The challenges of electricity quality in terms of the impact of decentralized production

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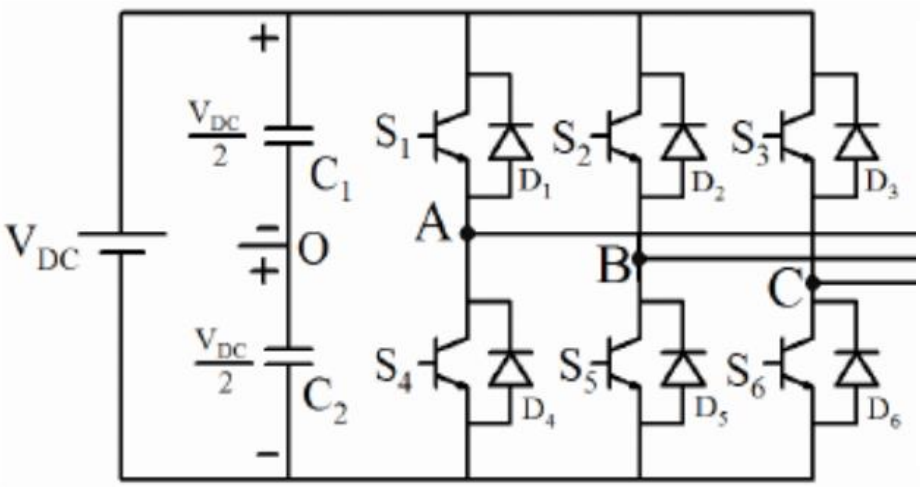
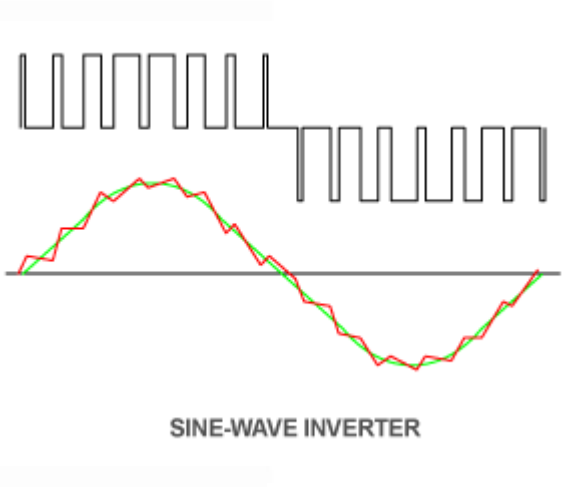
Aries energetika

1. Impact of PV power plants on distribution network
   - Measurement challenges
   - Problems caused by PV plants
2. Connection of wind power plants on meduim voltage networks
   - Grid standards and measurement
   - Fault behaviour
3. Power Quality monitoring solutions
   - Troubleshooting vs. monitoring
   - Data storage and visualization

