GRIDSCALE X ADVANCED PROTECTION ASSESSMENT

APA - TS Link Module

Simulating the Smart Electric Power Grid of the 21st Century

SIEMENS

Advanced Protection Assessment – TS Link is a simulation tool that gives electric power grid engineers the ability to design and evaluate the fast, wide-area control needed to avoid cascading outages and blackouts. This next-generation program integrates Advanced Protection Assessment as the premier existing protection simulation program with conventional transient stability programs using new control and communication models to help analyze and design the smart grid of tomorrow.

A survey of selected U.S. electric utilities and industry professionals and a technical white paper published by the North American Electric Reliability Corporation (NERC) indicate that this kind of analysis and simulation capability can be of great value to the industry in evaluating and improving the reliability of the electric grid.

The need for Advanced Protection Assessment – TS Link

Recent blackouts in the United States like the September 2011 and August 2003 disturbances were exacerbated by protection system relays that tripped electrical facilities. The US North American Electric Reliability Corporation (NERC) and the Federal Energy Regulatory Commission (FERC) concluded that overly conservative relays settings, combined with the fact that relay systems operated too quickly, led to large scale outages with millions of people losing power. For the August 2003 event, NERC also concluded that "the relay protection settings for the transmission lines (zone 3 impedance), generator and under-frequency load-shedding in the northeast may not be entirely appropriate and are certainly not coordinated and integrated to reduce the likelihood and consequence of a cascade – nor were they intended to do so." What is needed, therefore, is a means to simulate the bulk electric power system in a way that models the effect of protective relay operations on the dynamic behavior of the system.

Further, to ensure the reliable operation of the electric grid when subject to disturbances, tools are needed for the design and analysis of wide-area control and protection algorithms, which use sensor inputs not just locally, like conventional protective relays do, but from multiple locations in the network.

There has not been such a unified tool available until now. Indeed, it is difficult to model the thousands of local protection relays in a typical transient stability program and often only the action of a few selected relays are reflected, sometimes only manually, in a stability study. On the other hand, the typical software to study protection systems can model thousands of relays but not the dynamic behavior of the power system.

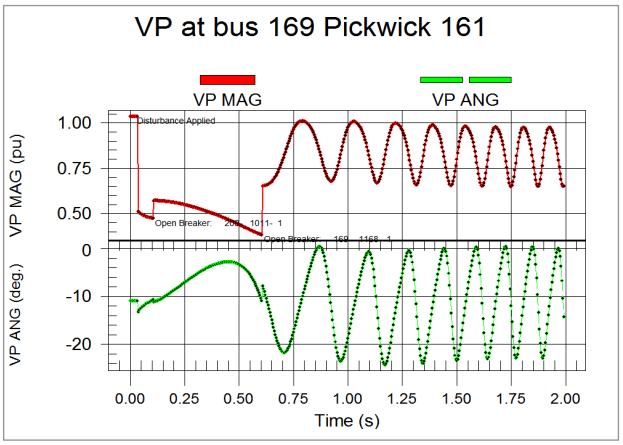

Figure 1: Advanced Protection Assessment – TS Link output showing a plot of the voltage magnitude and angle at a bus, including annotations for when the disturbance was applied, and when breakers opened. This particular simulation results in instability after the fault is cleared, as evidenced by the oscillation in the magnitude of the voltage.

The interdependence of system dynamics and relay actions must be captured if some of these cascading failures are to be accurately predicted and studied. Moreover, the increasing use of special protection schemes and wide-area controls makes it imperative that the available analytical tools be able to adequately model them. The Advanced Protection Assessment – TS Link brings these two approaches together.

How Advanced Protection Assessment – TS Link works

- Siemens PSS®E provides the dynamically changing voltages to Advanced Protection Assessment at each time step. The Advanced Protection Assessment model contains detailed knowledge of the protection system.
- Advanced Protection Assessment calculates branch currents using the PSS®E voltages and Advanced Protection Assessment's own zero- and negative-sequence networks and evaluates relay operation.
  If breakers operate, that information is passed on to PSS®E in that time step.

