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Grid measurements of 2 kHz - 150 kHz harmonics to support normative emission limits for mass-market electrical goods.
SupraEMI Final Workshop Webinar

April 2022

Agenda

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

6th April 2022 at 08h UTC to 11h UTC (10h CEST to 13h CEST).

1. Background to the problem of (2 to 150) kHz conducted EMI in public electricity networks. Paul Wright NPL. (20 mins) (08.00h-08.20h)

2. Discussion. (10 mins) (08.20h-08.30h)

3. A proposed framework for 2-150kHz measurement methods. Deborah Ritzmann, NPL (20 mins) (08.30h-08.50h))

4. Light Quasi-Peak: a computationally efficient method suitable for assessment of grid disturbance levels against compatibility levels in the (9 to 150) kHz range. Alexander Gallarreta. UPV/EHU (20 mins) (08.50h-09.10h)

5. Discussion. (10 min) (09.10h - 09.20h)

6. A comparison of performance and results of measurement methods applied to a selection of domestic appliances with emissions in the (2 to 150) kHz range. Helko van den Brom, VSL (20 mins) (09.20h-09.40h)

7. Experiences and conclusions of (2 to 150) kHz measurements under controlled grid conditions in the EDF concept grid in France. Daniella Istrate LNE (20 mins) (09.40h-10.00h)

8. Challenges in the application of measurement methods in grid measurements. Victor Khokhlov, TUD (20 mins) (10.00h-10.20h)

9. Discussion (10 mins) (10.20h-10.30h)

10. Mains impedance measurements and the suitability of Artificial Mains Networks for (2 to 150) kHz EMC testing. Jan Meyer/Robert Stiegler, TUD (20 mins) (10.30h to 10.50h)

11. Next steps and final discussion. (10 mins) (10.50h to 11.00h)

RAISE HAND TO SPEAK

- There are a lot of people on the call.
- Please mute your microphone (If not speaking, switch-off cameras to save bandwidth).
- If you want to make comment or ask a question…please use the comment facility.
- Questions in the comment box will be answered at the end of presentation if time allows.
- Also there are discussion sessions on the agenda.
- Thanks for your cooperation!

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Background to the problem of 2-150kHz conducted EMI in public electricity networks.

Paul Wright, NPL

SupraEMI Final Workshop, April 2022

Talk Outline

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

- The problem with 2-150 kHz conducted emissions.
- Some introductory case-studies.
- Definitions and terminology.
- Sources of emissions
- Regulation and Standardisation.
- Overview of the EU EMPIR SupraEMI Project.

Increasing 2-150kHz Emissions on public electricity networks

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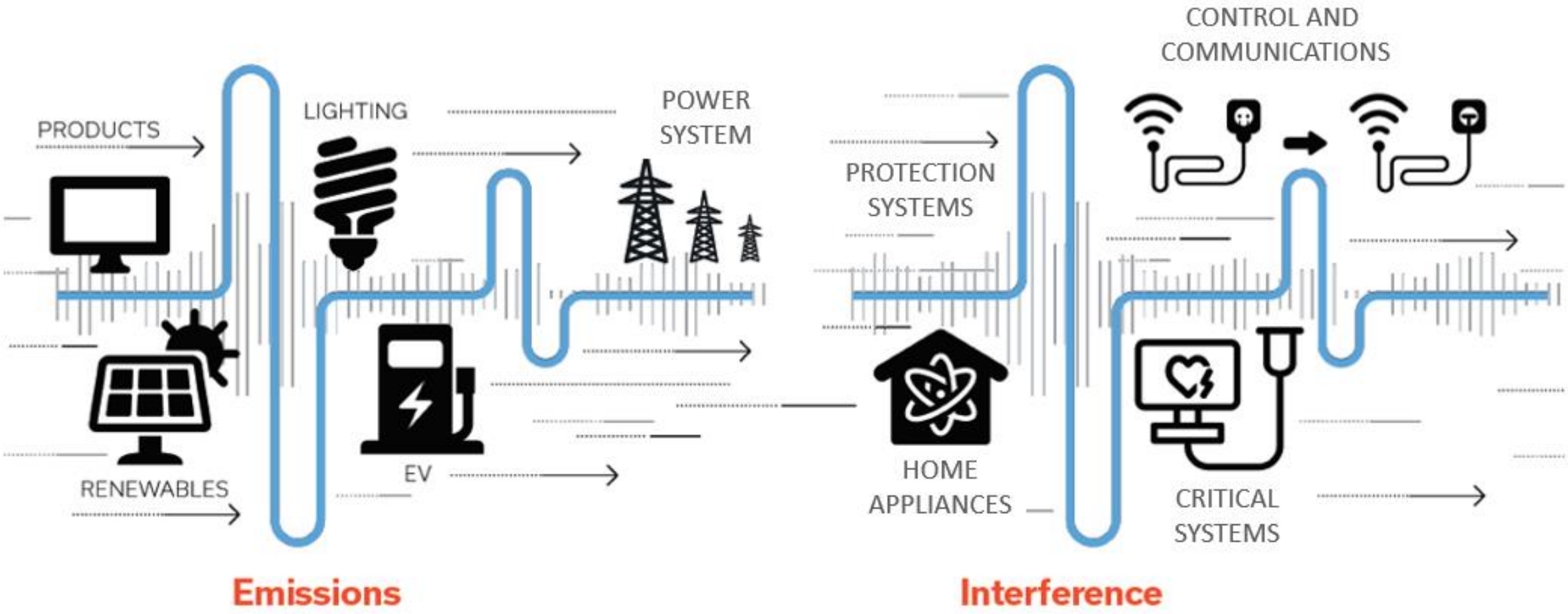

