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

DC Grids

Power Quality Compatibility Levels
in DC Power Networks

Daniele Gallo,
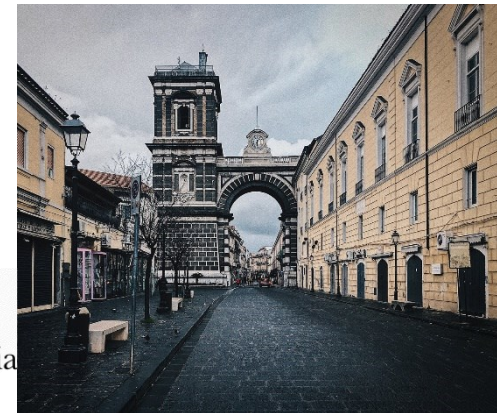University of Campania
Italy

WP4:
Metrological framework for practical surveys of "Compatibility level" and "Planning level" of DC PQ in LVDC grids (**SUN**, VSL, INRIM, LNE, CIRCE, TU-E, EDF)
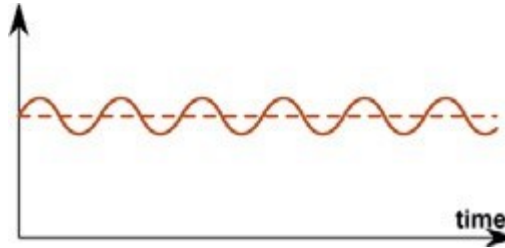
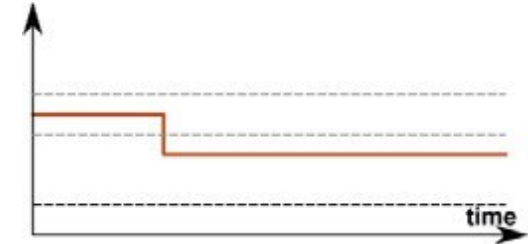V: Università degli Studi della Campania *Luigi Vanvitelli*
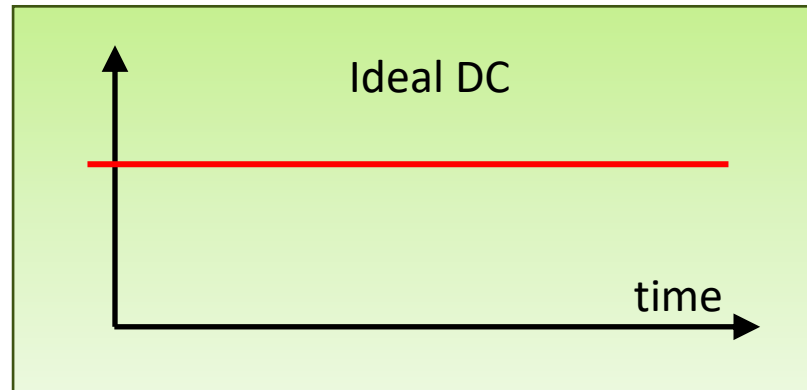
DC Power Quality - Phenomena
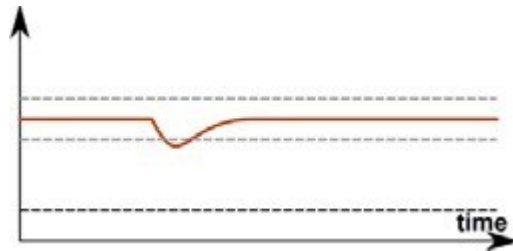

Fluctuation

Ripple

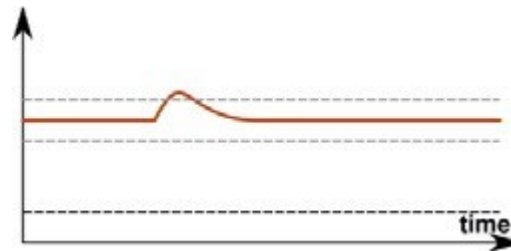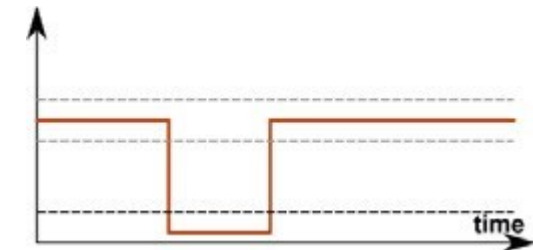Rapid Variation

