IEEE/PES Transformers Committee
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"GIC Currents and the Effects on Power Transformers"

-- Technical Presentation --
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1. Abstract

Geo-magnetically Induced Currents (GIC) are the result of solar flares. They typically pass through to power transformers through the neutral. These currents can cause power transformer core saturation and harmful effects in the transformer depending on the magnitude of these currents and the design of the transformer.

These Solar storms typically occur in a cycle of about 11 to 12 years. The highest magnitude of such solar magnetic storms occurred in the Northeast of the USA on March 13, 1989. This storm caused the power system of a major utility to collapse for 8 hrs, one large power transformer at another utility to fail, and a number of other power transformers in the Northeast to experience overheating of structural parts / tanks; leading to abnormal gas generation.

This tutorial has three parts to it. First, the process of the generation of these currents will be explained. This will be followed by a presentation of the effect of these currents on power transformers. This part of the tutorial will include results of analytical investigations and measurements of the effect of GIC currents on power transformers. Finally, methods used today to monitor GIC currents and available means of minimizing the magnitude of their effect on transformers will be presented.

2. Learning Objectives

This tutorial is planned to:

- Provide background to how GIC currents are induced.
- Explain the possible harmful effects of GIC currents in power transformers.
- Present actual incidents of high magnitudes of GIC currents and their harmful effects
- Explain factors that influence the magnitude of the effect of GIC on power transformers
- Present methods used today by utilities to monitor, mitigate, and protect against the effects of GIC

3. Learning Outcomes

As a result of attending this tutorial session, members will gain an understanding of the following:

- How GIC currents are induced
- Factors affecting magnitudes of the GIC currents
- What the harmful effects of GIC currents in power transformers are.
- Factors affecting the magnitude of the effect of GIC currents in power transformers
- Presently used methods to monitor, mitigate, and protect against the effects of GIC

4. Presenters' Biographies

Dr. Peter M. Balma (M'74, SM'95) is a Principal Consultant providing services to electric utilities, consulting firms, and research organizations in the fields of power system analysis and transformer design & application. Before forming "Peter M Balma Engineering Consulting" in 2006, Peter was with PSE&G Company for 25 years. There he held various technical and management positions in the T&D departments of this utility. Dr. Balma has more than 28 years experience in the design, installation and operation of major electrical equipment in substations, switching stations, and generating stations; in the study of power systems; and in the design and application of large power transformers. He received his BSEE from New Jersey Institute of Technology in 1975, and his M. Eng. and Ph.D. in Electric Power Engineering from RPI in 1980 and 2003; respectively. He is a contributing member of the IEEE/PES Transformers Committee and the IEEE Dielectrics and Electrical Insulation Society. He is also a member of Tau Beta Pi, Eta Kappa Nu, and Omicron Delta Kappa. Dr. Balma authored and co-authored several technical publications; and is a registered Professional Engineer and Planner in the State of New Jersey.

Dr. Leonard Bolduc (M'96, SM'01) is one leader of Hydro Quebec R&D activities in the area of "GIC and its effect on Power Transformers". Since his employment at HQ/IREQ in 1975, he has lead and executed many large experimental and theoretical studies on the subject, co-directing two doctorate theses, whose main results were published. On top of his research on transformers and air reactors, he now ensures an active follow-up of the literature, even harmonics recorded continuously by SMDA, GIC-alerts and DC-events affecting the HQ network. He was also responsible for the development of a sub-harmonics ferro-resonance damper for PT, a damper-filter to absorb and reduce harmonics, the Frequency Response of Stray Losses diagnostic method for transformers, a 2 MW Capacitive Divider Substation in operation since 1994, IVACE, overhead-ground-wire power supply regulated by IVACE (50 systems installed) and a blocking device for DC current in transformer neutral (NCBD). Léonard received his B.Sc. in Engineering Physics in 1970 and his Ph. D. in Physics in 1973 from Université Laval in Quebec City. He is a member of Ordre des Ingénieurs du Québec and IEC T38/WG42 (Ferro-resonance in PT).

Dr. Ramsis Girgis is the R&D Manager at the ABB Power Transformer plant, St. Louis, Mo. He is also the leader of ABB's global R&D activities in the area of "Transformer Core Performance". Most recently, he has been the project leader for developing the ABB technology for designing, manufacturing, and noise testing of ultra-low noise power transformers. Ramsis received his Ph.D. degree from the University of Saskatchewan, Canada, in Electrical Power Engineering in 1978. He has over 40 years of R&D experience in the area of power, distribution, and high-frequency transformers, and rotating machines. He has published and presented over 70 technical papers in IEEE, IEE, CIGRE, and other international journals and co-authored chapters in two electrical engineering handbooks on transformer design and transformer noise. He was awarded the IEEE Fellow Grade in 1986. Until recently, he was Chairman of the Performance Characteristics Subcommittee of the IEEE/PES Transformers Committee. He is presently heading the Task Force revising Section 13 of IEEE Standard C57.12.90, regarding transformer noise tests. He is the past Technical Advisor representing the US National Committee in IEC Power Transformer Technical Committee (14).

Dr. Hasse Nordman is the leader of ABB's global R&D activities in the area of "power transformer leakage flux, load loss, and thermal performance". Hasse received his Ph.D. degree from Helsinki University, Finland, in Mathematics in 1976. He has over 40 years of R&D experience in the area of power transformers. He has published and presented a number of technical papers in IEEE, IEE, and CIGRE. Dr. Nordman is a contributing member of the IEEE/PES Transformers Committee and also an active member of the IEC Power Transformer Technical Committee (14).