An example of 2-150kHz interference Causing Product Malfunction

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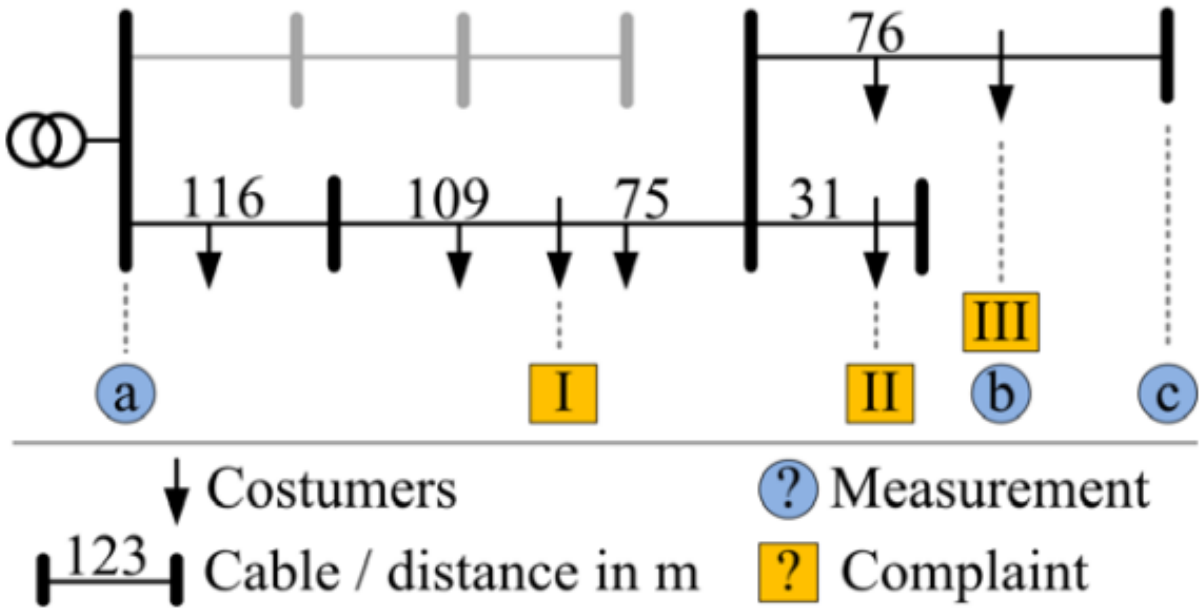
- Small town (7000 inhabitants), urban LV grid
- Customer complaints:
  - Coffeemaker grinds coffee, throws it away, lets out water (I)
  - Professional hair dryer turns itself on and off (40x / day) (II)
  - CNC mill control malfunction (III)

- Measurement sites:
  a) LV bus bar
  b) CNC mill POC
  c) Junction box

- Complaints limited to a small area



Survey of the Origin of the Interference

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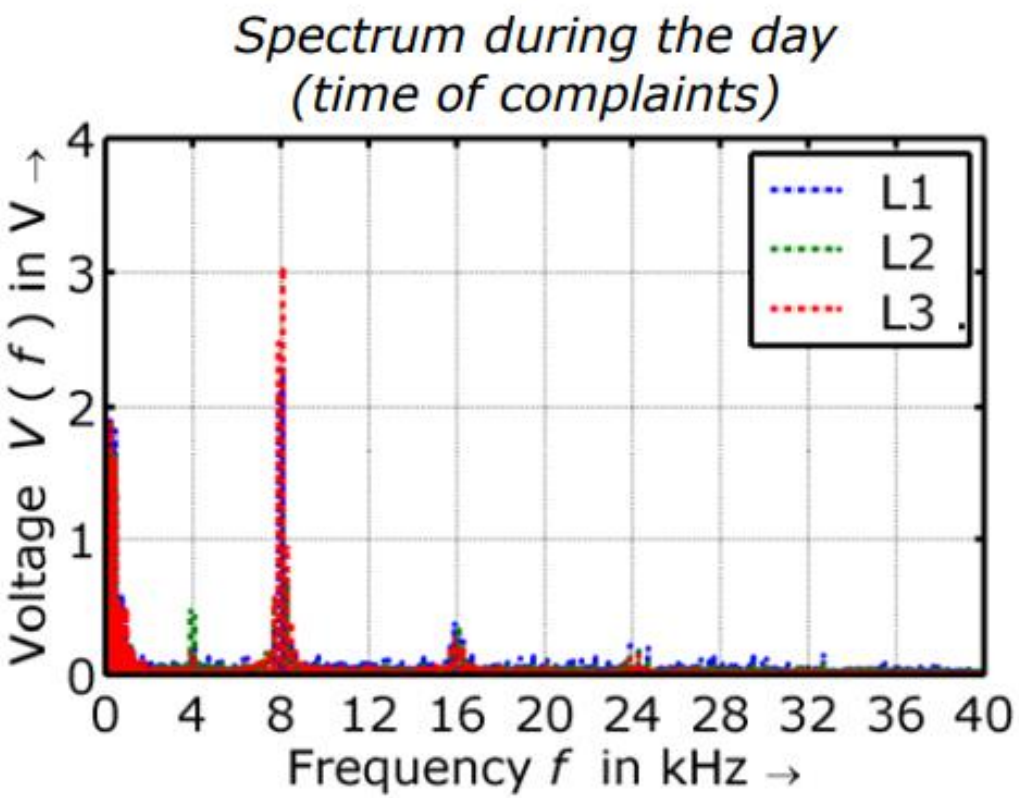

