IEEE PES Transformers Committee
Fall 2022 Meeting
Charlotte, North Carolina

Impact of GIC on Power Transformers and Power Systems – Case Studies

— Technical Presentation —
Thursday, October 20, 2022

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1. Abstract

Geomagnetically induced currents (GIC) can cause part-cycle core saturation depending on the magnitude of the GIC and the design of the transformer. This core saturation leads to additional Var demand and injects current harmonics into the grid. When large enough, a GMD can result in voltage instabilities and subsequent blackouts. Another consequence of core part-cycle saturation is additional heating of transformer windings and structural parts.

In May 2013, FERC issued Order 779, which directs NERC to submit reliability standards that address the impact of GMD on the reliable operation of the bulk power system. In response to this order, NERC developed the GIC TPL007 Standard. In response to requirements of this standard, power utilities in North America have been performing GIC system flow studies, GIC magnetic and thermal assessment studies of their fleet of power transformers, GIC system vulnerability studies and many installed GIC monitoring devices.

The IEEE Transformers Committee also produced the GIC Guide, IEEE PC57.163-2015, which is now being updated with the most recent information and new developments.

2. Learning Objectives

This tutorial provides opportunities to learn about the following:

- Objectives, tasks and timeline of NERC's GIC Standard TPL007
- Experiences of two utilities with GIC fleet assessment
- GIC thermal capability of core and shell form power transformers
- FirstEnergy's experience with GIC additional VAR demand study
- On-line monitoring of GIC and its thermal impact on transformers in real time

3. Learning Outcomes

By attending this tutorial, attendees will gain an understanding of the following:

- What is required of power utilities to comply with requirements of the TPl007 Standard
- GIC magnetic and thermal fleet assessments
- GIC thermal capability of different power transformer types and designs
- Impact of correct calculation of VAR demand
- Opportunities for on-line monitoring of thermal impact of GIC on a transformer in real time

4. Presenters' Biographies

Dr. Ramsis Girgis (IEEE Life Member) is presently the leader of Hitachi Energy's global R&D activities in the areas of Transformer Core Performance, GIC, and Low Noise Transformers. He has lead Westinghouse's, ABB's, and now Hitachi Energy's investigations in the area of magnetic and thermal effects of GIC on power transformers since the 1989 GMD event. Over the past 12 years, he has contributed to the activities of the NERC GMD task force, was a main contributor of the original IEEE GIC Guide and is presently the Vice Chairman of the working group updating the IEEE GIC Guide with latest information on the subject. Ramsis received his Ph.D. degree from the University of Saskatchewan, Canada, in Electrical Power Engineering in 1978. In 2013, he was awarded the IEEE Standards medallion for "Significant contributions to the Transformer Industry and Transformer Standards." In the mid 1980s, Dr. Girgis was the Technical Advisor, representing the US National Committee in the IEC "Power Transformers" Technical Committee – 14.

Dr. Thomas Hartmann has over 30 years of experience in the electric power industry. For the past five years, he has been working as an equipment expert for Pepco, the Washington, DC utility. Thomas' technical experience ranges from gas and oil-filled to solid insulated equipment. In research and development, he has dealt with the issue of magnetic losses, introduced the concept of extended range current transformers and made contributions to the field of dry-type power transformers. In the area of operations, Thomas took part in starting and developing two HV instrument transformer factories, one in Germany and one in the U.S. He also restructured a third factory in Mexico. In sales and marketing, he covered markets such as North America, Australia and Russia. In addition to working in the U.S. for a number of years, Thomas held positions in Germany, Mexico and the Ukraine. He graduated from Dresden University of Technology in Germany with a PhD in Electrical Engineering.

Gary Hoffman is an IEEE Life Fellow and Founder and President of Advanced Power Technologies. Prior to starting APT, Gary was the general manager of ALSTOM T&D Protection and Control Division in the United States. Prior to ALSTOM, he was with RFL Electronics, where he held various executive positions including Senior Vice President of Sales and Marketing, Vice President of Operations and Vice President of Engineering. Mr. Hoffman holds 13 U.S. and foreign patents in the areas of transformer monitoring and protection. He is also Working Group Chair of C57.12.10, C57.116, PC57.167 as well as Vice Chair of the working group that developed the original IEEE GIC Guide PC57.163. He is a member of CIGRE and a member of WG A2.57 and A2/D2,65. He is also Past Chair of the IEEE SA Standards Board, member of the IEEE-SA Board of Governors. He holds a BS in Engineering and MS in Electrical Engineering from the State University of New York at Stony Brook.

Mark Olson is the Manager of Reliability Assessments at the North American Electric Reliability Corporation (NERC). Since joining NERC in 2012, Mark has led several projects for developing reliability standards to reduce operating, cyber and physical risks to the reliability and security of the North American electric grid. He coordinates NERC's research partnerships and data collection program for assessing and reducing space weather impacts to the interconnected transmission system. Before joining NERC, Mark was a career officer in the U.S. Navy. He has a master's degree in electrical engineering from the Naval Postgraduate School and a bachelor's degree from the U.S. Naval Academy.

Anastasia O'Malley has been with Consolidated Edison Company of New York since 1990. She is currently a project manager in the Asset Management Section of Central Engineering and provides guidance on the purchase, installation, maintenance and replacement of power transformers on Con Edison's fleet. Anastasia is an active member of the IEEE PES Transformers Committee and served as an officer of the Doble Engineering Transformer and Advisory Committees. She also collaborates with EPRI to support projects that impact transformer condition assessment and life extension. She received her MSc in Electrical Engineering from Manhattan College, a BSc in Mechanical Engineering from Rutgers University and an MBA from Fordham University.

Christopher Slattery joined FirstEnergy in 2007 as a Substation Design Engineer. He moved into a role with FirstEnergy's Major Equipment Group in 2012 and began managing FirstEnergy's External Engineering, Equipment and Standards Group in 2015. He is currently in Distribution Engineering Support as the Manager of Applications and Systems Support while continuing as a transformer SME and advisor for FirstEnergy's Transmission and Substation teams. Christopher graduated from Ohio State University in 2004 with a BSc in Electrical Engineering.