- The calculation proceeds until the simulation time elapses or the user decides to halt the simulations.

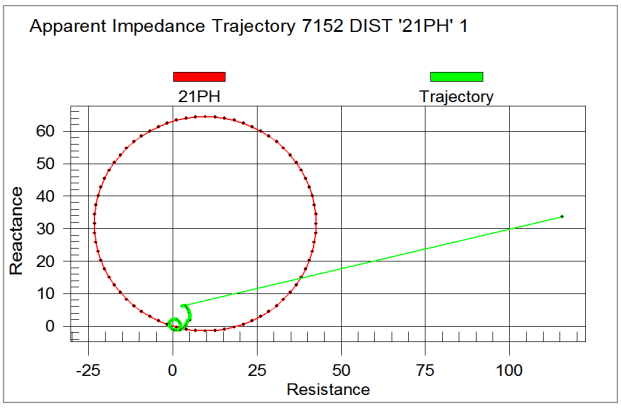

Figure 2: Above, trajectory of the apparent impedance measured by a distance relay. The apparent impedance enters the relay characteristic from the right. Below, a closer look at the trajectory.

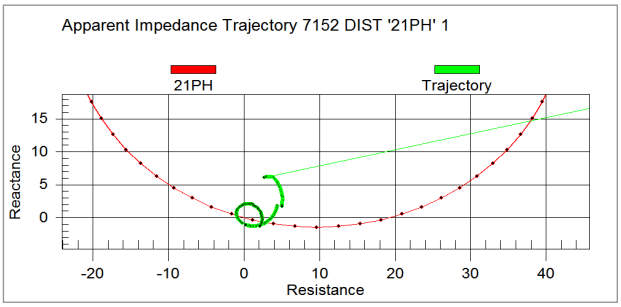

Figure 3: Advanced Protection Assessment – TS Link's simulation platform allows study of the impact of protective relay switching on the overall dynamic behavior of the system.

Advanced Protection Assessment – TS Link features and results

- Combines the detailed protection modeling and simulation environment of Advanced Protection Assessment with the transient stability modeling environment of PSS®E.
- Gives planning engineers access to a ready-made protection model, and the ability to use that protection model in their planning studies.
- Obviates the need to model relays and enter their settings in the planning environment.
- Eliminates the need for stability program vendors to get into the detailed algorithms of relays–the Advanced
- Protection Assessment protection model is used for that purpose.
- Provides updates on the one-line diagram via Advanced Protection Assessment's graphics interface as the simulation progresses.
- Creates time-varying plots of voltage magnitudes and angles, frequency, relay apparent impedance, generator rotor angles, branch PQ flow, etc.

Includes new (for Advanced Protection Assessment) types of relays: under/over frequency, out-of-step relaying, loss-of-field, V/Hz, etc.

Advanced Protection Assessment – TS Link provides a new simulation platform that allows engineers to study the impact of protective relay switching on the overall dynamic behavior of the system in an integrated and accurate manner. It combines the much-used electro-mechanical transient stability function with a detailed protection system simulation to yield a result that is indeed greater than the sum of its parts. It allows the study of different contingencies and scenarios, some of which may lead to cascading outages, while others may not. For the ones that do, the engineers will be able to tune the relay settings to confine their effect to a small area. Advanced Protection Assessment – TS Link also offers tools to design, model, analyze, and test a large variety of sophisticated next-generation protection and control systems. Such systems will help make the electric grid "smart" – one that almost anticipates developing problems, and takes steps to mitigate them.