Harmonics - Causes

Principle of switch-mode power electonics

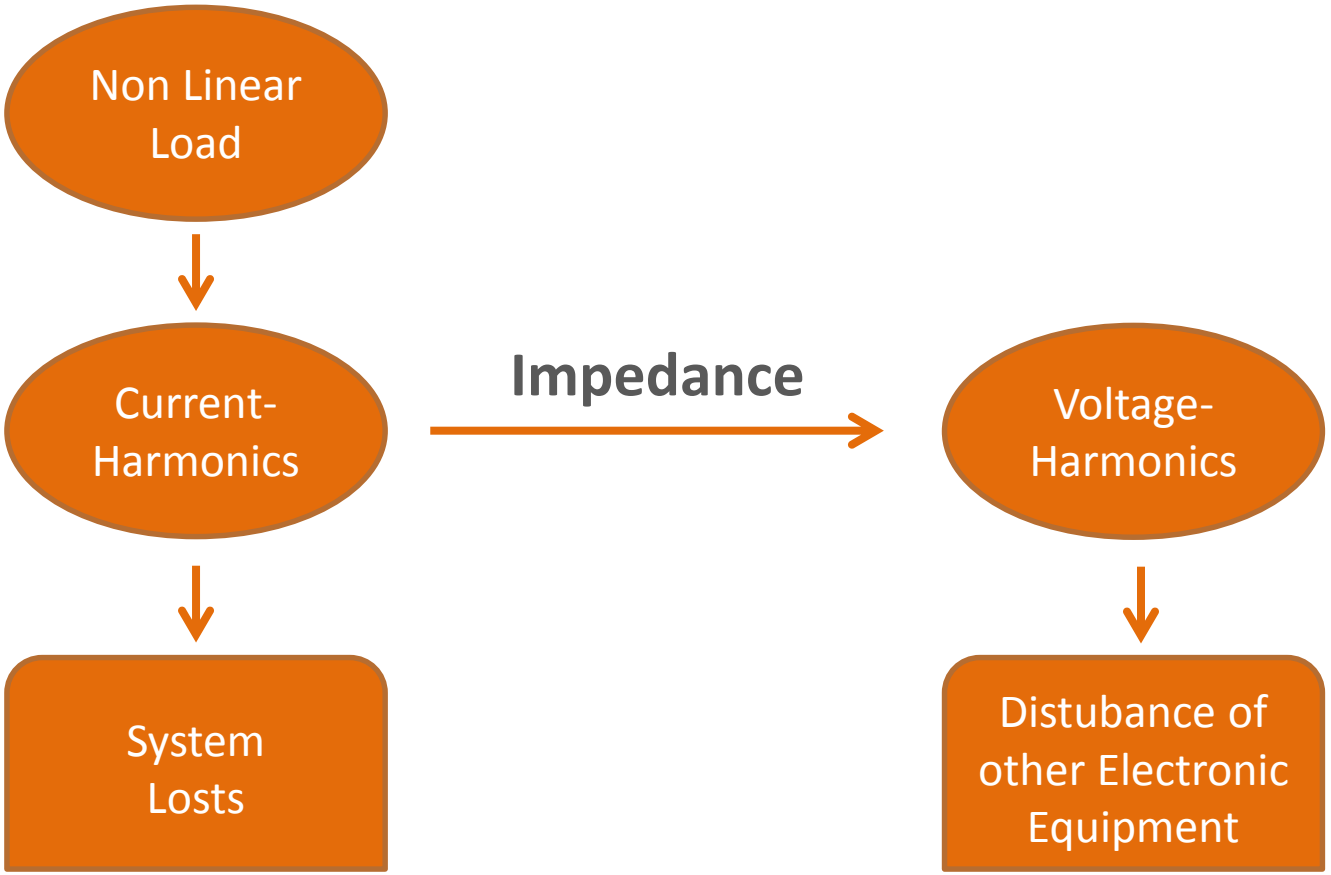




The switching frequency depends on power level

- Between 30 kW and 1 MW: switching frequency from 2.5 kHz to 4 kHz
- Below 30 kW: much higher frequencies can occur (e.g. 16 kHz at PV plants)
- E-mobility: 10 kHz to 150 kHz

Harmonics - Causes



Impedance and Current can be influenced → Voltage is the result!

High Impedance **and** non linear Load → High Voltage Harmonic!

