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Application of measurement methods to long-term measurements in public low voltage network

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Introduction

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Background

Measurement of network disturbances above 2 kHz:

- Two candidate measurement methods: IEC 61000-4-7, CISPR 16
- Typical use cases:
  - Reflecting impact of disturbances on thermal stress and equipment malfunction
  - Comparison of disturbance levels against compatibility levels in IEC 61000-2-2
- Proven methodology exists for measurements below 9 kHz

Open questions

- Application of candidate methods to continuous measurement of disturbances in the network
- Link between complementary measurement quantities (QP-, RMS-, Max-values)

Methodology

Measurements in frequency range below 9 kHz

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	Harmonics (interharmonics)	Emission in the range 2-9 kHz
Measurement		
Interval	10/12 cycles	200 ms
Results	$U_{\mathrm{RMS}}^{(h,ih)}$, $I_{\mathrm{RMS}}^{(h,ih)}$, THDu, THDi subgroup values	$U_{\mathrm{RMS}}^{(b)}$, $I_{\mathrm{RMS}}^{(b)}$ 200-Hz bands
Aggregation		
Common Intervals	150/180 cycles, 10 min	3 s, 10 min
Method	RMS and Maximum	
	RMS values: *(thermal) stress of circuit components* Max values: *perceptible malfunctions*	
Evaluation	Comparison of weekly 95th percentile of 10-minute values Comparison of daily 99th percentile of 3-s values	

Measurement methods

Suitability for measurement in the network

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IEC 61000-4-7

compliant with the agreed methodology for measurements in frequency range below 9 kHz

CISPR 16

Overview:

- Objective: reflecting impact on radio transmission
- Definition of receiver and setup under laboratory conditions
  Need for Line Impedance Stabilization Network (LISN)
- EUT-specific measurement procedure
  Measurement result (QP) – maximum of weighted amplitude envelope over the measurement time
- Significant overlap in time and frequency

Required adaptions:

- Definition of measurement time
- Method for aggregation of QP values
- Approach for calculation of integral disturbance levels

Measurement methods

Application to measurement in the network

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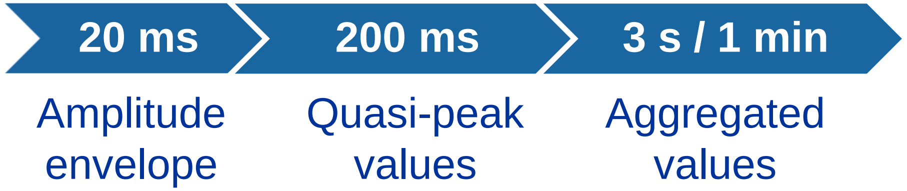
Measurement methods

CISPR 16

adaption of compatible digital method:

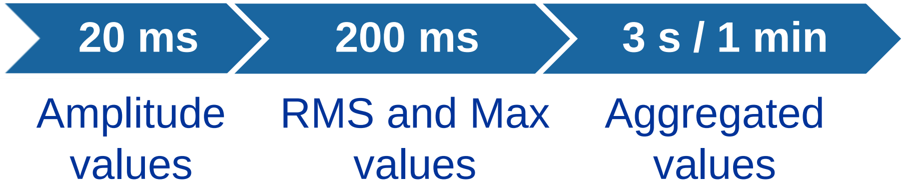
- Measurement time of 200 ms
- RMS and Maximum aggregation of QP values



IEC 61000-4-7

low-computational-costs modification (compared to the standard)

- Multiple measurement intervals of 20 ms (gapless)



Analysis

Calculation of selected percentiles of disturbances:

- Non-aggregated values (200-ms values)
- Aggregated values (3-s, 1-min values)

Measurement sites

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Characteristics

Continuous measurements at POCs:

- EV fast charging infrastructure (*45 min*)
- PV installation with PLC system for meter reading (*25 min*)

Analysed disturbances

EV charger:

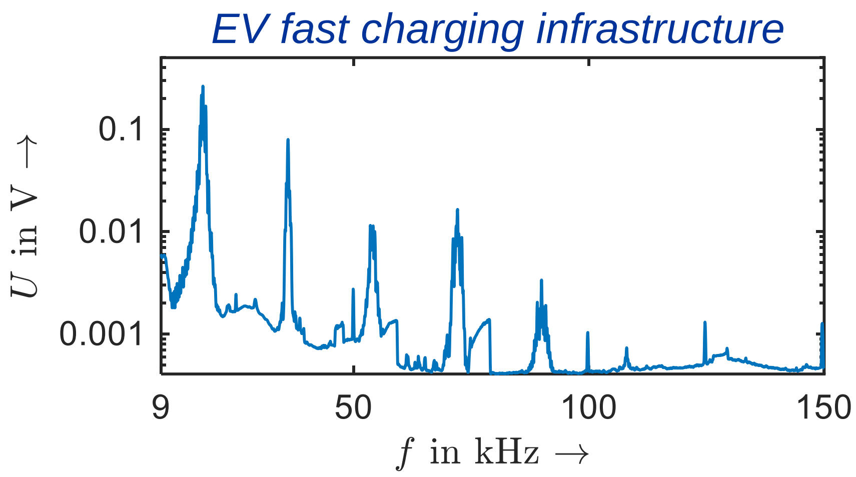
- Magnitude of disturbances around 18 kHz

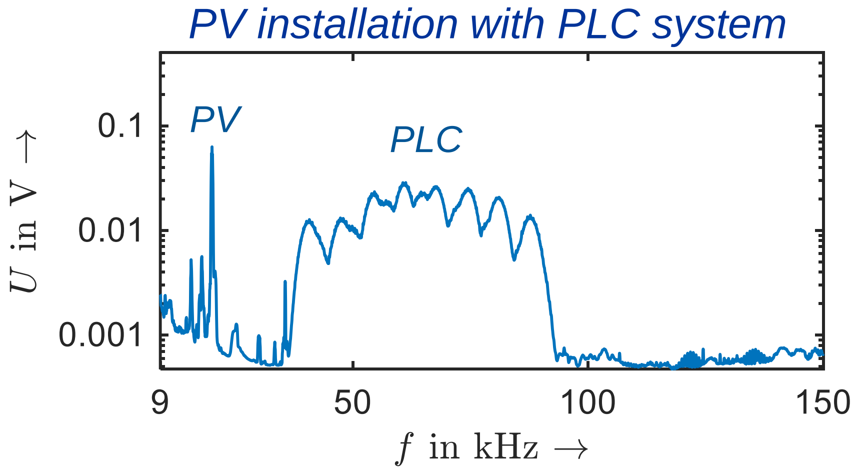
PV inverter:

- Magnitude of disturbances at 20 kHz

PLC system:

- Maximum magnitude of disturbances in 35-90 kHz range
- Integral level of disturbances in 35-90 kHz range





Measurement results

EV charger

Disturbance magnitude around 18 kHz in mV

200 ms

Percentile	0^{th}	50^{th}	95^{th}	100^{th}
CISPR 16 (QP)	2	148	260	267
IEC 61000-4-7	2	146	264	271
IEC 61000-4-7 (Max)	3	150	265	277

3 s

Percentile		0^{th}	50^{th}	95^{th}	100^{th}
CISPR 16 (QP)	*RMS/Max*	3/3	152/193	254/265	260/267
IEC 61000-4-7	*RMS/Max*	3/3	151/192	256/269	264/271
IEC 61000-4-7 (Max)	*RMS/Max*	4/5	154/197	258/271	266/277

1 min

Percentile		0^{th}	50^{th}	95^{th}	100^{th}
CISPR 16 (QP)	*RMS/Max*	3/4	197/255	-	212/267
IEC 61000-4-7	*RMS/Max*	3/4	201/260	-	214/271
IEC 61000-4-7 (Max)	*RMS/Max*	4/6	202/263	-	216/277

- Fairly constant character of disturbances
- High degree of comparability between CISPR 16 (QP) and IEC 61000-4-7
- IEC 61000-4-7 (Max) provides a conservative estimate for CISPR 16 (QP)
- Similar conclusions apply for the other source: higher percentiles of PV inverter and PLC system disturbances

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Measurement results

PLC system

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Integral level of disturbances

represents total signal power e.g. for reflecting the thermal impact or impact on PLC system

$$\mathrm{TSHV} = \sqrt{\sum_{B=1}^{N} U_B^2}$$

CISPR 16

Adaptions of the method is required to compensate overlap in time and frequency

Currently under discussion:

- CISPR QP: window- and overlap-depending correction factor
- CISPR AV: use of a fixed (pre-defined) overlap and reduction factor

Integral level of disturbances in mV (non-aggregated 200-ms-values)

Percentile	0^{th}	50^{th}	95^{th}	100^{th}
CISPR 16 QP	11	116	251	278
CISPR 16 AV	8	37	163	178
IEC 61000-4-7	9	11	210	251

- Large deviations with IEC 61000-4-7 in the middle
- Possible misinterpretation of thermal stress equivalent by CISPR 16 method