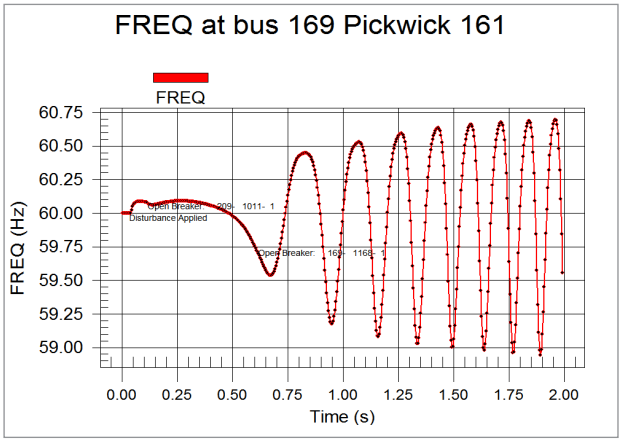

Figure 4: Advanced Protection Assessment – TS Link output showing a plot of the frequency at a bus, including annotations.

Typical applications

- Conventional planning studies, with full consideration of protective relay behavior
- Post-mortem analysis of events where protective relays played a part in spreading the blackout
- Operations planning studies – for example, if transmission facilities (line, generator or transformer) are out of service for maintenance or other reasons, and if a fault occurs, are the protective relay settings still able to maintain dependability and security? Furthermore, do relay operations create stability problems for the system?
- Relay settings adjustments to help prevent stability problems while maintaining the ability to operate quickly and securely for faults

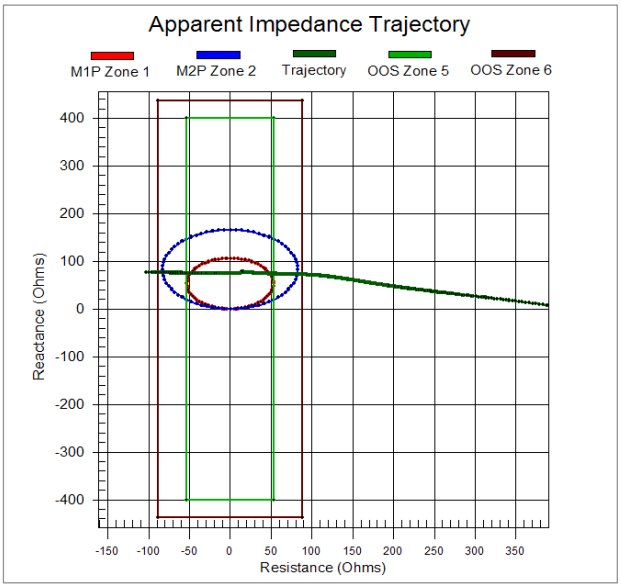

Figure 5: The apparent impedance trajectory enters the relay characteristic from the right. The out-of-step blinders measure the impedance traveling speed and declare a stable power swing condition. Therefore, the operations of Zone 1 and 2 distance protection have been blocked.

Advanced Protection Assessment – TS Link is proven in real-world testing

The U.S. Department of Energy supported the development of the Advanced Protection Assessment – TS Link module. The program module provides a link between Advanced Protection Assessment protective relay simulation program and PSS®E transient stability analysis program. Using this link, we simulated the effect of protective relay operation on the dynamic behavior of the electric grid. Tests have shown that by modifying relay settings or introducing additional protection components, we can alter system behavior. Validation testing has been performed to confirm the simulation with actual events, using existing real-world stability and protection models. Both the Eastern and Western US system models have been utilized in Advanced Protection Assessment – TS Link testing.

Advanced Protection Assessment Team: expertise, stability, and responsiveness … when you need us

We are dedicated to serving the utility industry and protection engineering. When you use Advanced Protection Assessment, we become an active partner in your success. For example, conversion of your existing electronic data from most popular formats is included with Advanced Protection Assessment. Our custom training program gets your team started quickly and confidently. We are known for our ongoing technical support: expert, thoughtful, and very responsive.

How can Advanced Protection Assessment's power help you?

Call us any time. Our staff is happy to answer your questions about putting Advanced Protection Assessment to work to improve the effectiveness of your protection engineering function.

Figure 6: Advanced Protection Assessment product experts deliver customized training classes to get you and your team started quickly and confidently.

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