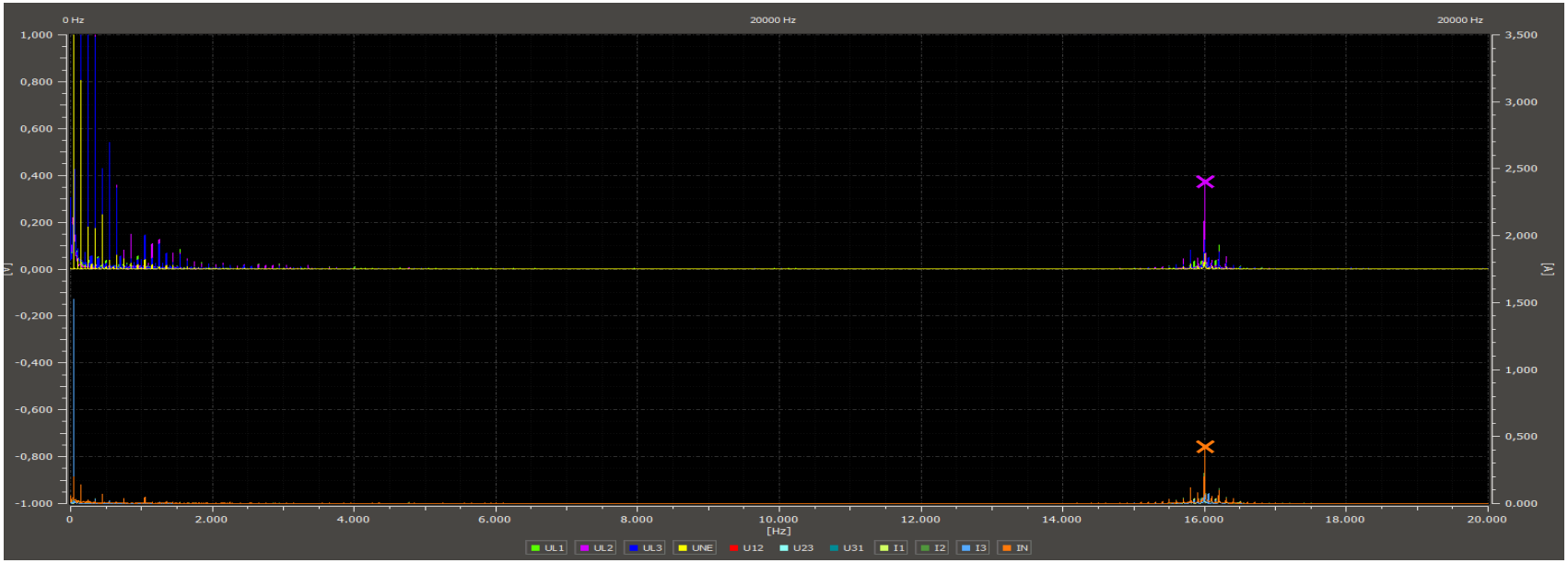
Harmonics - Causes

- Currents are producing voltage drops at net impedance
- The normal sine wave will be superimposed by high frequent voltage drops which results from the harmonic current caused by an electrical consumer!