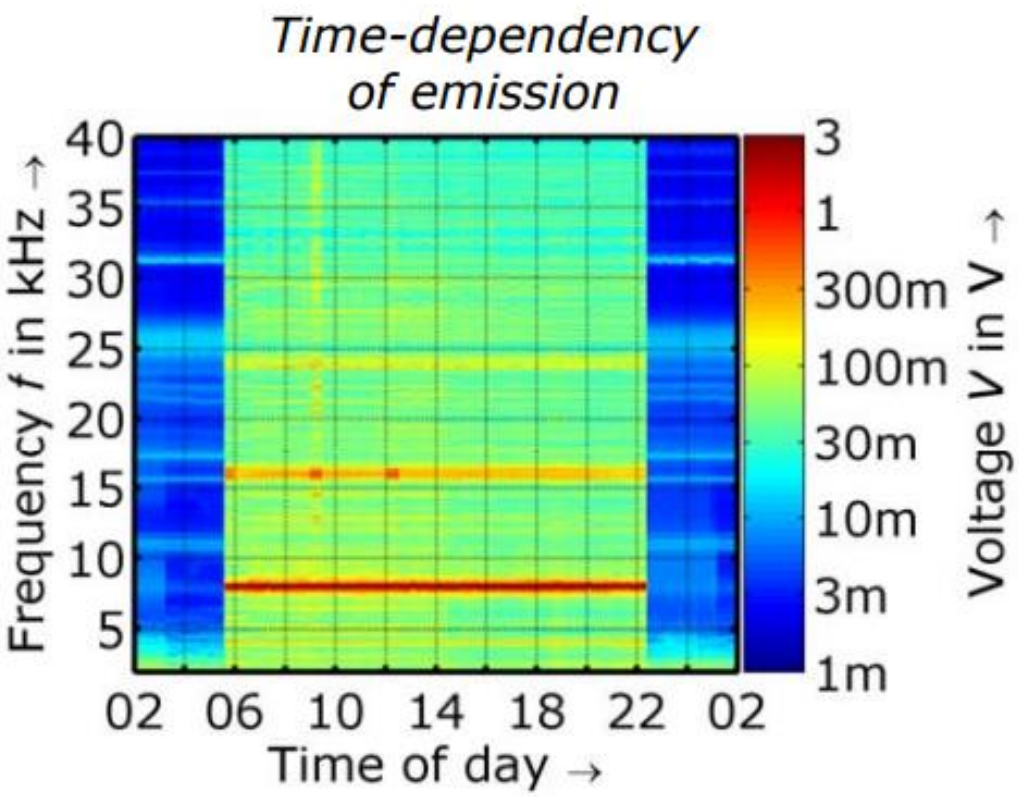

- Supraharmonic emission at 8 kHz of about 1.5%
- Occurs only on working days between 6 a.m. and 10 p.m.
  → Origin of disturbance is CNC mill (no EMC filter has been ordered)

An example of 2-150kHz interference Shortening Product Lifetime

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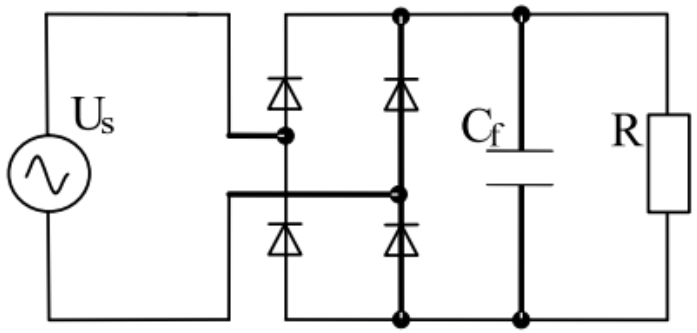
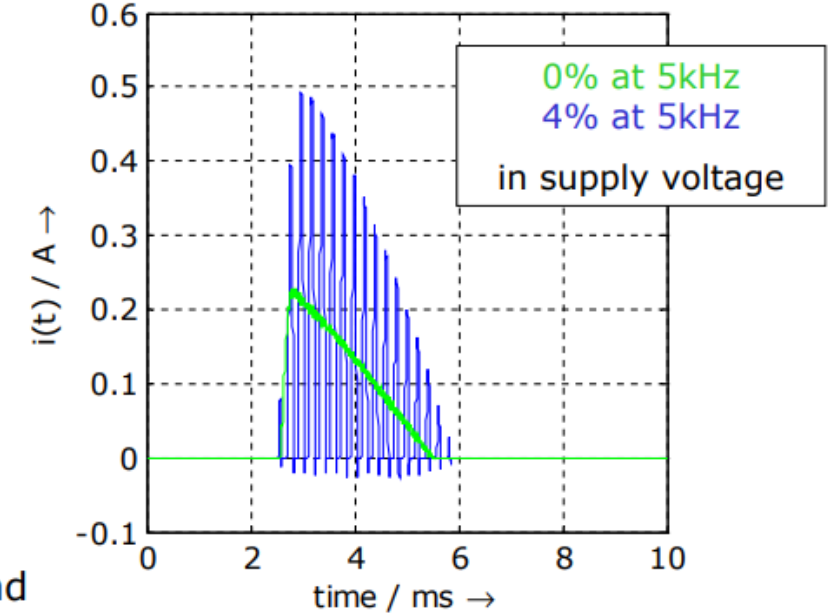
B/D: Thermal stress of electrolytic capacitors (1)

Simplified circuit of a compact flourescent lamp

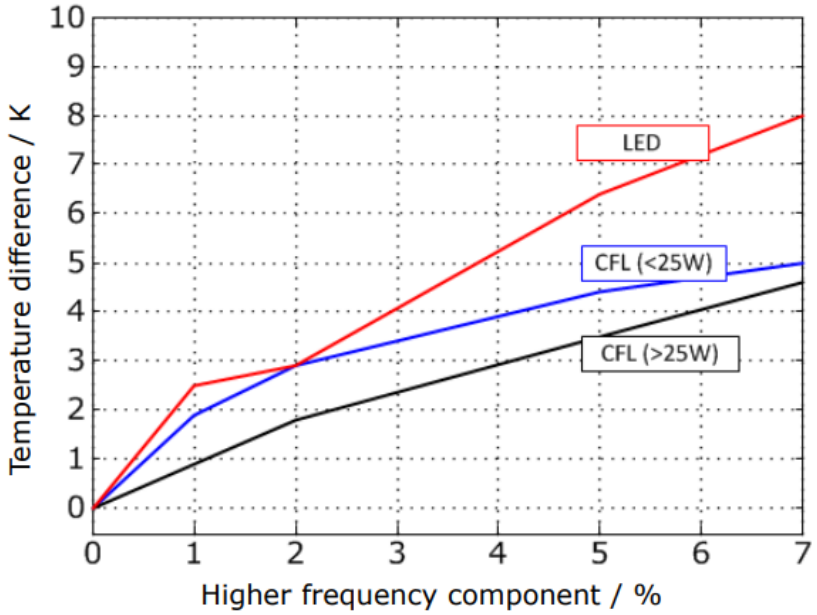


- Additional thermal stress for some components (diodes, DC link capacitor)
- Increased aging of components and possible reduction of lifetime
- Damage due to overheating