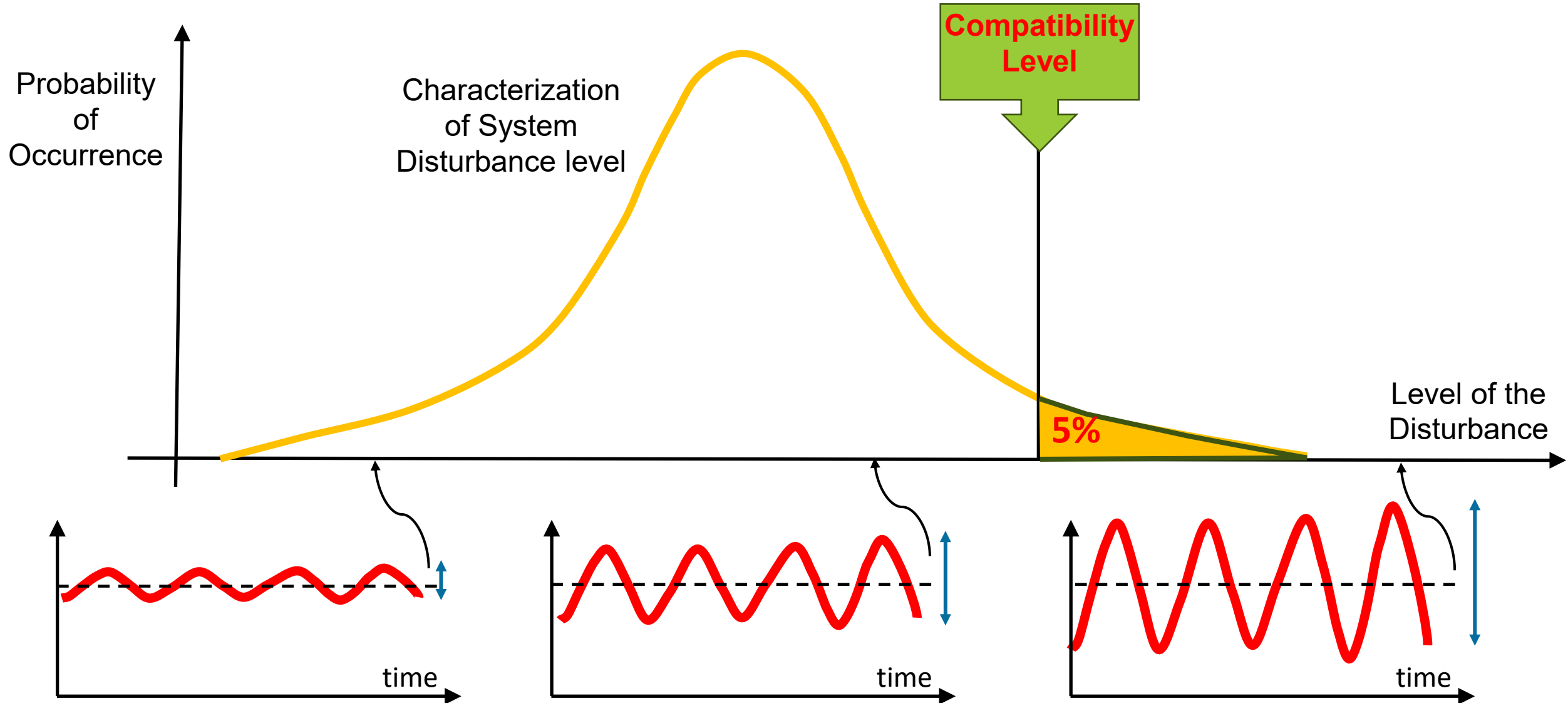Impulsive transient

Ideal DC

Oscillatory transient

Dip

Swell

Interruption

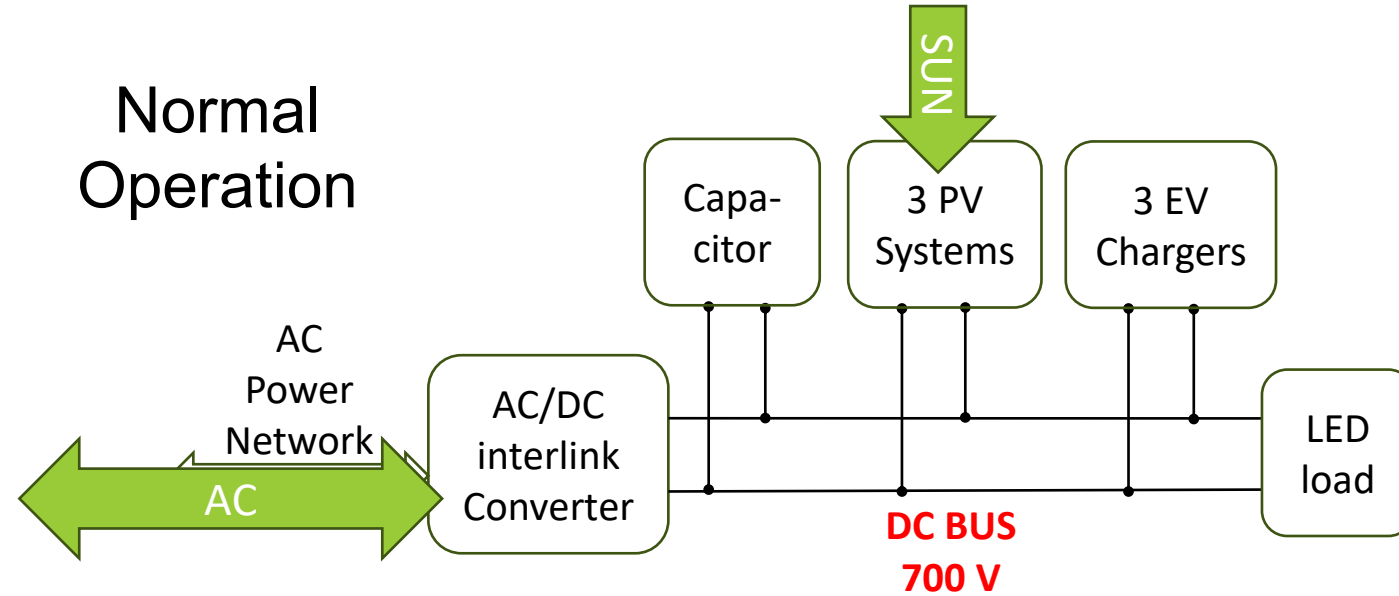# DC Power Quality – Severity indexes