- The Voltage sine save will be distorted
- All other electrical consumers will see the distorted voltage sine wave, reacting on that or are disturbed from it.

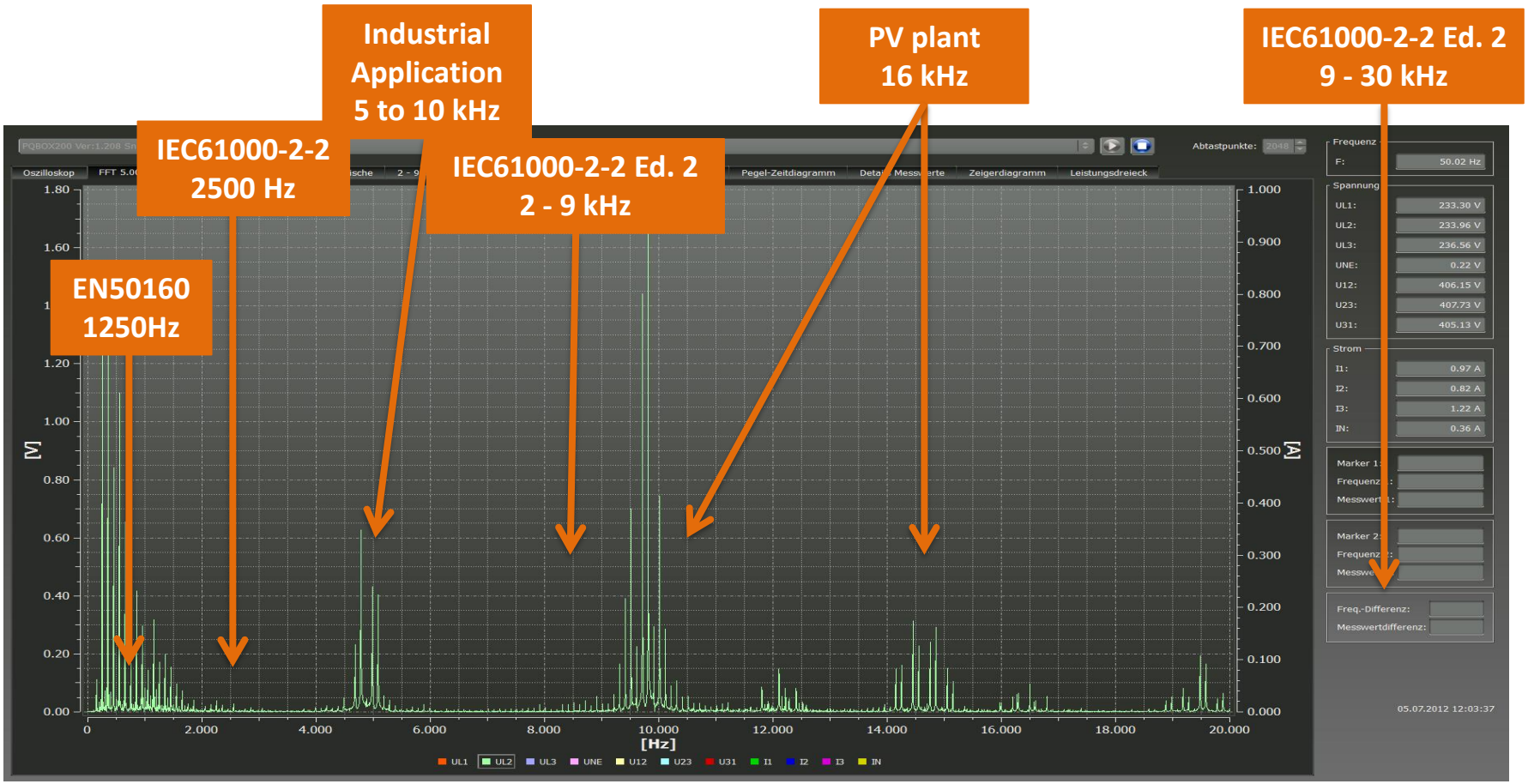
Voltage L1 / L2 / L3 at CPC (Point of Common Coupling) – caused by an Solar Inverter