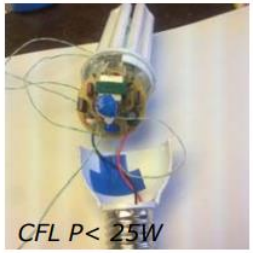
Waveform with/without HF component



Increased aging normally not evident to the user



Simple LED lamp


CFL P< 25W

Definitions, causes and sources

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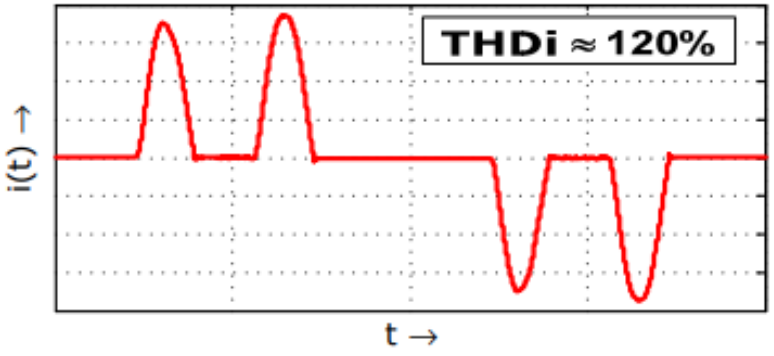
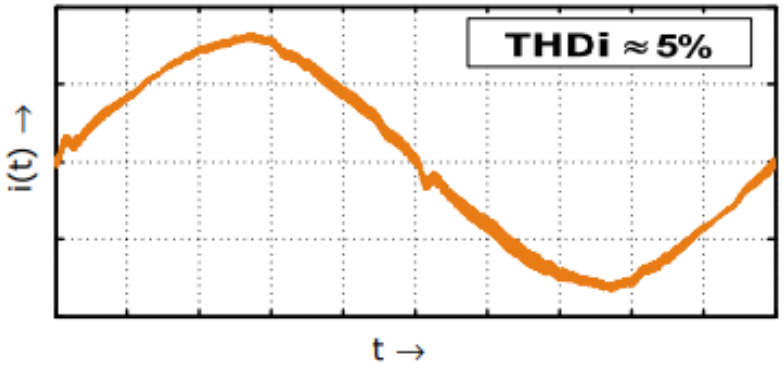
"Traditional" power electronics



Electronic equipment using line-commutating topologies

Low frequency distortion (below 2 kHz)

"Novel" power electronics



Electronic equipment using self-commutating topologies

Higher frequency distortion (2 kHz .. 150 kHz)

Continuous shift of emission towards beyond 2 kHz

Major sources of non-intentional emission

- Frequency converters with and without active frontend (e.g. in VSD-applications)
- Rectifiers with active power factor correction (e.g. switched mode power supplies, EV chargers)
- Self-commutating inverters (e.g. PV installation)
- Converter for storage applications

Major sources of intentional emission

- Narrow-band Powerline-Communication (about 30 kHz ... 95 kHz)

Terminology

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Low frequency distortion (below 2 kHz)

Integer and non-integer multiples of power frequency

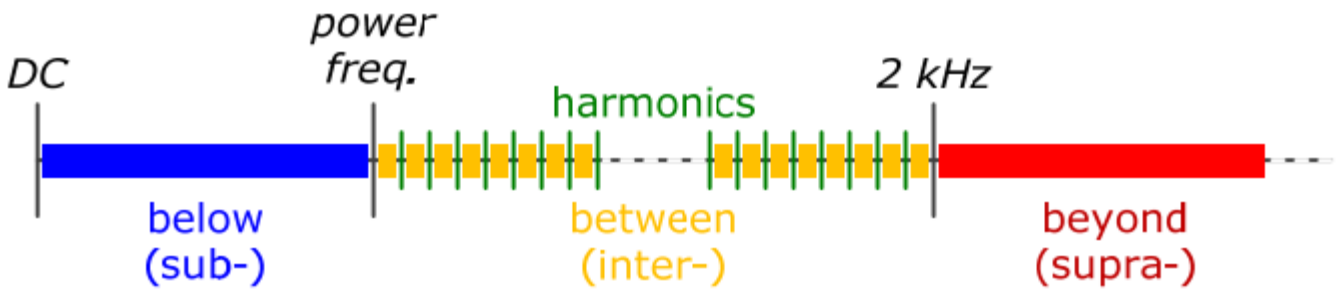
a. DC component
b. Subharmonics
c. Harmonics
d. Interharmonics

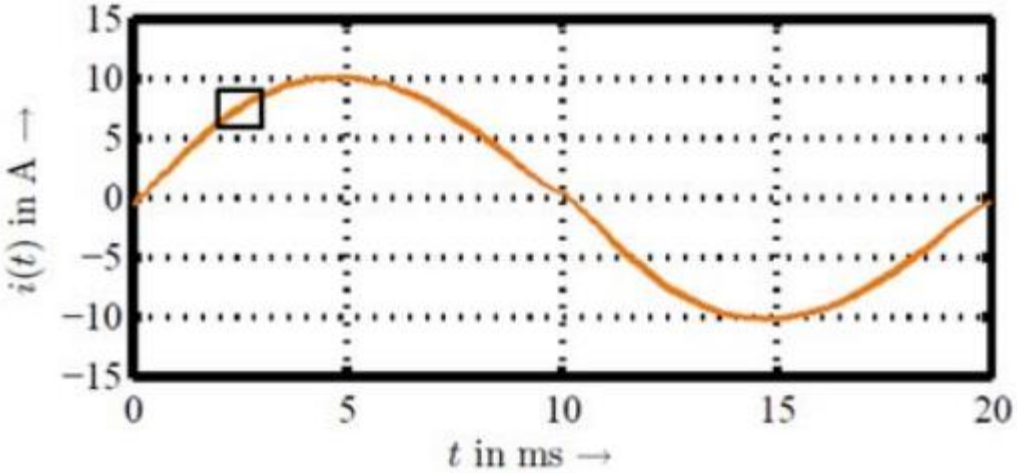
Higher frequency distortion (2 kHz .. 150 kHz)

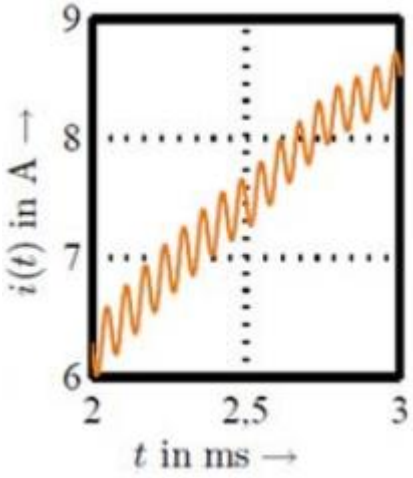
"Independent" of power frequency

a. Supraharmonics

- ***Supra = beyond***
- ***First mentioned at IEEE PES GM 2013***







Almost Sinusoidal?
Measurements may miss the superimposed high frequency component!

