TIP 403: EPRI: GIC RF Sensor Demonstration

Context

Geomagnetically Induced Currents (GIC) in the transmission system can result in half cycle saturation of transformer cores, which in turn may result in transformer overheating, harmonics and VAR consumption. These in turn may result in unexpected outages or transformer failures impacting the reliability and resiliency of the transmission system.

Measurement of GIC in energized AC transmission lines and transformer windings enables fuller understanding of the behavior and effects of GIC on Autotransformers due to GIC that passes through the autotransformer series winding. GIC flow through this winding cannot be determined by neutral measurement alone.

No manufacturer currently produces a device for measuring the quasi-DC current of GIC in the live High Voltage (HV) AC environment and transport measurement information wirelessly. Available technology is limited to application only at ground connection points of three phase transformers, reactors, and other wye grounded HV equipment. The sensors used in this project not only directly measurement of GIC at points of interest on a transmission grid, they also provide measurement of harmonic current. This project includes a sensor for measuring transformer tank wall vibration.

Description

In order to address the shortcoming of only measuring GIC currents in the neutral of transformers, EPRI has developed a "clamp on" sensor which can be attached to the energized leads of the transformer. The sensor is able to simultaneously measure low levels DC current in addition to AC currents. The sensor transfers measurements wirelessly using RF communications in the same way the other EPRI RF sensors do and can be integrated with the other EPRI suite of sensors. The sensor harvests the energy needed to power the sensor electronics from the magnetic field created by the currents flowing in the energized conductor. A technology demonstrator of the EPRI RF GIC sensor has been successfully tested in the laboratory and a prototype sensor is under construction for pre-demonstration testing.

This project furthers the development of the GIC RF Sensor through laboratory testing and demonstrates this technology on an operating transformer at BPA

Task 1: EPRI Laboratory Performance Testing - The prototype Clamp on GIC RF sensor is to be tested in the laboratory under high voltage, high AC current and varying levels of DC current to confirm its measurement performance. Based on the results, modifications may be performed to meet the requirements of the field demonstrations.

Task 2: Field Demonstrations - One field demonstration is planned to be implemented in order to learn about the performance of the sensors in use and different applications:

1. 500kV I 230 kV Auto transformer
   a. Four (4) sensors (two on 500 kV, one on 230 kV, and one on neutral)
   b. One tank wall seismic sensor
   c. Solar Powered Base station which communicates to the EPRI server using a cell phone modem (120V AC Powered Base station is possible as well).

Task 3: Data Storage and Visualization - The data from the sensors will be stored on EPRI research servers and visualized via an HTML interface for the 24-month period. Alerts can be created based on the magnitude of the currents measured and sent to BPA staff.

Why It Matters

BPA continues to leverage its R&D relationship with EPRI to develop technologies important to the Agency's needs. Direct measurement of GIC flow through interconnections with foreign owned facilities and networks will provide a known value instead of the assumed to be approximate value presently derived using simplified and empirically calibrated models. This will lead to developing more effective network boundary models, and closer representation of actual GIC conditions when assessing impact to transformers. Direct measurement data from HV locations within a transmission network will be extremely valuable in calibrating network modeling for recently developed GIC study tools by providing measured values necessary to verifying the science and assumptions used in the mathematical computations. Having measured quantities beyond the existing application at neutral connection points would also further expand our understanding of the behavior of GIC flow during actual solar storms. Access to direct measured GIC also enables closing a gap in real time situation awareness because GIC flow in critical locations that cannot be determined using only neutral current measurements. The wireless communications feature, demonstrates a means of faster implementation and at less installation cost than traditional methods requiring significant design and construction time along with installation of hard wire and/or fiber optic cables. Because of a modular configuration using non-wired power, and clamp on sensors, it also demonstrates the possibility of using the system to assess multiple transformers over time by moving the measurement system to another location within the station or to another site as needed.

Goals and Objectives

The goal of this project is to measure GICs through actual transformer windings enabling a better understanding of the phenomena and potentially provide improved awareness to operators. This demonstration is one of the first applications for measuring GIC beyond the capabilities of currently available technology.

Deliverables

The non-proprietary results of this work will be incorporated into EPRI R&D Program 37 Substations, and made available to the public.

Field Demonstration Data - GIC RF Sensors and Base Stations installed at BPA Substation. The data will be hosted and visualized on EPRI servers for 24 months.

Report - A Report documenting the results of Tasks 1- 3.

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Project Start Date: April 1, 2018

Project End Date: March 31, 2020

Reports, References, Links

Participating Organizations

Electric Power Research Institute (EPRI)

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