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Adapting the CISPR 16-1-1 standard for power quality measurements

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Motivation

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- IEC 61000-2-2: grid compatibility levels

4.12 Voltage distortion in differential mode from 9 kHz to 150 kHz

4.12.1 General

In this document, voltage distortion from 9 kHz to 150 kHz is considered in relation to long-term effects, i.e. for a duration of 10 min or longer.

The compatibility levels for voltage distortion in differential mode from 9 kHz to 150 kHz, given in 4.12.2 and 4.12.3, are related to disturbance levels between any phase conductor and the neutral conductor measured with a quasi-peak detector and with a bandwidth of 200 Hz in accordance with CISPR 16-1-1.

Is CISPR 16-1-1 standard suitable for grid measurements?

Content

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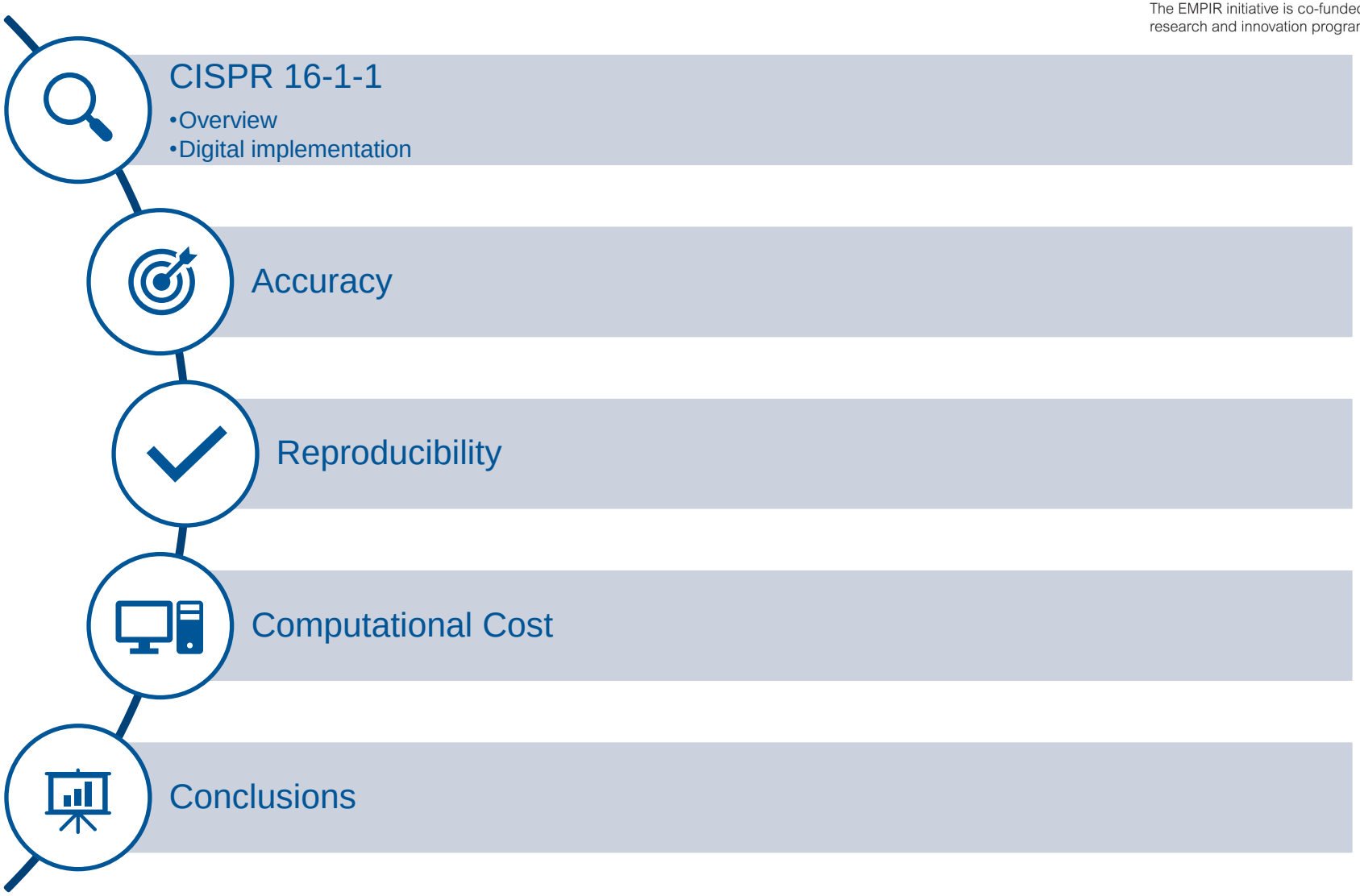

