IEEE/PES Transformers Committee
Spring 2009 Meeting
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"Frequency Response Analysis (FRA) Diagnostic Method"

-- Technical Presentation --
Monday, April 20, 4:45 to 6:00 p.m.

By Larry Coffeen, Alexander Kraetge, Anthony McGrail,
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1. Abstract

Frequency Response Analysis FRA is a valuable non-intrusive diagnostic tool for verifying the mechanical integrity and other associated properties of power transformers. SFRA testing produces traces or "fingerprints", which provides information related to the physical geometry of the test specimen. Changes in the geometric configuration alter the fingerprints and reveal a wide range of failure modes. This presentation presents the general concepts, current practices, and analysis strategies associated with frequency response analysis testing. Representatives from both the utility and transformer manufacturing communities will discuss their FRA perspectives and experiences, which will focus on FRA test application and analysis, which helps bring out the relevant importance of the FRA test.

2. Learning Objectives

This tutorial is planned to:

- Provide FRA fundamentals as they relate to test application and analysis. When and why FRA diagnostics are applied.
- Investigate and focus on how FRA tests are performed; factory, commissioning, relocation, and post event.
- Review case studies and explain how the analysis strategy indentified the incipient failure mode.
- Present utility and manufactures perspectives and experiences.
- Demonstrate how to integrate FRA diagnostics as part of condition-based maintenance or asset management program.

3. Learning Outcomes

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

- Fundamentals of frequency response analysis testing.
- Application and test procedures.
- Interpretation of the data and basic analysis strategies.
- Failure modes identified by FRA testing.
- Combining the FRA test as part of a complete condition-based test protocol.

4. Presenters' Biographies

Larry Coffeen: Larry Coffeen is a Research Engineer for NEETRAC, a research organization with a membership of power equipment manufacturers and electric utilities. NEETRAC is also a part of the school of Electrical and Computer Engineering at the Georgia Institute of Technology. Larry's current work includes the development of test techniques and test equipment to perform OFF-line and ON-line transformer frequency response analysis. Before joining NEETRAC, Mr. Coffeen was employed for 29 years by Georgia Power Company. As a Senior Test Engineer, he performed Transmission Substation Testing and High Voltage Testing which continued after the formation of NEETRAC in 1996. Larry received a Bachelor of Electrical Engineering degree from Georgia TECH in 1970. He is a senior member of IEEE and holds three U.S. patents on power transformer FRA testing.

Alexander Kraetge: Dr. Alexander Kraetge is product manager for transformer testing equipment with OMICRON. His main focus is on partial discharge and SFRA testing. He was born 1967 in Berlin, Germany. After vocational education and practice as electrician he studied high voltage and power engineering at the Berlin University of Technology (Germany) and graduated in 2001 as M.E.E. Until 2006 he worked as a research engineer for power transformer condition assessment at the High Voltage Department of the same University on behalf of the German Scientific Society and received a PhD degree in engineering sciences in 2007. He is member of the German Electrical Engineering Society, Cigré and IEEE and is active member of several working groups regarding testing of power transformers. He authored more than 40 technical and scientific papers about this subject. In the field of FRA testing he was a member of Cigré WG A2/26, is a member of IEEE WG PC 57/149 and has been nominated as the national expert for the planned IEC WG 14/597.

Anthony McGrail: Anthony McGrail is the Manager of Asset Policy Engineering at National Grid US, the department responsible for the development and maintenance of asset strategies for all distribution and sub-transmission physical assets. Previously, he spent several years with National Grid in the UK as a Substation Engineer specializing in transformers and condition monitoring, managing a number of R&D projects, including a significant development related to transformer FRA and PD. He has published a number of papers in industry journals and conferences, is a member of the IEEE Asset Management WG, ECNE's Reliability and Asset Management WG, is Vice-Chair of the Doble Asset and Maintenance Management Committee and was a member of CIGRE's DataMining Task Force. His first degree was Physics, with a subsequent M.Sc. in Instrument Design and Application, and a Ph.D. in Electrical Engineering and an MBA.

Mark Perkins: Mark Perkins is presently a principle engineer in ABB's Transformer Remanufacturing and Engineering Solutions (TRES) group. As part of his responsibilities, Mark participated in developing the ABB MTMP transformer risk & life assessment technology and advanced field & factory testing techniques; including DGA & oil analysis, FRA, and Dielectric Frequency Response. Mark began his professional career with Westinghouse at their Advanced Systems Technology Division in Pittsburgh, Pa., where he performed power system studies, transient analysis, and field testing. In 1988, Mark became a senior test engineer and later the test manager at the Westinghouse large power transformer plant in Muncie, Indiana. In 1998, he joined the development engineering team and later the TRES group at the ABB power transformer division in St. Louis, Mo. He has served as the chairman of IEEE Standards WG for low frequency dielectric tests and WG for Performance Characteristic revisions to ANSI C57.12.90. He is the author of numerous technical papers and 4 US patents. Mark graduated from BYU in 1975 with a M.Sc. degree in Electrical Engineering.

Charles Sweetser: Charles Sweetser received a B.S. Electrical Engineering in 1992 and a M.S. Electrical Engineering in 1996 from the University of Maine. He joined Doble Engineering Company, Watertown, Massachusetts, in 1996, where he presently holds the position of Product Manager for the SFRA and Circuit Breaker Test (TDR) products, which includes research and development of new products and applications. While at Doble, he has published several technical papers for IEEE and the Doble Client Committees. As a member of IEEE Power & Energy Society (PES) for 14 years, he actively participates in the IEEE Transformers Committee, and presently holds the position of Chair of the FRA

Working Group PC57.149. He is also a member of several working groups and subcommittees in the Committee. Additional interests include condition assessment of power apparatus and partial discharge.

Peter Werelius: Peter Werelius was born in Stockholm, Sweden, 1966 and works as application expert and product manager at Megger Sweden. He has a M.Sc. in Electrical Engineering (1991) and a Ph.D. in Electrical Engineering (2001) both at KTH (Royal Institute of Technology) in Stockholm, Sweden. He started his professional career starting up a spin-off company, WaBtech, in 1996, manufacturing FDS/DFR (Frequency Domain Spectroscopy/Dielectric Frequency Response) test equipment for manly applied to cables and power transformers. From 1999, he continued the work on the FDS/DFR application, now within Programma Electric and later within GE Energy Services. In 2005, he together with others founded Pax Diagnostics that in October 2008 was acquired by Megger. He has published a number of papers/articles mainly related to FDS/DFR measurement techniques and application. He is member of IEEE and Cigré and actively participates in work groups and task forces especially those related to FDS/DFR and SFRA.