IEEE/PES Transformers Committee
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"A Review of the Latest Revisions to IEEE Standard 4, and the K-factor Method of Lightning Impulse Voltage Parameter Extraction"

-- Technical Presentation --
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1. Abstract

IEEE Standard 4, Standard Techniques for High Voltage Testing was extensively revised, and all technicians and engineers who are involved in high voltage testing according to IEEE standards need to become familiar with this newly revised standard. The new revisions will likely require modification to existing testing and measurement procedures. The first portion of this presentation reviews the major changes to that standard.

One of the Standard 4 revisions concerns how the measurement of peak voltage and overshoot on a lightning impulse (LI) voltage wave is defined. In earlier revisions of the standard, when overshoot was present, a single frequency (500 kHz) was used as the basis for peak voltage measurement. This single frequency basis made measurements of peak voltage problematic when the actual overshoot on the LI wave was very close to that frequency. The ever present limits of quantization and "noise" on digitally recorded signals could cause the calculated voltage peak value to change from one impulse application to another.

The k-factor portion of this presentation will provide a historical perspective on the old "single valued 500 kHz method" of LI voltage parameter extraction, the reasons for the introduction of a new methodology, and the development work that ultimately produced the "k-factor" methodology. Examples of typical LI voltage wave records will be presented with parameters computed using both methods. Current imperfections in the k-factor method and activities being considered to further develop this methodology will also be reviewed.

2. Learning Objectives

To inform attendees of the newly revised portions of IEEE Standard 4, so that they can prepare for high voltage testing and measurement procedural changes that may need to be implemented in their test departments.

In particular, to introduce attendees to a revision of the methodology used to calculate the parameters of lightning impulse voltage records. This revision will require a major change in the procedure used to calculate the peak voltage and overshoot when oscillations are present on the peak of an impulse voltage wave. Test departments which use impulse measurement recorders that automatically measure the impulse voltage parameters will need to obtain a new software program to perform this measurement.

3. Learning Outcomes

Attendees will gain the following information from their attendance at this tutorial:

- Learn of new revisions to high voltage test and measurement requirements.
- Be introduced to the theory and principles of k-factor LI voltage measurements.
- Observe from examples how the changes will affect their own LI voltage measurements.
- Be informed of how they need to comply with the new requirements.
- Be prepared to apply these changes in the factory test field.

4. Presenters' Biographies

Jeffrey A. Britton is presently employed in the position of Chief Engineer at Phenix Technologies, Inc., based in Accident, Maryland, where he has worked for the past 18 years in the design and development of high voltage, high current and high power test systems. He received his BSEE in 1991 and MSEE in 1994 from West Virginia University, where he worked as a graduate assistant, teaching laboratory courses and summer courses in Electromechanical Energy Conversion and Power Systems Analysis. He has been a member of IEEE for 21 years, and presently serves as the secretary for the High Voltage Testing Techniques Subcommittee (HVTT) of the Power System Instrumentation and Measurement Committee (PSIM), and is an active participant in the IEEE/PES Transformers Committee. He is also a member of CIGRE, and is a member of the US Technical Advisory Group to IEC Technical Committee 42 on High Voltage Testing Techniques.

Dr. Wolfgang Hauschild received the Diploma degree in 1965, the Ph.D. in1970, and the *habilitation* (university lecturing qualification) in 1976 from the Technical University (TU) of Dresden, Germany. In 2007, he became *doctor honoris causa* of the Technical University of Graz, Austria. From 1966 to 1979 he was a researcher of TU Dresden managing a research group on SF6 insulation. In 1980, he moved to industry and has been in leading positions of HV test equipment production in Dresden, from 1990 to 2007 as the Technical Director of HIGHVOLT Prüftechnik Dresden GmbH. After retirement he is still active as a consultant. Dr. Hauschild is a member of IEEE, VDE, CIGRE and was German speaker to IEC TC 42 (HV test technique) from 1995 to 2009. He published two books and numerous papers on HV engineering, especially HV testing.

James E. McBride received a Bachelor of Electrical Engineering degree from Georgia Institute of Technology in 1988. He has been a member of IEEE Power Engineering Society since 1988 and currently serves as the secretary for the PSIM committee. He has worked in power system research and development for 28 years. Jim has worked extensively with a calibration, high voltage testing, and frequency response testing. His areas of expertise include data acquisition, software development, and high voltage testing. Jim has developed several pieces of equipment used for evaluation and testing of power system equipment. Jim is currently president of JMX Services, Inc. JMX Services is a provider of impulse test equipment, online frequency response and transient monitoring equipment, arrester test systems, and other high voltage test equipment for the power industry.

Arthur Molden trained as a High Voltage Development Engineer at Ferranti Ltd UK, a manufacturer of Large Power Transformers and High Voltage Test Equipment. Completing an 8-year training program that included both attendance at Oldham Technical College and full time employment at the Ferranti factory. Progressed from apprentice to technician, to HV development engineer while completing the Higher National Certificate in Electrical and Electronic Engineering. Additional employment included: Wilson Electric Transformers, Glen Waverley, Victoria, Australia; Bougainville Copper, Papua New Guinea and Hipotronics Inc, Brewster, NY, USA. Currently self-employed, consulting as AMEESCO and re-manufacturing HV Test Equipment as MBILM LLC. Over 30 years, experience in the Power Transformer and High Voltage Test Equipment industries, and 20 years as an active member of the IEEE.