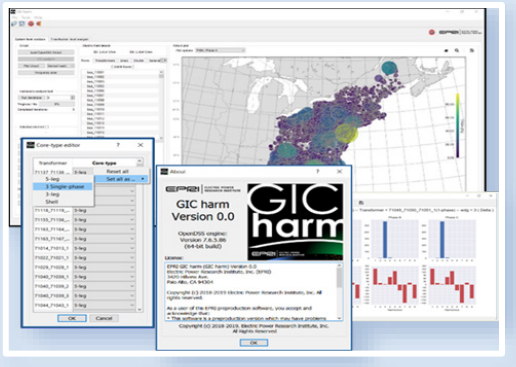
Supplemental Project Notice

GEOMAGNETICALLY INDUCED CURRENT (GIC) HARMONIC ANALYSIS

Determining GIC-Related Harmonic Impacts on the Bulk Power system



PROJECT HIGHLIGHTS

- Characterize the level of harmonic currents and voltages in the bulk power system during a GMD storm.
- Improve understanding of how harmonics impact assets during GMD events.
- Inform planning analysis and disposition of equipment that may be susceptible to GMD events.

Background, Objectives, and New Learnings

The interconnected bulk power system (BPS) has a long record of reliable, secure delivery of electric power. However, geomagnetic disturbance (GMD) events have demonstrated their ability to disrupt the normal operations.

To assess the performance of power systems subjected to GMDs, it is necessary to model the GIC produced by different levels of geomagnetic activity. Assessments of BPS's operational security using only fundamental frequency analysis (e.g., load flow and dynamic stability) may underestimate the risks of severe GMD. A more complete assessment should consider the harmonic effects, including where they cause loss of reactive support, increase the reactive power demand, and increase the probability of faults and other abrupt disturbances that could trigger system instability and collapse.

System harmonic performance evaluation for GMD events, however, is particularly challenging due to the following factors:

- GIC-saturated transformers result in a large number of harmonic sources distributed throughout the transmission grid.
- Current injections are significant over a range of harmonic frequencies, including both even and odd orders.
- Harmonic voltage distortion interacts with transformers to alter the magnitude and phase of the injected harmonic currents (i.e., saturated transformers do not behave as ideal harmonic current sources).
- The harmonic source characteristics of three-phase transformers are complex, and the sequence components of the harmonics produced do not appear exclusively in the classic pattern (e.g., non-triplen harmonics have zero-sequence components).

The objective of this research is to enhance the technical knowledge of GIC-related harmonic analysis using the newly-created GICHarm tool. The outcome of this research will lead to a better understanding of the threat posed by severe GMD events on the BPS and, as a result, provide society with a more reliable, secure, and economical delivery of electric power.

Benefits

Harmonics studies are an integral part of any GMD vulnerability assessment, and as such are a key component of related reliability and planning assessments and associated regulatory requirements. These studies will further improve the understanding of how harmonics impact assets during GMD events and result in enhanced reliability of the BPS.

Project Approach and Summary

EPRI plans to conduct the following GIC-harmonic analysis he tasks, in consultation with participating members:

1. Convert participating utility BPS model data into a format compatible with EPRI's GICHarm tool.
2. Conduct GIC calculations using one or two GMD Benchmark cases selected by participating member.
3. Characterize harmonic current injections from GIC-saturated transformers using EPRI's GICHarm tool and based on harmonic power flow. If transformer core type is not available, assumptions will be made based on engineering experience.
4. Examine the harmonic results from Task 3 against screening criteria outlined in the Assessment Guide: GMD Harmonic Impacts and Asset Withstand Capabilities.[1] Characterize harmonic components in the following assets: capacitor banks, transformer tertiaries, and generators.
5. Provide results to each participating utility. Results may be used to determine the appropriate protection system response to GIC-induced harmonics.

Deliverables

Each participant will receive:

- Utility-specific technical report for each of the respective tasks
- Models developed for the use of GIC-Harmonic Analysis

The non-proprietary results of this work will be incorporated into EPRI's Transmission Planning and Operations R&D program and made available to the public for purchase or otherwise.

Price of Project

The cost of participation is $75,000 for non-ISO entities. ISO's will be priced separately. The project can be funded over two calendar years. The project qualifies for self-directed funding (SDF).

Project Status and Schedule

The project typically takes six months to complete.

Who Should Join

Asset owners, planners, and operators of the bulk power system responsible for conducting GMD vulnerability assessments per TPL-007 (Transmission System Planned Performance for Geomagnetic Disturbance Events).

Contact Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

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[1] *Assessment Guide: GMD Harmonic Impacts and Asset Withstand Capabilities*. EPRI, Palo Alto, CA: 2016. 3002006444.

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