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HVDC Converter Transformers
Polarity Reversal Impact on Dielectric Design
-- Technical Presentation, Monday, October 25, 4:45 p.m. --

by Ugo Piovan

1. Abstract

In today's complex transmission network, HVDC interties are being increasingly utilized as a means to control power flow. By reversing the polarity on a HVDC link, a system controller can reverse the direction of the power flow. In some transmission systems the polarity of HVDC interties can be changed several times per day. This is in contrast to the traditional use of many HVDC lines where the polarity was typically reversed only a few times per year. Reversing the polarity of a HVDC intertie places unique and critical dielectric stresses on the converter transformers.

Until now, HVDC dielectric design has been approached by means of static electric field plots (DC field based on material conductivities and Polarity Reversal (PR) field as a superposition of DC and traditional AC fields). However, some insulation systems designed in full accordance with this approach have nonetheless failed during the Polarity Reversal Test or, worse, during operation. An improved approach is to base the design of insulation systems on dynamic electric field studies, which allow a better understanding of polarity reversal transients, i.e. the change of the electric field with time.

We will present a typical HVDC transformer insulation system and compare information that can be obtained by the static and dynamic approach. In addition, we will make considerations on the present way to perform PR test by comparing dielectric stress applied during PR test according to standards with stress during operation.

Finally some consideration will be made on material properties and their influence of electric fields.

2. Learning Objectives

Attendees of this tutorial session will receive an introduction to HVDC transformer insulation design principles. They will learn how the use of transient (time varying) electric field simulation allows for a better (when compared to static fields) understanding of what goes on inside the transformer during Polarity Reversal operations. They will also learn how the stress on insulation during Polarity Reversal test described by IEEE C57.129-1999 compares with the one in operation.

3. Learning Outcomes

The information learned from this session should help attendees to:

- Optimize HVDC transformers insulation
- Increase HVDC transformers reliability
- Reconsider how to carry out DC and PR dielectric tests
- Resolve problems related to dielectric failures of HVDC transformers

4. Presenter's Biographies

Ugo Piovan: Mr. Piovan is presently Manager of Electromagnetic Services at Weidmann Transformerboard Systems AG, Rapperswil, Switzerland. He is responsible for the R&D for transformer insulation design tools and consulting services related to magnetic problems in transformers (3D stray flux loss calculation, effects of current harmonics etc.) Before joining Weidmann in 2000, he was Chief Engineer for industrial transformers in TAMINI Trasformatori, Italy. He is a member of IEEE Working Group for Arc Furnace Transformers and of IEC Working Group 21 Converter Transformers (Industrial and HVDC) and of IEC Working Group 29 High temperature insulation systems.
He is a Registered Professional Engineer in Italy. He received his M.S. degree in Electrical Engineering from the Polytechnic of Milan, Italy in 1994.