Sources of Emission – EV Charging

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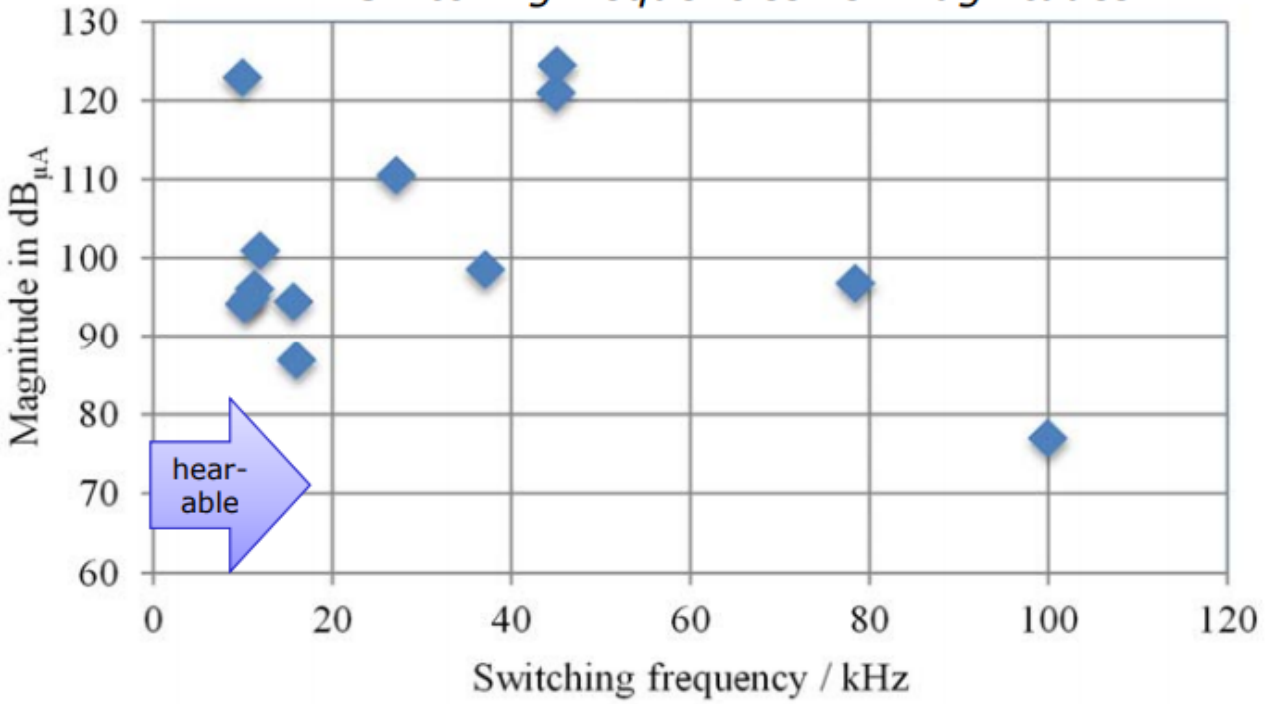
Electric vehicle chargers

- Measurement of about 80% of the EV types in the German market (Identifiable switching frequencies for 12 of 19 EVs)
- Large diversity in magnitude and switching frequency

Switching frequencies vs. magnitudes



- Most of the data is available in PANDA

equiPment hArmoNic DAtabase

http://panda.et.tu-dresden.de

(100 dBuA = 100 mA; 130 dBuA = 1.3 A)

Sources of Emission - PV

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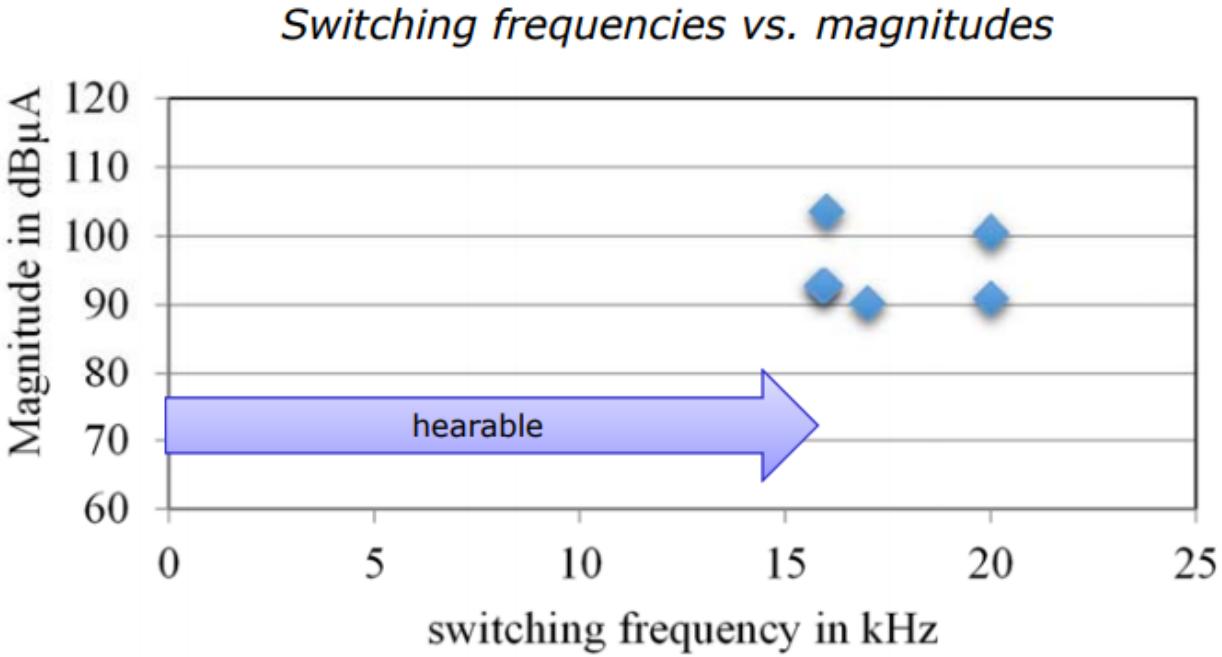
Photovoltaic inverters



