion to the traditional EMS bus name – breaker format is preferred by most members.

Member Company Survey

PSERC

- Most of the PSERC members preferred the use of a multiprocessor architecture to improve the real time performance of the tool.
- The option to stop clearly stable or unstable cases was also preferred by most members.
- A clear majority of the responders wanted the ability to analyze faults other than three phase faults. One responder wanted the ability to analyze faults that did not occur only at buses.

Member Company Survey

PSERC

- There was unanimous agreement among the responders regarding the need to represent relay operation in the tool.
- There was strong agreement among the member companies with regard to the ability of the tool to calculate critical operating limits.
- A majority of the responders expressed the need for the tool to represent preventive and corrective control strategies.

Member Company Survey

PSERC

- Several of the responders provided a list of the corrective and preventive control strategies needed.
- There was unanimous agreement among all member companies regarding the need to represent special protection systems.
- Several companies expressed the need to evaluate limit changes with changing operating conditions or parameters without repeating the entire exercise.

Member Company Survey

PSERC

- The need to detect voltage problems during the transient swings was also deemed important.
- The system size required by the member companies ranged from 500 buses to 50,000 buses, 200 generators to 10,000 generators, and a single run computation time of less than a minute.
- Two companies currently have tools which they are testing.
- Several companies identified desirable features in tools they would consider.

New Directions for R&D

PSERC

- The analysis of the vendor survey and PSERC member survey clearly indicates a need for on-line transient stability tools.
- The member companies have clearly identified a need for the tool.
- In addition, the responses from the survey clearly indicate a need for research and development in several areas:

New Directions for Research

PSERC

- Protective Control strategies in conjunction with limits derived from on-line transient stability analysis.
- Optimization of the protective control strategies.
- Corrective Control strategies in conjunction with limits derived from on-line transient stability analysis.

New Directions for Research

PSERC

- Optimization of the corrective control strategies.
- Representation of generalized special protection schemes.
- Options for a wide range of preventive and corrective control schemes should be incorporated in the tool.

New Directions for Development

PSERC

- Ability to represent faults other than three phase faults is important
- Ability to locate faults at locations other than at buses is needed.
- Dynamics of the external equivalent needs to be incorporated in some detail.
- Flexibility in terms of relating transient stability limits to system operating parameters should be provided.

New Directions for Development

PSERC

- Graphical display of results for wide-area view; data archiving capabilities; scenario creation and simulation for operator training purposes should be developed.
- Ability to identify additional elements that must be tripped as a result of a breaker failure contingency event.
- Correctly model bus fault or breaker fault contingencies.

Analysis of Needed Analytical Development

PSERC

- A detailed literature survey of the recent work conducted on the topic of DSA was also conducted.
- It was found that the structure preserving energy function method has the potential for being significantly more efficient than other techniques.
- New ideas towards the goal of improving the structure preserving energy function methods have been proposed.

Analysis of Needed Analytical Development

PSERC

- The basic idea is to use detailed quadratized models to represent the system and use this structure to compute equilibrium points and energy functions.
- This approach is promising for two reasons:
  - The computation of the equilibrium points is more efficient since quadratized models converge quickly to the solution – using Newton's type algorithms and
  - The construction of the energy function is simpler and permits more efficient calculation of stability regions.
- The proposed approach needs to be evaluated and its merits be proven.