DC Power Quality - Compatibility Level

Probability of Occurrence

Characterization of System Disturbance level

Compatibility Level

Equipment Immunity Level

5%

Emission limits individual sources

Planning levels

Immunity test levels

Level of the Disturbance
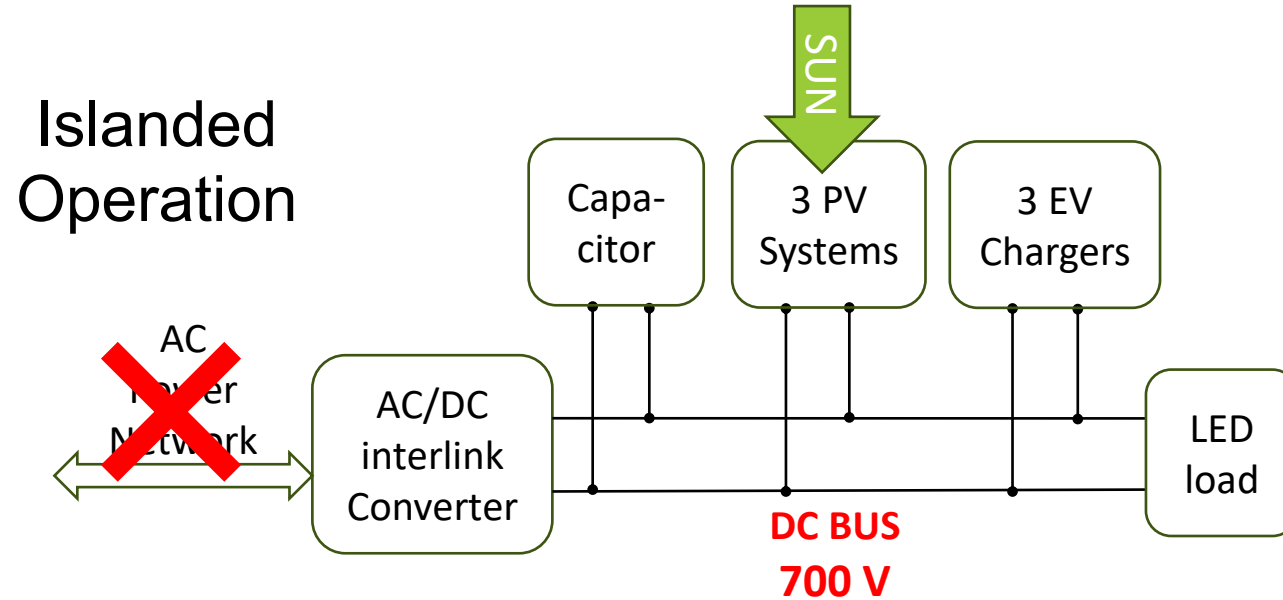
DC Grids
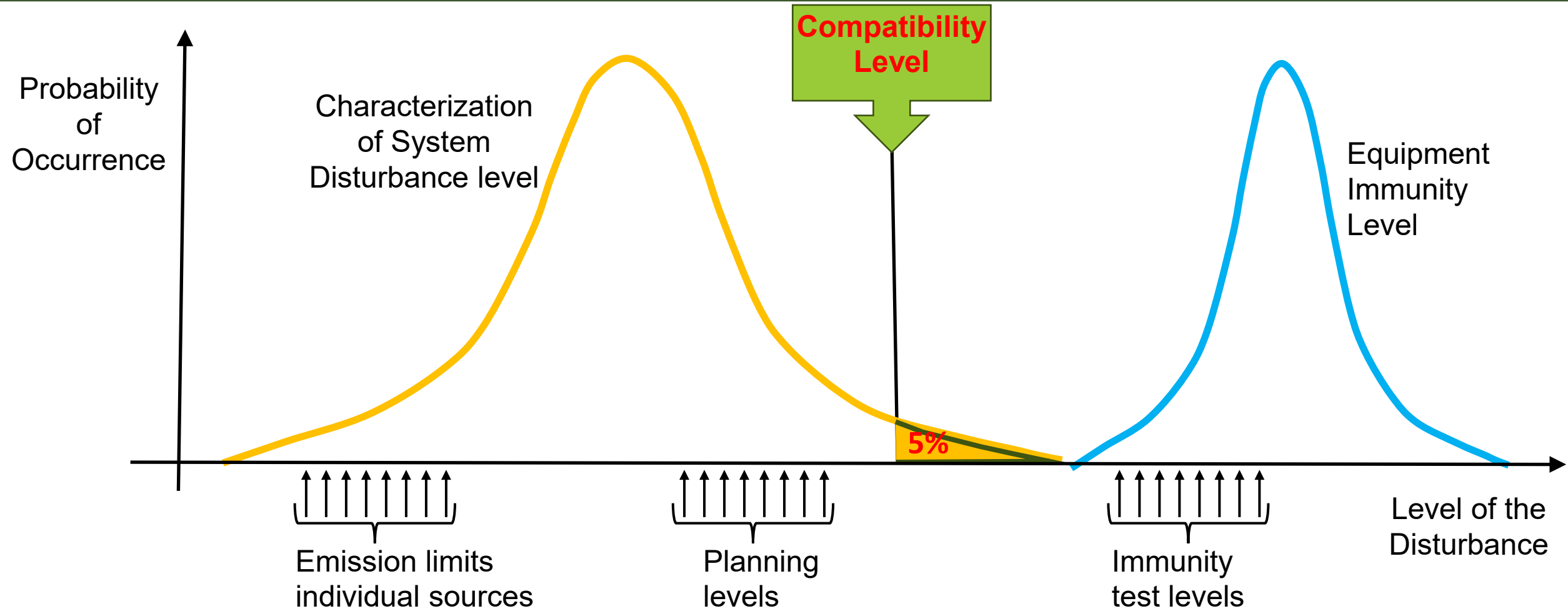
Compatibility Level Assessment