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http://panda.et.tu-dresden.de

- 6 PV-inverter below 10kW (roof-top application)
- Measured using an impedance of about 0.4Ω (resistive)

(100 dBuA = 100 mA)

Sources of Emission - Household appliances

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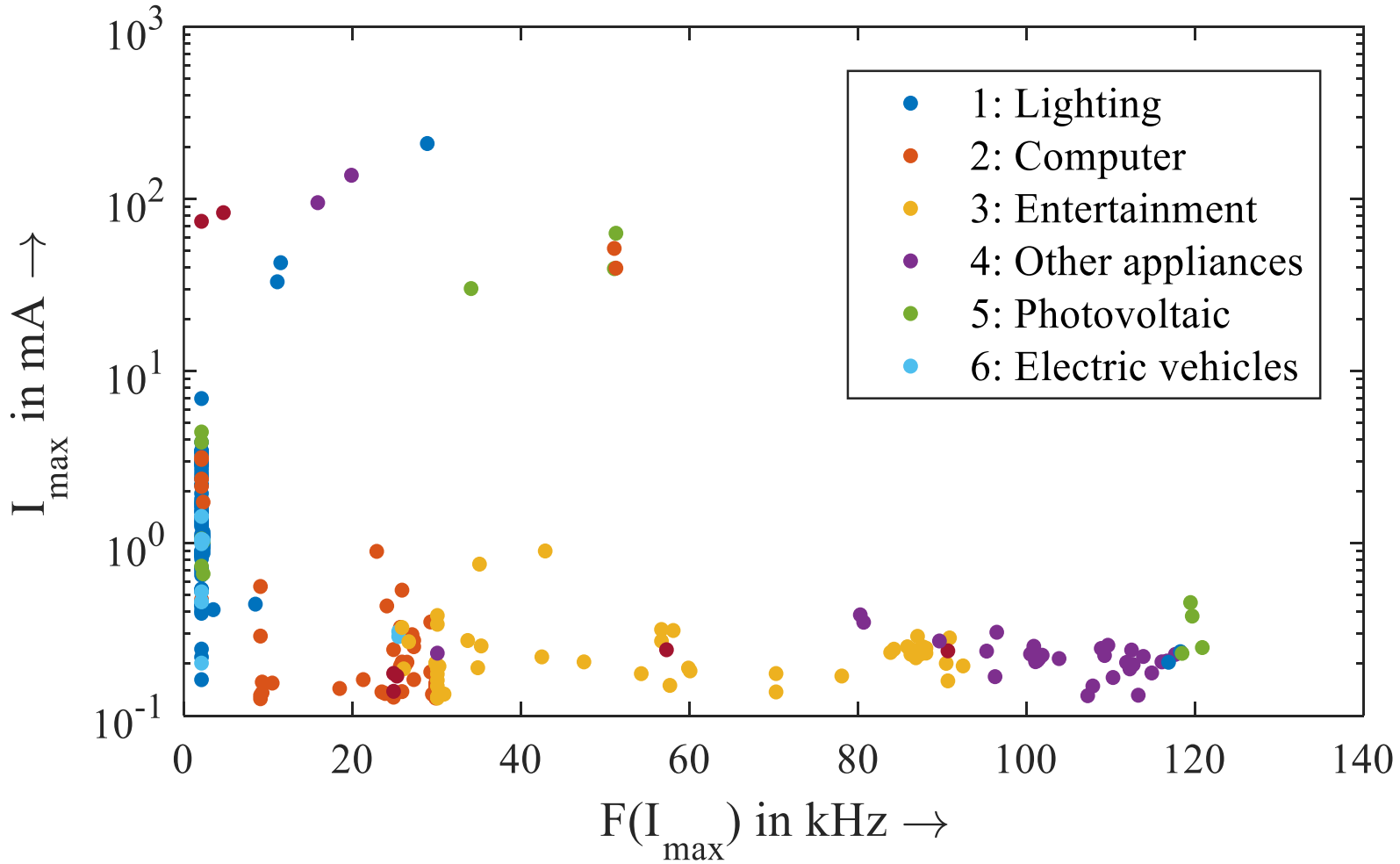

Emissions from houshold appliances are present through out the entire frequency range.

Plot of the highest 200 Hz band in the 150kHz frequency range for assorted appliances