Summary

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Continuous measurement in the network

Required adaptions of CISPR 16 compatible method:

- Measurement time

  Is the commonly used 200-ms interval suitable for CISPR 16?
- Method for aggregation of QP values

  Can maximum aggregated QP value be reflective of any relevant interference mechanism?
- Calculation of integral levels

  Proposed approaches may misinterpret the thermal stress equivalent

Link between complementary measurement quantities

- High degree of comparability between CISPR 16 (QP) and IEC 61000-4-7

  Moderate difference compared to the deviation range caused by freedom in CISPR 16 implementation
- Conservative estimation of CISPR 16 (QP) by IEC 61000-4-7 (Max)

Next steps

Study of longer network disturbance measurements over days and weeks

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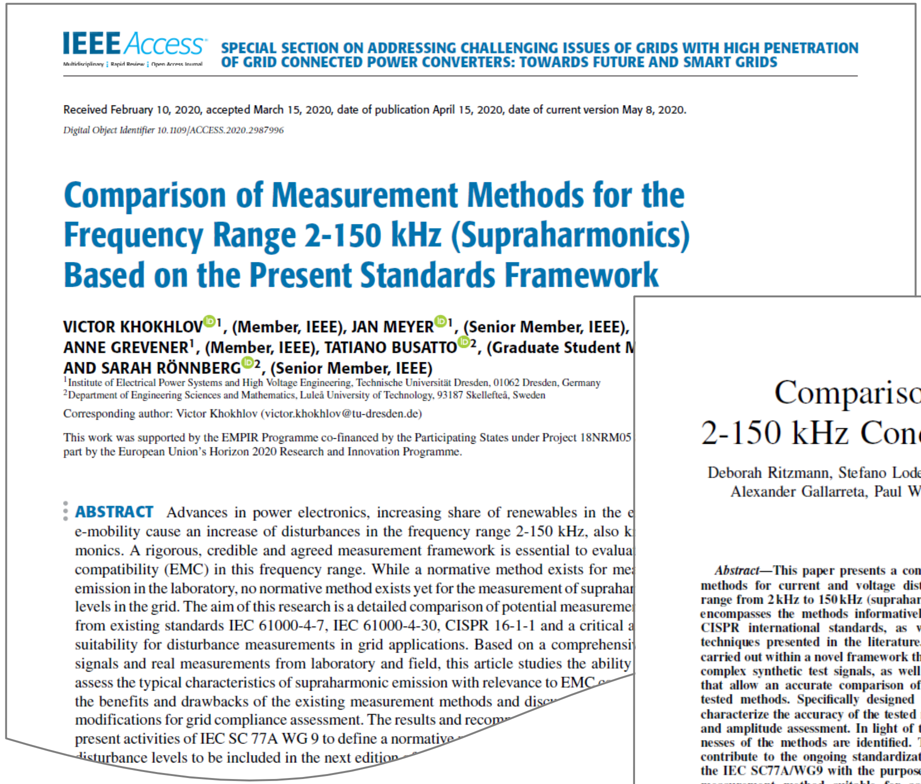
Thank you
for your attention!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Comparison of Measurement Methods for the Frequency Range 2-150 kHz (Supraharmonics) Based on the Present Standards Framework