✓ **Define PQ severity indexes and Standard Measurement Procedures**

✓ **Monitor severity indexes over the time**

✓ **Calculate 95% percentile values (Compatibility Levels)**

? **Check compliance with standard limits**

Experimental Application

Normal Operation

SUN

Capacitor

3 PV Systems

3 EV Chargers

AC Power Network

AC

AC/DC interlink Converter

DC BUS 700 V

LED load

LVDC grid (700V)
in an open parking garage
in Utrecht,
the Netherlands

Experimental Application
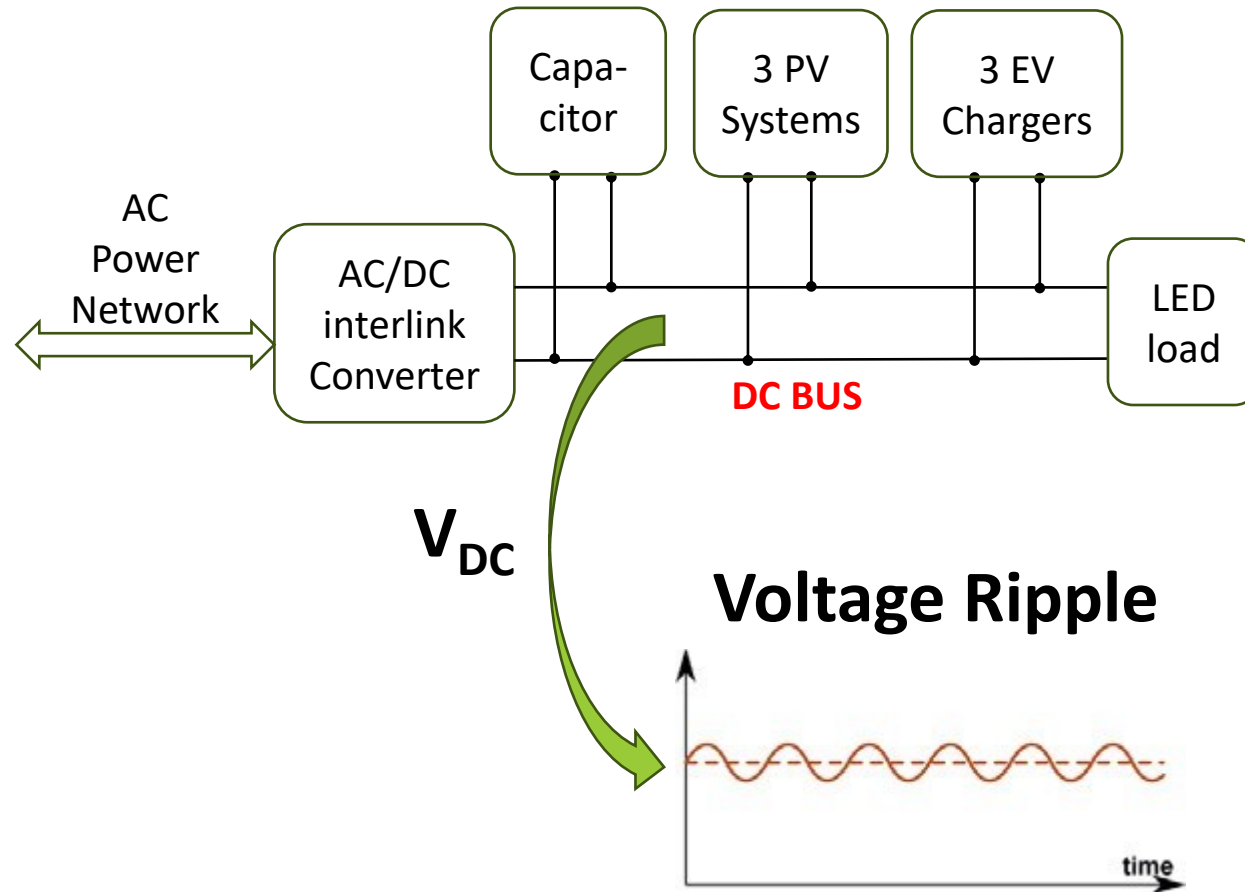

Islanded Operation

LVDC grid (700V)
in an open parking garage
in Utrecht,
the Netherlands

Experimental Application

LVDC grid (700V)
in an open parking garage
in Utrecht,
the Netherlands

- **Time Domain**

- **Frequency Domain**
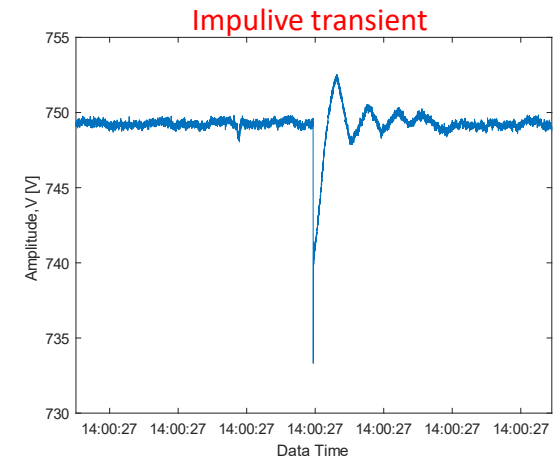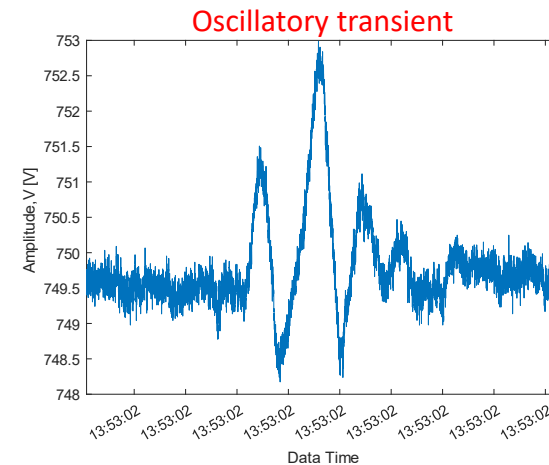
Event Flagging for ripple assessment