Typical Frequency Ranges

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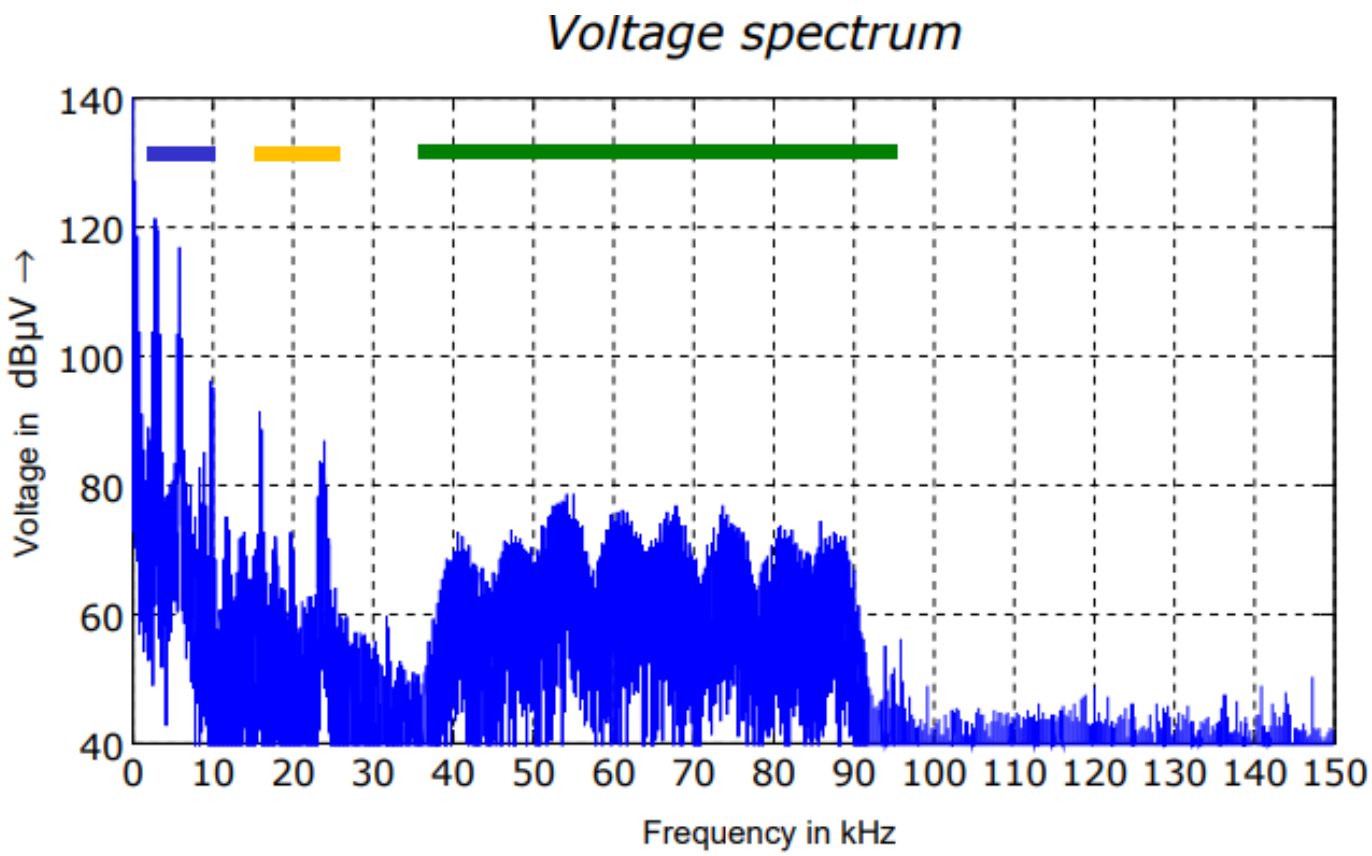

- 9 **large inverters** of S_r=100kW (switching frequencies below 10 kHz)
- 10 **small inverters** below 10kW (switching frequencies around 15-20 kHz)
- **Narrow-band PLC application** for meter communication (35 kHz – 95 kHz, 8 channels)

- Higher power of device → lower switching frequencies
- PLC-communication usually above 30 kHz

