Tutorial 4

Supraharmonics (2 kHz to 150 kHz) in low voltage networks

Background

Equipment connected to the distribution grid is changing quickly. On consumer side more and more energy-efficient equipment is introduced (e.g. electric vehicle charger, LED lamps, active PFC power supplies). Also on generation side inverter-based equipment (e.g. PV-inverters, converters for storage applications) are increasing. Most of this equipment is characterized by emission in the frequency range between 2 kHz and 150 kHz (supraharmonics). The same frequency range is also used in several European countries by network operators for PLC applications, which further increase the challenges to ensure EMC in this frequency range.

Aim of the tutorial

The tutorial will inform about most recent findings in the field of supraharmonics. It discusses the typical emission of modern electronic devices as well as immunity issues, especially of mass-market equipment. Furthermore, guidance is provided on measuring supraharmonic voltages and currents. Propagation of supraharmonics in the network as well as the importance of network harmonic impedance including resonances are described and modelling approaches are discussed. An overview of the existing situation and recent activities in standardization work finish the tutorial.

The tutorial provides to the participants a holistic look on the frequency range 2-150 kHz in low voltage networks. The participants (network distributors, equipment manufacturers, consumers, researchers and regulators) can improve their knowledge and understanding for this network disturbance.

Content

1. Introduction
   - Introduction of speakers
   - Basics on supraharmonics
2. Measurement
- Suitable measurement equipment
- Methods for pre- and post-processing for different signal presentations (time-domain, time/frequency-domain, frequency-domain)
- Suitable indices for quantifying supraharmonic distortion

3. Equipment emission
- Emission of consumer equipment and inverter-based generation
- Equipment harmonic database projects (PANDA, ORCA)
- Equipment immunity
- Interaction between end-user equipment and PLC

4. Propagation and network aspects
- Survey on supraharmonic levels in public LV networks
- Network harmonic impedances at frequencies above 2 kHz
- Propagation characteristics
- Modelling approaches

5. Standardization
- Standardization framework
- Recent developments in IEC SC77A compatibility levels, emission limits, immunity limits, measurement methods
- Present discussions in CENELEC SC205A

6. Discussion

Expected benefits
Participants will gain a holistic understanding of supraharmonic with respect to:
- major sources of intentional and non-intentional emission
- principles of propagation and modelling approaches
- guidance on measuring and quantifying supraharmonic distortion
- possible interference between equipment and PLC
- comprehensive overview of recent standardization in the field of supraharmonic

Who should attend?
This tutorial is intended for all stakeholders (network distributors, equipment manufacturers, certification labs, consumers and regulators) who want to improve or refresh their knowledge in the field of emission in the frequency range between 2 kHz and 150 kHz in distribution grids.

Support material
Copies of presented slides will be handed out.
About the presenters

Jan Meyer

Jan Meyer is senior academic assistant and team leader of the Power Quality research group at the Institute of Electrical Power Systems and High Voltage Engineering at Technische Universität Dresden, Germany. His research interests include network disturbances and their assessment, especially for harmonics below and above 2 kHz as well as all aspects of the design, implementation and data analysis of large Power Quality monitoring campaigns. He is a member of national and international EMC working groups and is/has been involved in several CIGRE working groups related to EMC and Power Quality (C4.112, C4.24, C4./C6.29, C4.40 and C4.42). He regularly organizes and presents at national and international seminars and workshops in the field of network disturbances and its assessment.

Math Bollen

Math Bollen is professor in electric power engineering at Luleå University of Technology, Skellefteå, Sweden. Earlier he has among others been R&D manager electric power systems at STRI AB, Gothenburg, Sweden, technical expert at the Energy Markets Inspectorate, Eskilstuna, Sweden, lecturer at the University of Manchester Institute of Science and Technology (UMIST), Manchester, U.K., and professor in electric power systems at Chalmers University of Technology, Gothenburg, Sweden. Math Bollen is one of the leading researchers on power quality, having defined voltage dips as a research area and recently having introduced harmonic distortion in the frequency range 2 to 150 kHz as a research area, as well as introducing the "hosting capacity" as an important measure for quantifying the performance of smart grids. He has published two textbooks on power quality, "understanding power quality problems" and "signal processing of power quality disturbances" and two on the future power system, "integrating distributed generation in the power system" and “The smart grid – adapting the power system to new challenges”.

Sarah Rönnberg

Sarah Rönnberg is assistant professor with Luleå University of Technology, Skellefteå, Sweden. She has made several contributions to the research in the field of power quality, harmonics and supraharmonics. She is secretary of CIGRE working group C4.24 and is an active member of several other CIGRE and IEEE working groups.
Anne Grevener is a research student with the Institute of Electrical Power Systems and High Voltage Engineering at Technische Universitaet Dresden, Germany. Her research is focused on the frequency range 2-150 kHz as well as harmonics. She works on the analysis of measurements and the development of new indices.

Organizer and contact for correspondence:
Jan Meyer (jan.meyer@tu-dresden.de)