CISPR 16-1-1
Overview

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- Purpose
  - Instrument characteristics and methods for the 9-150 kHz range
  - Emissions from equipment under test (EUT), in laboratory setting
  - Objective: protection of radio transmission from interference
  - Not intended for power quality grid measurements

- Measurement method
  - Classically: analogue super-heterodyne EMI receivers (very slow, gaps)
  - Recently: emulated by digital FFT-based instruments (fast, gapless)
  - Black-box approach – set of compliance tests

CISPR 16-1-1
Digital implementation

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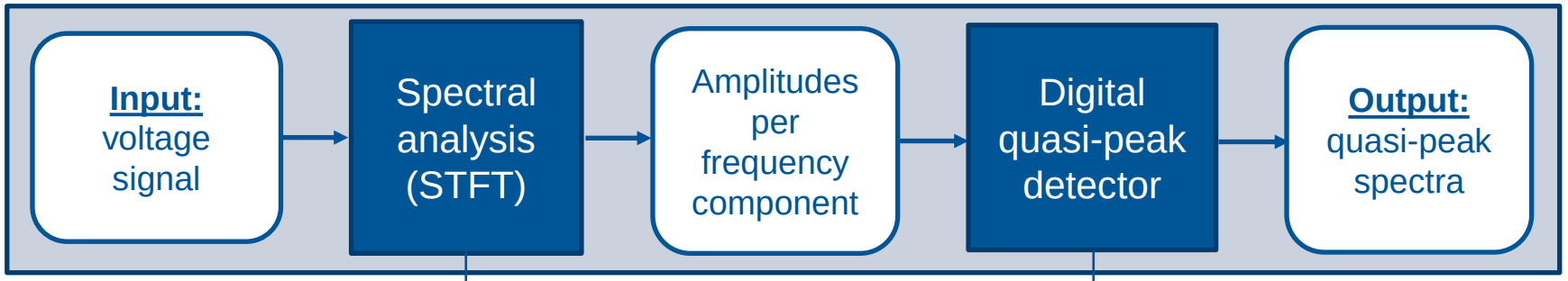
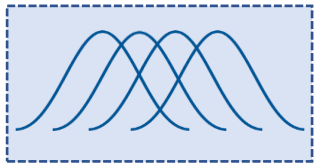
Main stages of an **FFT-based implementation**:



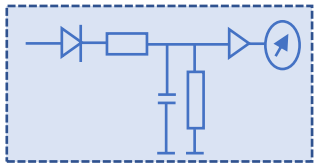
Short-time Fourier Transform (STFT)

Weighting window with compliant resolution bandwidth (200 Hz at 6dB)



Quasi-peak detector

Simulated digitally with IIR filters or physics equations



Accuracy

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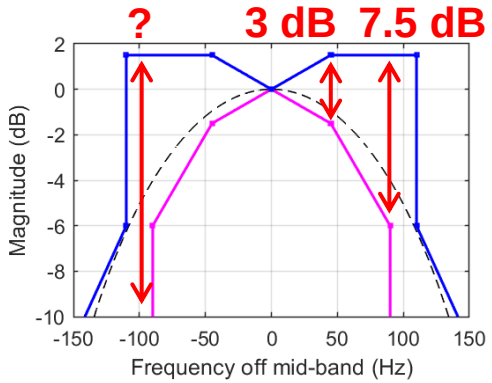
Minimum accuracy requirements

Frequency selectivity

Frequency response of the weighting window must fit into this mask:



Sine-wave tolerance

Sine-wave voltage measurement

Accuracy:

- **± 2 dB**
- -21/+26 %

Response to pulses

Pulse train test measurement.
1 absolute test and 7 relative tests

Accuracy (abs):