Spectrogram – Duration/Occurrence of Emission

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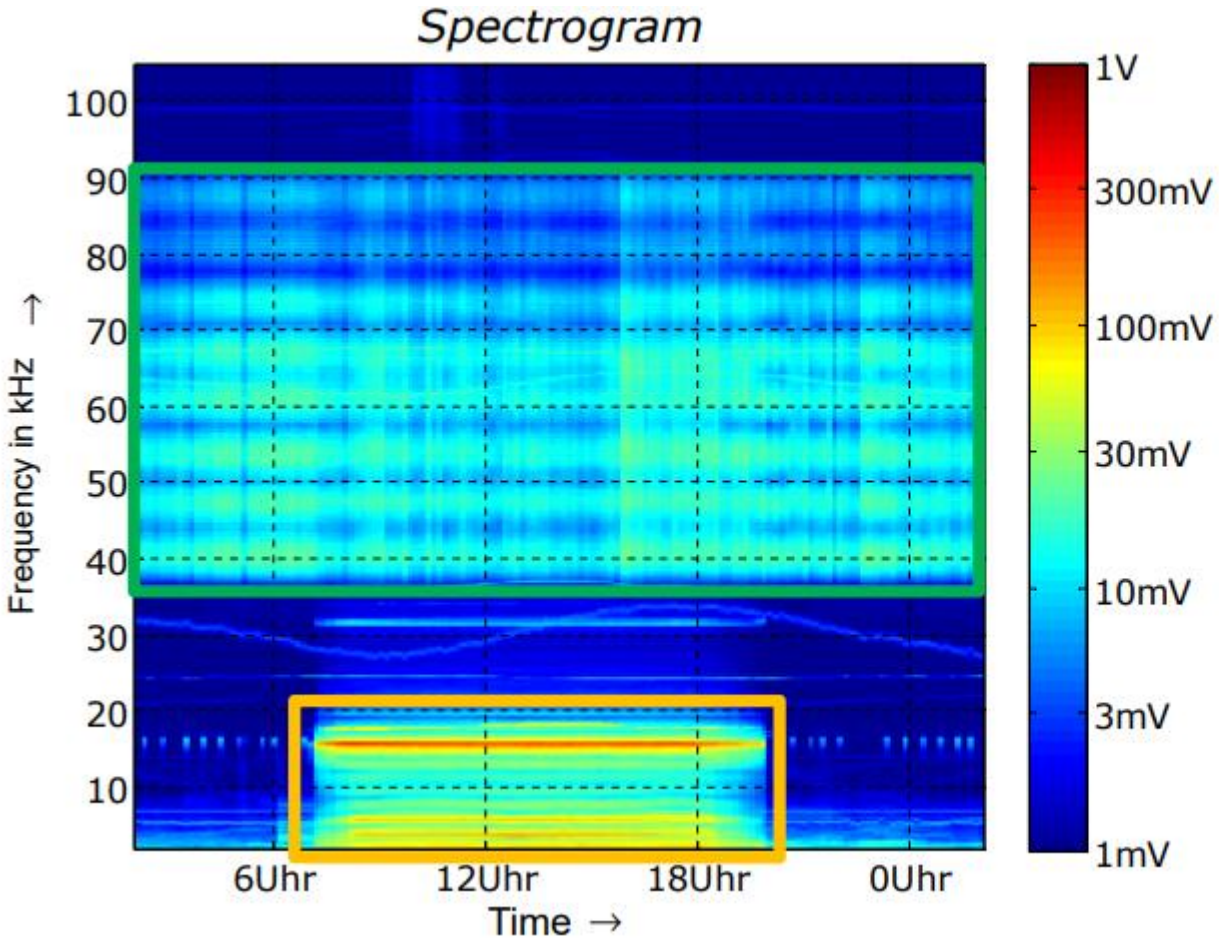
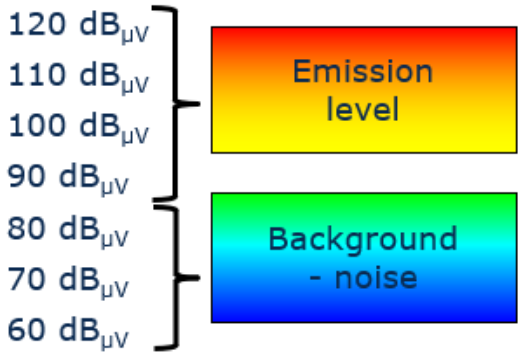
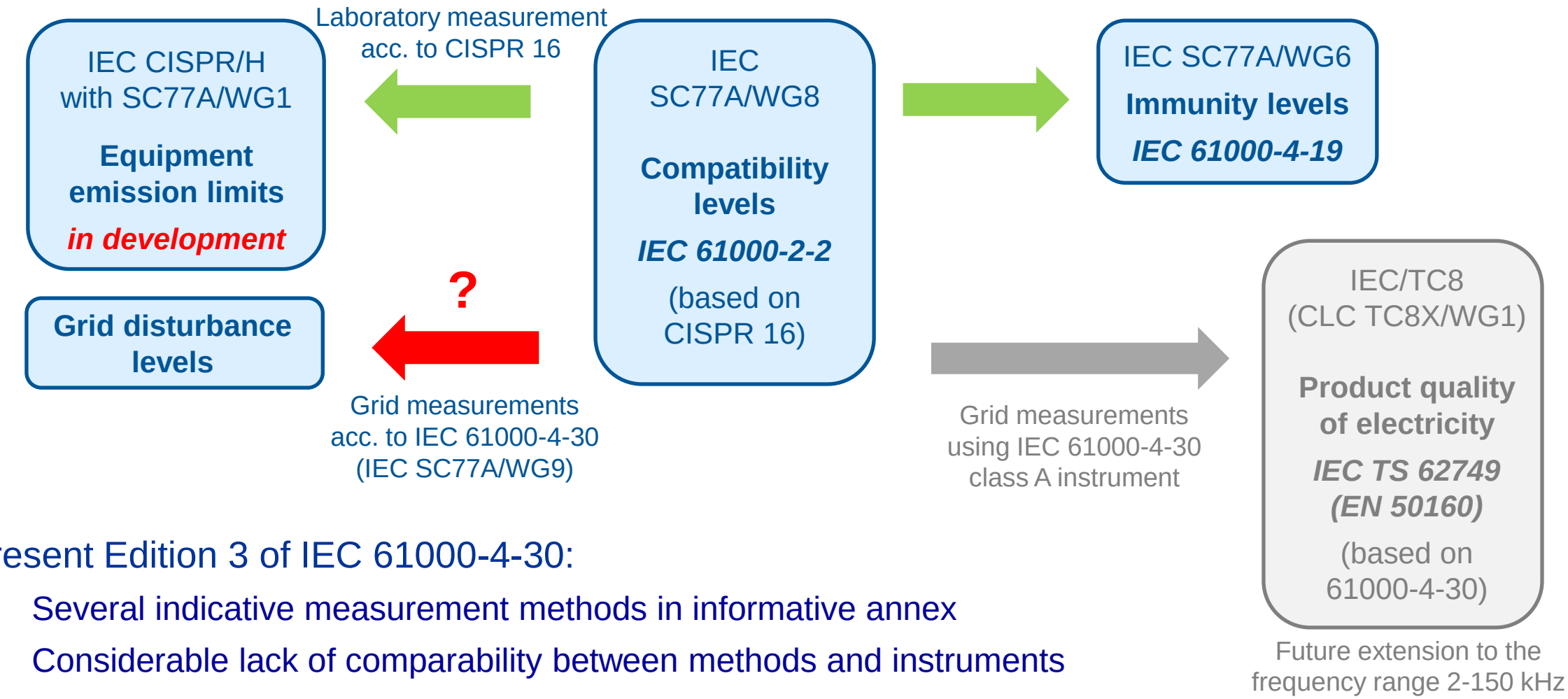


- LV-grid with 13 PV installations (74 kW peak)
- **PLC application**
  - Frequency range 35-95 kHz
  - Continuous operation
- **PV-inverters**
  - Switching frequencies in the frequency range 15-20 kHz
  - Operation only during daytime



(100dBuV=0.1V; 120dBuV = 1V)

Status quo of standardisation (9-150 kHz)



- Present Edition 3 of IEC 61000-4-30:
  - Several indicative measurement methods in informative annex
  - Considerable lack of comparability between methods and instruments

EU EMPIR Project SupraEMI

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Purpose: Support standardisation with necessary input to develop an widely agreed method for grid compliance assessment in the frequency range 2-150 kHz

- Start date: May 2019 for 3 years. (This is the end-project workshop)
- Pre-normative R&D project. Funded by H2020/EMPIR, EMN SEG →
- National Metrology Institutes of UK, FR, NL and CH.
- University Partners:

  TU Dresden (DE), UPV/EHU (ES) and U of Campania (IT).
- Chief Stakeholder: Dr. Michael Schwenke, IEC77A WG9 Convener

EUROPEAN METROLOGY NETWORK

SMART ELECTRICITY GRIDS

NPL National Physical Laboratory · LNE Laboratoire National de Métrologie et d'Essais · VSL Dutch Metrology Institute · Technische Universität Dresden · METAS · Università degli Studi della Campania Luigi Vanvitelli · Universidad del País Vasco / Euskal Herriko Unibertsitatea

Summary

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

- 9-150kHz is a growing power quality (PQ) problem and more power convertors are connected to the grid (Renewables, EVs, storage, efficient appliances).
- Just like traditional PQ, grid operators need surveillance of their networks to manage compatibility levels.
- This requires a PQ measurement method that can be implemented in PQ instruments (and computationally efficient method for affordable instruments)
- This workshop will present the findings of the *supraEMI* project and progress towards a fit-for-purpose measurement method and its practical application.

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