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# Characterization of different types of emission in the range 2-150kHz.

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### Introduction



### Purpose of the study:

The evaluation of measurement methods require some previous tasks:



#### Aim of the characterization

 Identify the main aspects of the waveforms present in the LV grid in the range 2kHz-150kHz.

# **Characterisation of emissions Emissions** I



### **Tonal emissions**



- Main characteristics:
  - Average value quite stable with time
  - Fast variations (tens of milliseconds) —
  - Narrow bandwidth (from 80Hz to 1kHz at -3dB)

### Harmonics of tonal emissions



- Accuracy is required in:
  - Amplitude (RMS, peak, quasi-peak)
  - **Frequency resolution**
  - Frequency step size
  - Variation with time (fast variations)

40

20

0

-20

-40

-60

-80

-100

-120

# **Characterisation of emissions Emissions II**





- Main characteristics:
  - Amplitude varies with frequency and time
  - Very different bandwidths
    - (from a few tens of kHz to 80kHz)

### **Colored** noise



- Accuracy is required in:
  - Occupied frequency range
  - Power in the occupied frequency range
  - Peak detection
  - Average level (RMS)
  - Variation with time (mid-term variations)

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60

40

20

0

-20

-40

-60

-80

-100

150

# **Characterisation of emissions** Emissions III



### Impulsive noise



- Main characteristics:
  - Short impulses (from a few ms to tens of ms)
  - Isolated or repeated in time
  - Very variable bandwidth

### **Periodical emissions**



- Accuracy is required in:
  - Occupied frequency range
  - Peak detection
  - (Periodical: Variation with time)

# **Characterisation of emissions** Emissions IV



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#### **PLC** bursts 100 4.5 90 4 3.5 80 3 (s) 2.5 70 60 2 50 1.5 40 0.5 30 0 100 50 150 Frequency (kHz)

- Main characteristics:
  - Known central frequency and bandwidth
  - Short impulses
  - The duration of the bursts depends on the information to be transmitted, always few ms



- Issues to be considered:
  - In Power Quality these emissions are not desired.
  - In communications, PLC bursts are the emissions to be preserved.

Amplitude (dBµV)

# **Characterisation of emissions** Overview

Huge diversity in time and frequency in the characteristics of the emissions.

The results depend on the measurement method.

Grid measurements are a combination of several types of emissions.



Synthetic signals, where amplitude values of PSD can be theoretically calculated, are needed to test the measurement methods.

The theoretical amplitude values can be used as reference levels.



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### Synthetic signals Reference values of the PSD



Reference values are calculated:

• **AWGN-based:** Considering the AWGN power is homogeneously distributed in the spectrum, the reference values are calculated as the PSD multiplied by the frequency response of the filter.

• **Polar coding:** As the PSD of the polar coding is a sinc function, the reference levels are calculated multiplying the amplitudes in the spectrum by the frequency response of the filter.

# Synthetic signals Combining emissions I



- It is possible to combine different types of waveforms to create more complex signals.
  - The reference values of both methods are compatible to be combined.
- It is possible to adapt the ResBW and the Frequency Step Size of the reference values.
  - By default the values are given in dBµV per Hz.



# Synthetic signals **Combining emissions II**



Signals similar to those recorded in the LV grid can be generated by combining different types of test synthetic signals. 90



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#### **Advantages**

- The real level can be theoretically calculated and used as a reference level in the evaluation of measurement methods
- Flexibility to generate ad-hoc waveforms with some specific particularities and evaluate those effects in the results of the measurement methods (time variability, impulsive emissions, narrowband emissions...)

#### **Disadvantages**

• The intrinsic variability of the basic signals is reduced with longer signals. Therefore, a minimum duration of 5s is recommended.





- The characterization of the LV grid Non-Intentional Emissions in time and frequency domains allows the identification of the relevant aspects to be considered by the measurement methods.
- Two procedures to generate synthetic signals with reference levels are proposed. They allow to evaluate the accuracy of the measuring methods.



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### Thank you for your attention!