- **± 1.5 dB**
- -16/+19 %

cf. ± 5 % in IEC 61000-4-7

Reproducibility
Motivation

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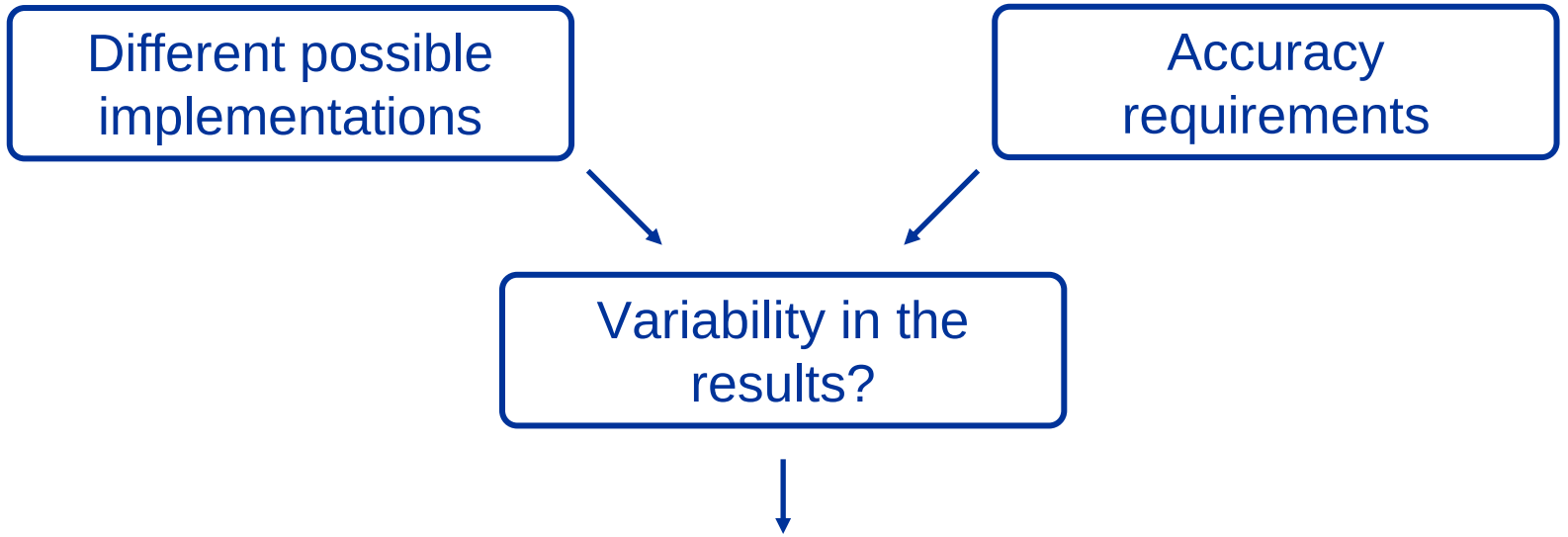

This could compromise the **reproducibility**

- How big are the differences in results, for the same input?
- Is it a reproducibility issue?

Computational cost

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- Comparison of total number of operations for 200 ms of input signal
- Assumption: 95% overlap and 100 Hz frequency step in digital CISPR 16 implementation

Implementation method	IEC 61000-4-7 Annex B (2-9 kHz)	CISPR 16
Sampling frequency	327.68 kHz	409.6 kHz
Window length	200 ms	20 ms
Single FFT size	65,536	8,192
Number of FFTs per 200 ms	1	181
Number of final frequency components	710	1410
$\frac{\text{Number of operations}}{\text{Number of operations for IEC Method}}$	**1**	**22**
FFT stage	82%	72%

- Digital CISPR 16 implementation exceeds IEC 61000-4-7 Annex B by factor > 20
- Drivers:
  - overlap – increases number of FFTs,
  - post-processing – number of parallel quasi-peak detectors

Summary

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Concerns in adapting the CISPR 16 method to grid measurements

Reproducibility
- Different implementations give significantly different results

Existing **tolerances >10%** are very permissive
- 5-10% is the target below 2 kHz (cf. IEC 61000-4-7 for harmonics)

Computational effort
- Higher than *IEC 61000-4-7 Annex B*

Other concerns

- Quasi-peak values: for protection of radio transmission. Are they reflective of PQ interference mechanisms?
- Measurement time and aggregation strategies need to be defined

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Thank you