Tutorial Title

CIGRE TB976 - Methods for identification of frequency response characteristic of voltage measurement systems

Speaker

Name	Dr.-Ing. Erik Sperling
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Webpage/CV link/short bio	Erik Sperling is a recognised expert in instrument transformers, low-power instrument transformers and monitoring applications in MV and HV grids. He graduated in high-voltage technology at the University of Karlsruhe (Germany) in 1998, and completed his PhD on wide-band RC voltage dividers at the University of Dresden (Germany) in 2017. His professional journey began in 1998 at HAEFELY Trench (Switzerland) with a focus on HV capacitors, RC dividers, and CVTs. He then joined the PFIFFNER company (Switzerland) in 2005 with the focus on CVTs, VTs, LPITs and new technologies. Since 2020, he has served as a Corporate Consultant at OMICRON electronics GmbH (Austria) from Switzerland, supporting the management of primary testing, the instrument transformer department, and fundamental scientific research. He is the national IEC Swiss chairman of TC38 and the national CIGRE Swiss chairman of A3. Erik is the convenor of IEC TC38 MT58 for instrument transformers on IEC61869-2, -3, -5. He is the convenor of MT20 in IEC TC33 and takes care of the standard IEC60358 family. Erik was an active member of WG B3.39 (TB 814), as well as was/is member in A3.44, A3.50. He was the convener (2019-2025) of WG A3.45, responsible for the newly published TB 976. To date, Erik Sperling has published more than 50 academic papers, either as author or co-author, at national and international conferences, in workshops and in specialist journals. He has twice been awarded the prize for the best paper by CIGRE SC A3.

Abstract

The technical brochure of CIGRE TB0976 titled "WG A3.45: Methods for Identification of Frequency Response Characteristic of Voltage Measurement Systems" addresses the evolving requirements of voltage measurement systems in the context of modern electricity grids and was published in January 2026. The introduction highlights the impact of the energy transition on power systems, necessitating advanced voltage measurement systems to handle a wide range of frequencies, including transients. These systems serve as critical interfaces between primary power systems and secondary applications like metering, monitoring, and control.

Chapter 2 discusses the types of voltage measurement systems, distinguishing between conventional voltage transformers (inductive and capacitive) and low-power voltage transformers (voltage dividers and optical sensors). It delves into the design principles, accuracy calculations, and environmental impact factors affecting precision. The chapter also introduces non-conventional voltage measurement systems not covered by existing standards.

Chapter 3 focuses on grid requirements, addressing disturbance phenomena such as voltage fluctuations, flicker, and unbalance, as well as grid events like dips, swells, and interruptions. It emphasizes the need for voltage measurement systems to accurately capture signals below and above the nominal frequency to assess grid conditions and asset impacts.

Chapter 4 examines performance characteristics, separating parameters into frequency and time domains. It introduces key concepts like ratio error and phase displacement, and discusses the importance of determining the first resonance frequency for selecting appropriate measurement systems. The chapter also covers PQ parameters, transient voltage impulses, and the influence of constructional, ambient, and operational factors on measurement accuracy.

Chapter 5 provides guidance on mathematical identification and measurement methodologies, highlighting the importance of selecting appropriate test setups and methodologies. It introduces black box, white box, and grey box modelling, with vector fitting as a tool for digital twin applications. The chapter outlines equivalent circuit diagrams for different frequency ranges and discusses nonlinear elements and their impact on system response. Additionally, guidance on how to measure all the individual voltage signals by the use of the relevant and proper test setup is given.

Chapter 6 presents a classification mapping of the topics covered, summarising phenomena, applications, measurement requirements, and performance ranges. This mapping aids in identifying consequences and requirements for future applications.