Harmonics - Causes

- The PowerQuality regarding EN50160 and IEC61000-2-2 in this example is out of the band of the threshold of the voltage Harmonics.
- Harmonics, Interharmonics (switching frequencies) can be seen below
- Causes for Harmonics are always the non sine wave current of the electrical consumers like PC‘s, frequency converter for DC-Drives, frequency converter for Drives, Phase shift controllers, switching operations…



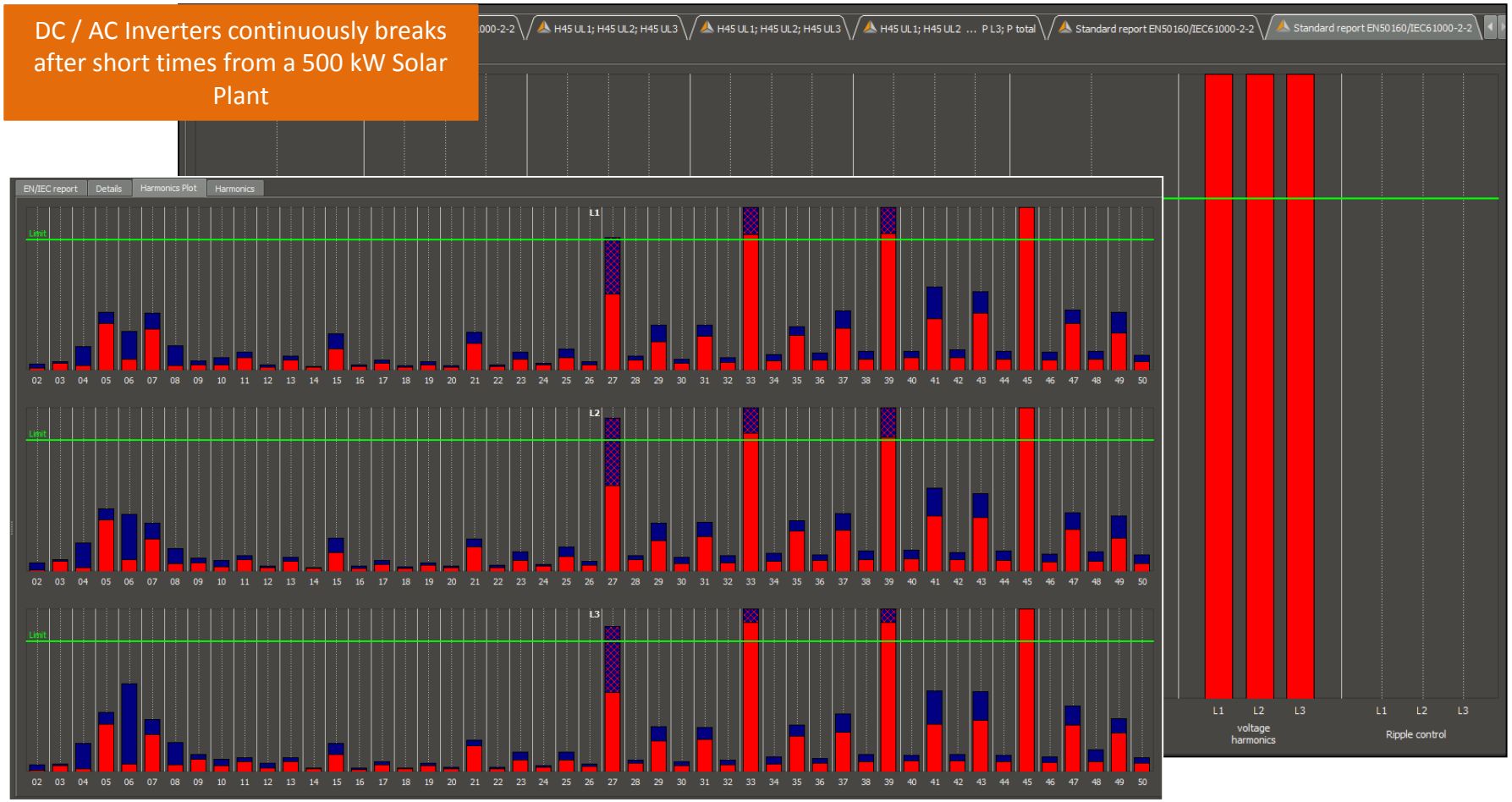
Harmonics Disturbance Levels



For harmonic disturbances in the range of 30 kHz to 150 kHz there are no compatibility levels defined yet. There have been limit values up to a frequency of 30 kHz for voltage and current harmonics.

PV plants Example #1

DC / AC Inverters continuously breaks after short times from a 500 kW Solar Plant



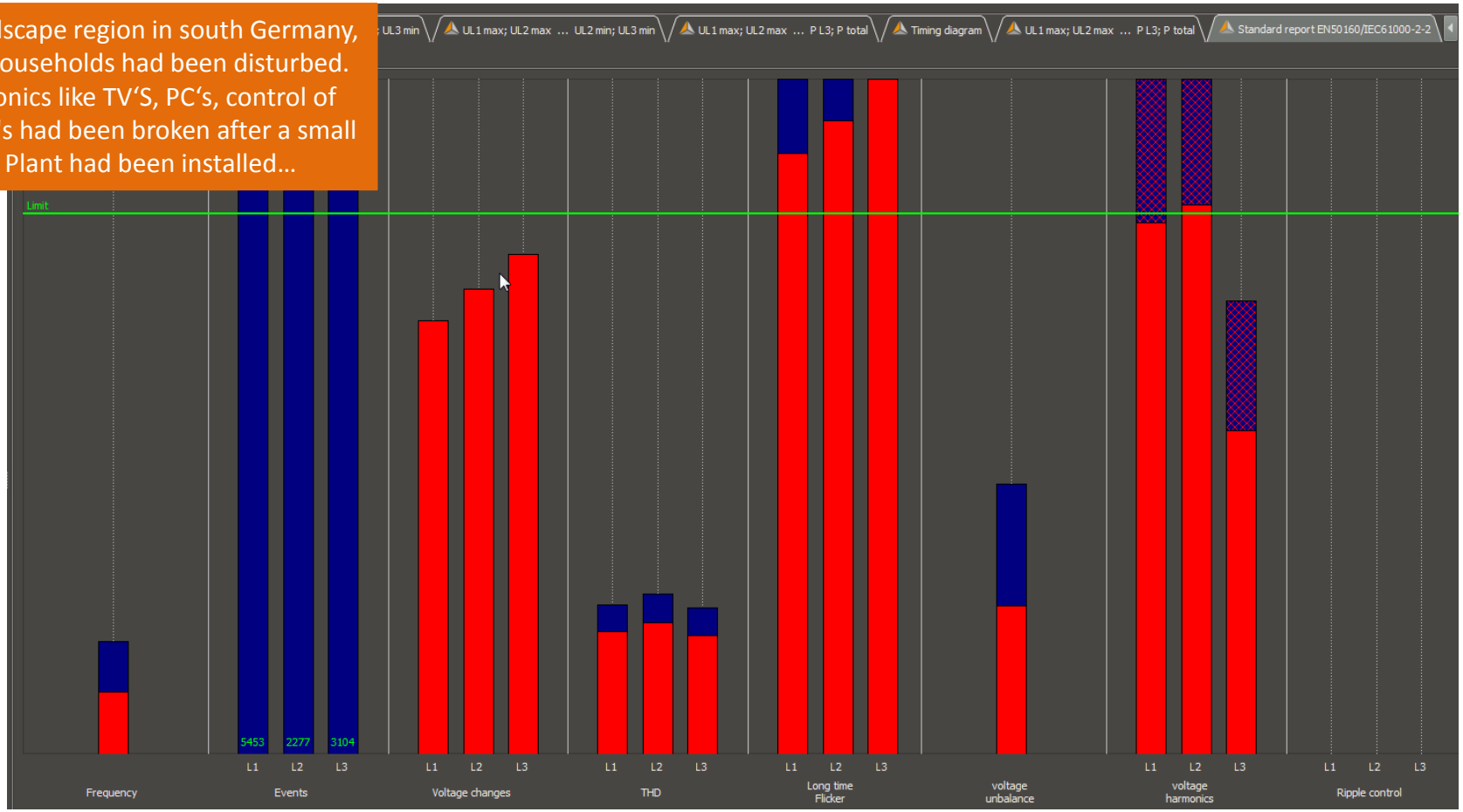
A measurement of 42 days brings following result