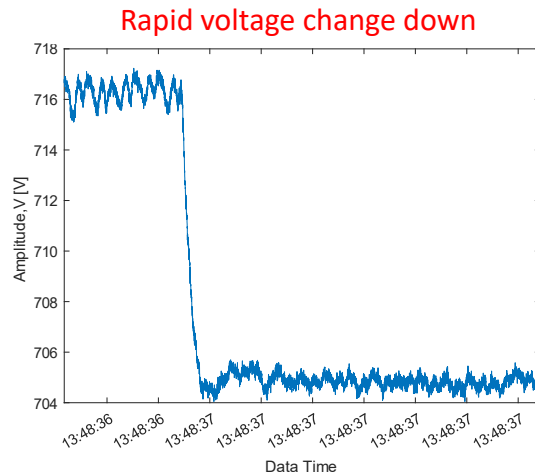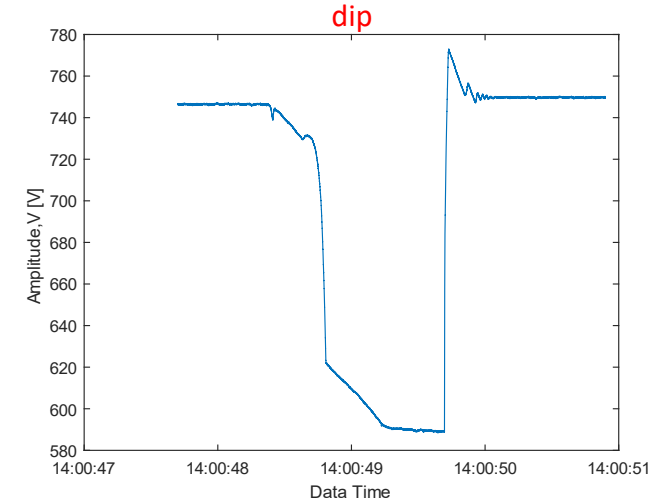- Severity index measurement methods for stationary PQ disturbances are not applicable or lead to unreliable results when transient disturbances occur.
- for example, it is meaningless to measure spectral components when voltage dips, swells, or interruptions occur.
- the presence of a transient phenomenon should be preliminary detected by proper trigger mechanisms and corresponding data should be flagged and not analyzed
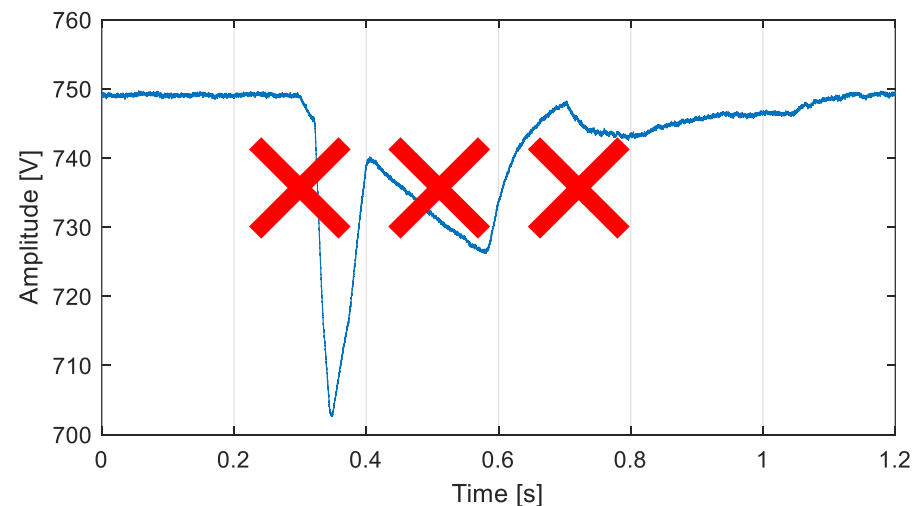
Event Flagging for ripple assessment

98 flagged time-frames

- **Interruption**
- **Dip/Swell**
- **Transients**

interruption

dip

Rapid voltage change down

Rapid voltage change up

Oscillatory transient

Impulive transient
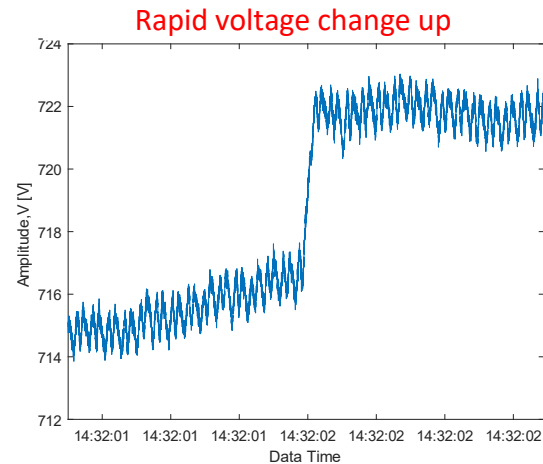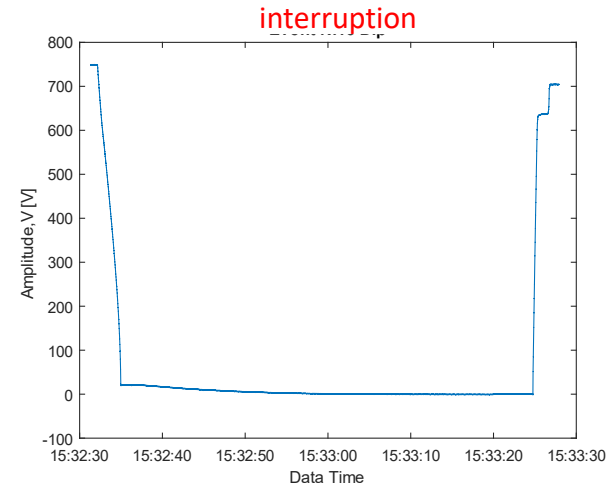
Ripple Analysis – time domain

