TIP 264: Modeling Geomagnetically Induced Current for Evaluation and Mitigation

Context

Power systems are vulnerable to time and spatial variations in DC ground voltages caused by geomagnetic disturbances (solar storms). Geomagnetically induced currents (GICs) flow through circuits formed by the earth, a grounded transformer, a high-voltage transmission line, and another grounded transformer at the far end of the transmission line. The dc bias can force transformers to saturate for part of the normal ac cycle, causing harmonics, reactive power loss, and transformer heating that can lead to failure of protection schemes, voltage instability, potential large-scale voltage collapse and possibly transformer damage. Solar storm or geomagnetic disturbance events have disrupted normal operations of the power grid (e.g., 1989 Hydro Quebec).

While a number of systems in North America have Geomagnetic Disturbance (GMD) event operating procedures, a NERC report on the subject states, "severe GMD events present risks and vulnerabilities that may not be fully addressed in conventional bulk power system planning, design, and operating procedures." Modeling the effects on a power system of a GMD event has not been studied thoroughly at most US utilities. These effects are highly dependent on the power system's electrical characteristics (transformer configuration, DC resistance, ground mat resistances, orientation of transmission lines). Again from the NERC report: "Modeling GIC flows is vital to permit planners and operators to evaluate appropriate combinations of mitigation equipment and operational procedures."

Description

The approach of this project is to integrate GIC calculations directly within PowerWorld Simulator, so that power engineers can readily see the impact of GIC on their systems and consider mitigation options. In addition, PowerWorld proposes using the GIC tool to perform a study of BPA's system for evaluation and mitigation.

Study results could be used by BPA to decide where to install protective hardware and how to respond to GMD events operationally should they occur. The project study will better ensure resiliency for these low-frequency, high-consequence events.

GIC calculations use common power flow and fault-analysis parameters, such as line resistance, transformer-grounding configuration, ground resistance and generator step transformer parameters. All of these model inputs can be input to PowerWorld Simulator, even for very large systems.

Why It Matters

Two major risks result from the induction of GICs onto the power system. First, it leads to a loss of reactive power support, which could lead to voltage instability and power system collapse; and second it may damage power system assets, typically transformers due to heating. Replacing failed Extra-High Voltage (EHV) transformers is a large and costly undertaking with potentially dire system consequences, requiring months to reconfigure and up to 2 years to replace. Thus, these low-frequency but high-consequence events beg further study.

Power system restoration times from these two risks are significantly different. System collapse from voltage instability may be restored in hours or days, while replacing transformers requires months or longer. This is why these types of events require concentrated attention.

Goals and Objectives

The objective of this proposed project is to help ensure that BPA's system is fully prepared and reliable for a GMD event. This project will take advantage of modern power system analysis software to improve the modeling, validation, and mitigation of GIC flows. A GIC study will be performed for BPA helping to determine the risks BPA faces on this important topic.

Deliverables

The deliverable for this task will be reporting on the impact and mitigation of GIC flows on the BPA system, which may be used in the future as a starting point for all BPA GIC studies. This includes the following steps:

1. Completion of a GIC Study of the BPA System
2. Development of Algorithms to Determine Optimal Mitigation Strategies
3. Validation of GIC Parameters for BPA's System
4. Improved Visualization of GIC Flows in the PowerWorld Simulator

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Project Start Date: October 1, 2012

Project End Date: September 30, 2013

Reports & References (Optional)

Links (Optional)

Participating Organizations

PowerWorld Corporation

Funding

Total Project Cost:	$253,000
BPA Share:	$126,000
External Share:	$127,600
BPA FY2013 Budget:	$126,000

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