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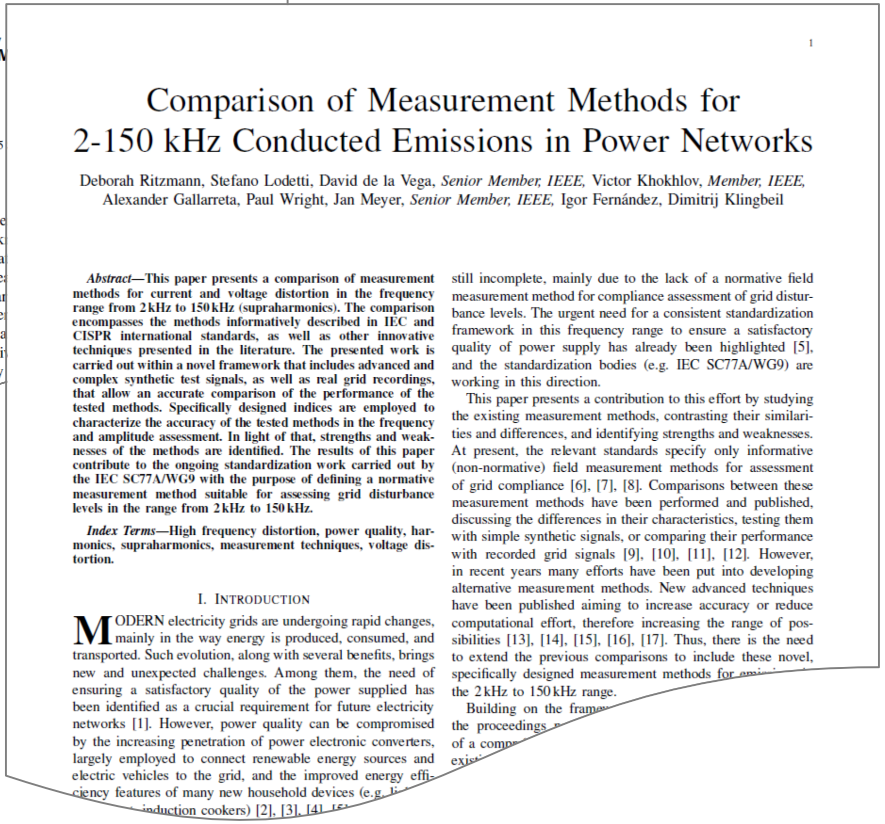
ABSTRACT Advances in power electronics, increasing share of renewables in the e e-mobility cause an increase of disturbances in the frequency range 2-150 kHz, also k monics. A rigorous, credible and agreed measurement framework is essential to evalua compatibility (EMC) in this frequency range. While a normative method exists for me emission in the laboratory, no normative method exists yet for the measurement of suprahar levels in the grid. The aim of this research is a detailed comparison of potential measureme from existing standards IEC 61000-4-7, IEC 61000-4-30, CISPR 16-1-1 and a critical a suitability for disturbance measurements in grid applications. Based on a comprehensi signals and real measurements from laboratory and field, this article studies the ability assess the typical characteristics of supraharmonic emission with relevance to EMC the benefits and drawbacks of the existing measurement methods and disc modifications for grid compliance assessment. The results and recom present activities of IEC SC 77A WG 9 to define a normative disturbance levels to be included in the next edition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Comparison of Measurement Methods for 2-150 kHz Conducted Emissions in Power Networks

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***Abstract*—This paper presents a comparison of measurement methods for current and voltage distortion in the frequency range from 2 kHz to 150 kHz (supraharmonics). The comparison encompasses the methods informatively described in IEC and CISPR international standards, as well as other innovative techniques presented in the literature. The presented work is carried out within a novel framework that includes advanced and complex synthetic test signals, as well as real grid recordings, that allow an accurate comparison of the performance of the tested methods. Specifically designed indices are employed to characterize the accuracy of the tested methods in the frequency and amplitude assessment. In light of that, strengths and weaknesses of the methods are identified. The results of this paper contribute to the ongoing standardization work carried out by the IEC SC77A/WG9 with the purpose of defining a normative measurement method suitable for assessing grid disturbance levels in the range from 2 kHz to 150 kHz.**

***Index Terms*—High frequency distortion, power quality, harmonics, supraharmonics, measurement techniques, voltage distortion.**

I. Introduction

Modern electricity grids are undergoing rapid changes, mainly in the way energy is produced, consumed, and transported. Such evolution, along with several benefits, brings new and unexpected challenges. Among them, the need of ensuring a satisfactory quality of the power supplied has been identified as a crucial requirement for future electricity networks [1]. However, power quality can be compromised by the increasing penetration of power electronic converters, largely employed to connect renewable energy sources and electric vehicles to the grid, and the improved energy efficiency features of many new household devices (e.g. induction cookers) [2], [3], [4]

still incomplete, mainly due to the lack of a normative field measurement method for compliance assessment of grid disturbance levels. The urgent need for a consistent standardization framework in this frequency range to ensure a satisfactory quality of power supply has already been highlighted [5], and the standardization bodies (e.g. IEC SC77A/WG9) are working in this direction.

This paper presents a contribution to this effort by studying the existing measurement methods, contrasting their similarities and differences, and identifying strengths and weaknesses. At present, the relevant standards specify only informative (non-normative) field measurement methods for assessment of grid compliance [6], [7], [8]. Comparisons between these measurement methods have been performed and published, discussing the differences in their characteristics, testing them with simple synthetic signals, or comparing their performance with recorded grid signals [9], [10], [11], [12]. However, in recent years many efforts have been put into developing alternative measurement methods. New advanced techniques have been published aiming to increase accuracy or reduce computational effort, therefore increasing the range of possibilities [13], [14], [15], [16], [17]. Thus, there is the need to extend the previous comparisons to include these novel, specifically designed measurement methods for emi the 2 kHz to 150 kHz range.

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