PV plants Example #1

Every Time when the AC / DC converters supplied Power to the network, the H45 Harmonic is over the Threshold

PV plants Example #2

In a landscape region in south Germany, many households had been disturbed. Electronics like TV'S, PC's, control of Heating's had been broken after a small PV Plant had been installed…



Many PQ – Events

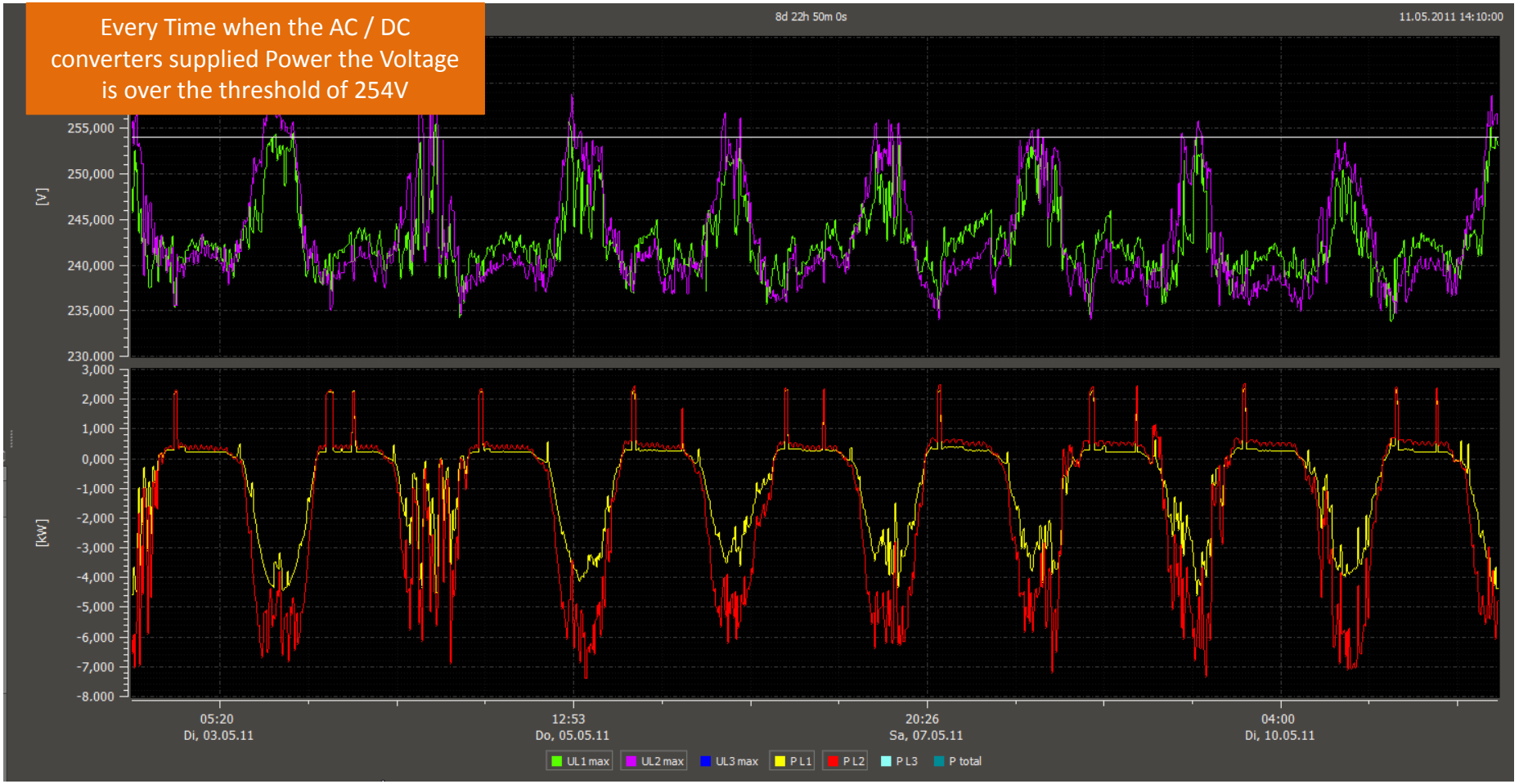
Voltage is very high

Long Term Flicker is over the Threshold

Voltage Harmonics are over the Trheshold

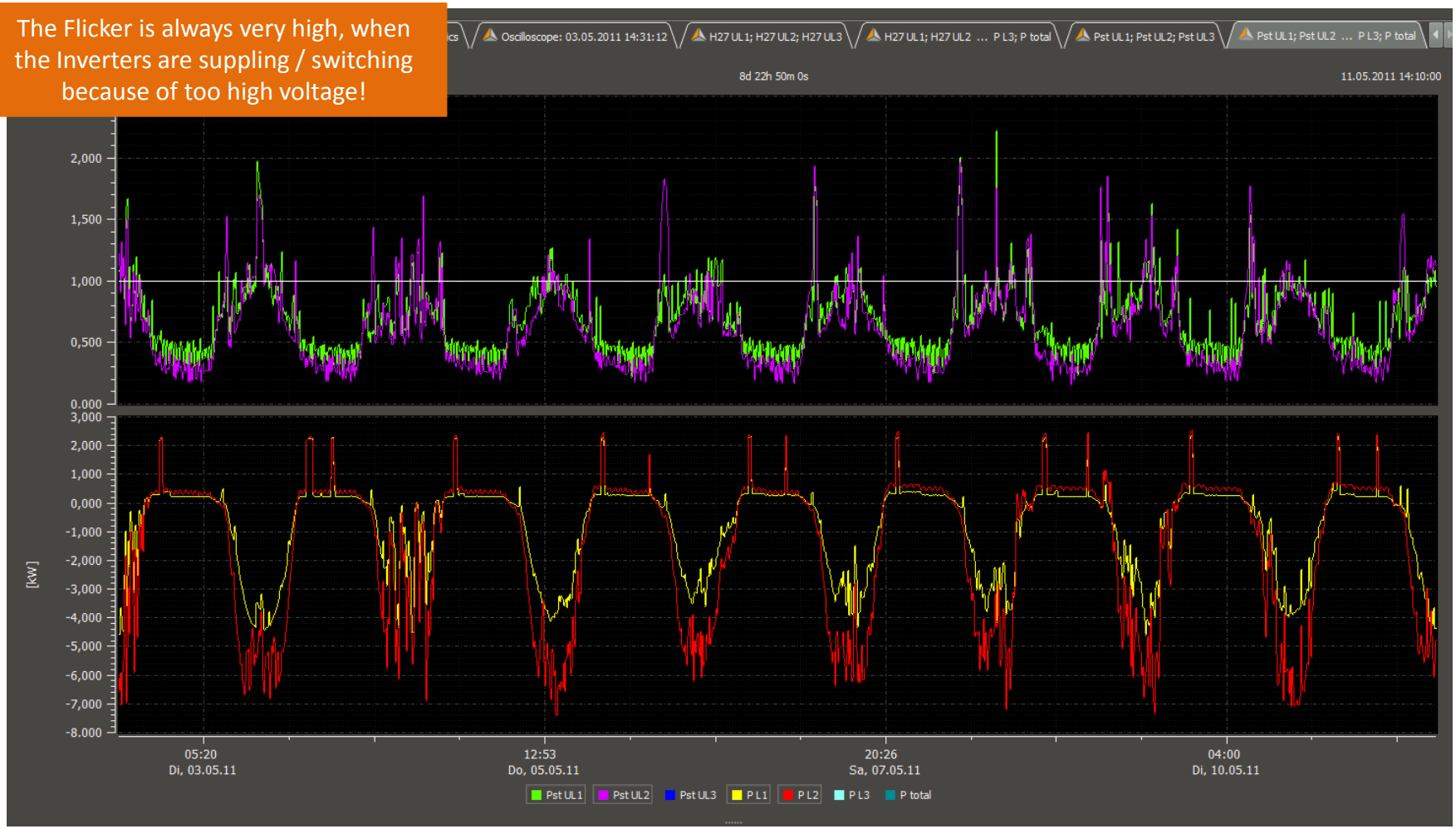
PV plants Example #2

Every Time when the AC / DC converters supplied Power the Voltage is over the threshold of 254V



PV plants Example #2

The Flicker is always very high, when the Inverters are suppling / switching because of too high voltage!



PV plants Conclusion

- **Penalty Fees** because of reaching THD thresholds or single harmonic thresholds can be **reduced** by measuring harmonics at PCC before installing a Solar Plant!
  E.g. if high harmonics are measured before installation of a solar plant, it's clear the harmonic THD will be violated reached after installation!