Rpl-rmsC

Mean value 0.305
Coef. of variation 35%
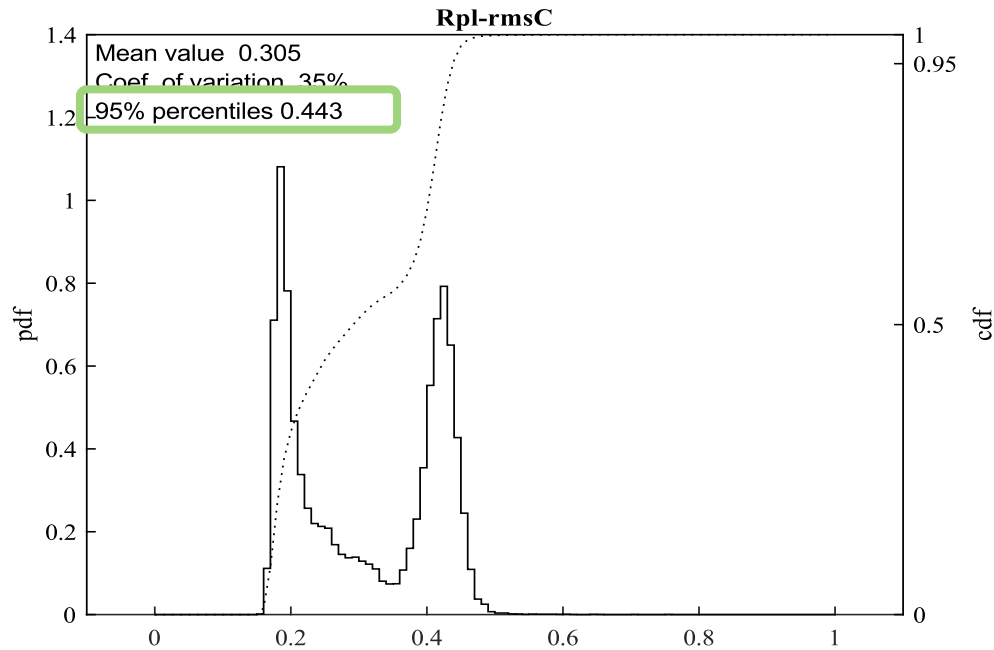95% percentiles 0.443

Ripple Rms Amplitude (V)

Rpl-pk-pk pctileC

Mean value 1.52
Coef. of variation 28%
95% percentiles 2.11

Ripple Peak to Peak Value (V)

Def:

$$\hat{X}_{rms}^2 = \langle (x(t) - X_0(t))^2 \rangle_T$$

T=200 ms

$$X_{pp}^k = \max_k \{x(t) - X_0(t)\} - \min_k \{x(t) - X_0(t)\}$$

**Compatibility Level of
Rms Amplitude   =   0.44 V**

**Compatibility Level of
Peak to Peak Value   =   2.1 V**

Ripple Analysis – frequency domain

Definition

No fundamental component

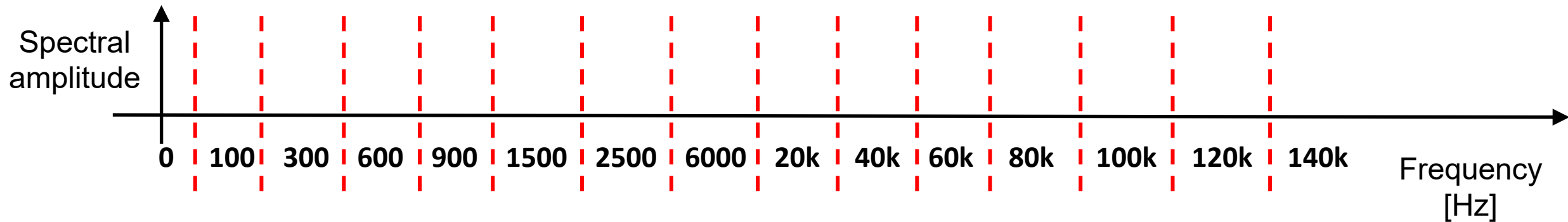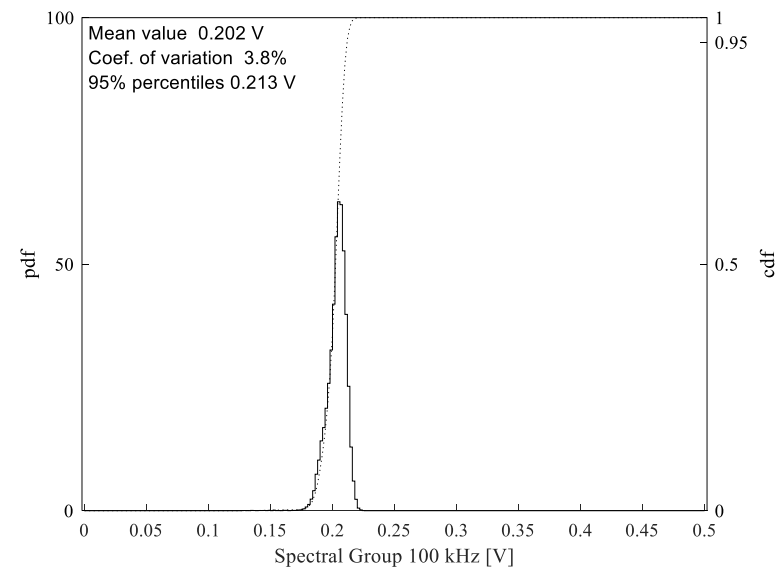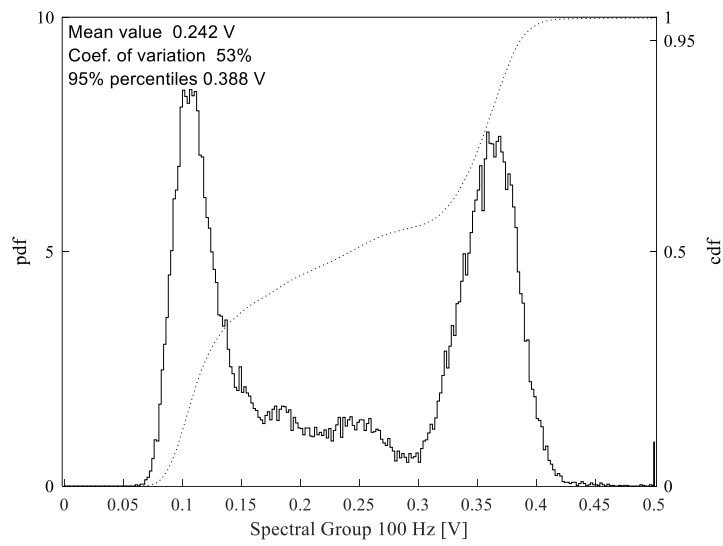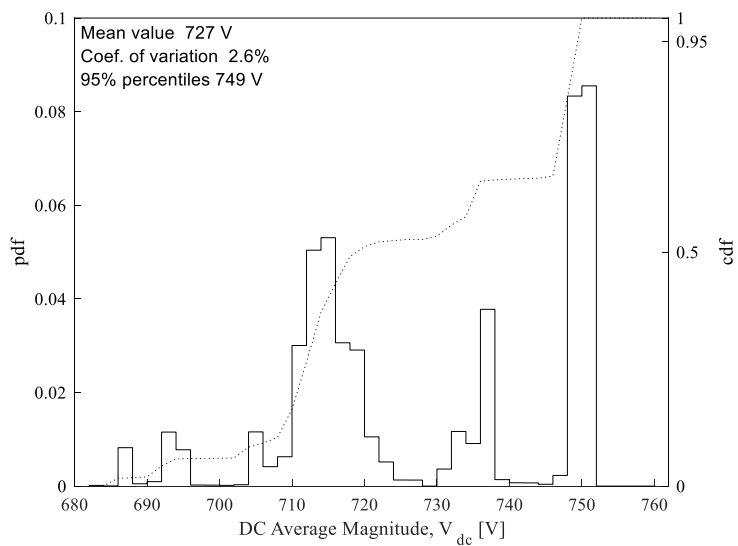**Frequency Bands**

$$SG_h = \sqrt{\sum_k C_k^2}$$

$$k \in h^{th} \; frequency \; band$$

Ripple Analysis – frequency domain

Results

Reference Frequency [Hz]	0	100	300	600	900	1500	2500	6000	20k	40k	60k	80k	100k	120k	140k
Mean [V]	727,04	0,24	0,1	0,04	0,03	0,06	0,05	0,09	0,13	0,12	0,12	0,14	0,2	0,15	0,11
95% percentile [V]	749,37	0,39	0,16	0,04	0,03	0,06	0,05	0,1	0,13	0,12	0,12	0,15	0,21	0,17	0,11

Mean value 727 V
Coef. of variation 2.6%
95% percentiles 749 V

Mean value 0.242 V
Coef. of variation 53%
95% percentiles 0.388 V

Mean value 0.202 V
Coef. of variation 3.8%
95% percentiles 0.213 V

Conclusions

- **Standard procedures able to assess PQ severity was defined**

- **Trigger procedures for flagging was defined**

- **Procedures was successfully applied in field measurements**

- **More field data are required for fixing limits**

D6: Industry guide on equipment specifications and methods for PQ "compatibility levels", and "planning level" surveys in LVDC grids for DC parameters

Power Quality Compatibility Levels in DC power networks

Thank you!

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