  (because of interference and superimposition harmonics of Inverters)
- Continuous recording and evaluation with PQ-Recorder and **PQ Data Base** of THD and all other PQ measures and disturbances can **reduce costs** in future for damaged inverters, or other **Lifetime Reduction** of controllers.
- Finding technical issues (in order to reduce costs in future for damaged inverters, or other interferences in Solar Plants) without a recorder which can record all necessary data (THD, PST, **Supraharmonics**) **at one spot** is nearly impossible!
  In Solar Plants the most Tissues occur in the frequency bands of Supraharmonics between 2…150kHz and therefore it is only possible to analyse with the mobile analyzers like PQ-Box 300 which can record these values continuously and also provide these values in Online Data Mode with WinPQ Mobil Software.

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Wind plants Connection Types

Direct connection – grid synchronous with gearbox:

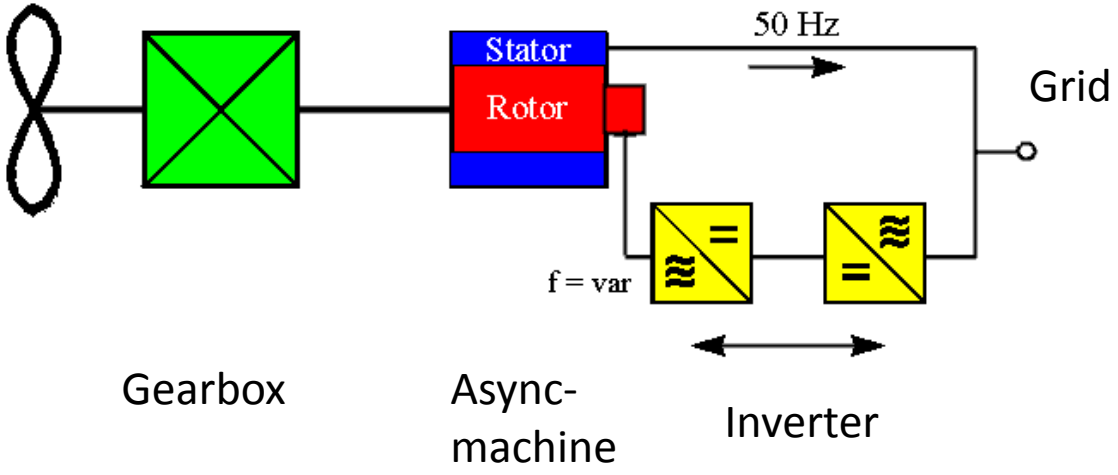
- No harmonic problems
- Difficult regulation, heavy

Full power inverter (Asynchronous- or synchronous generator):

- Easy regulation
- High losses

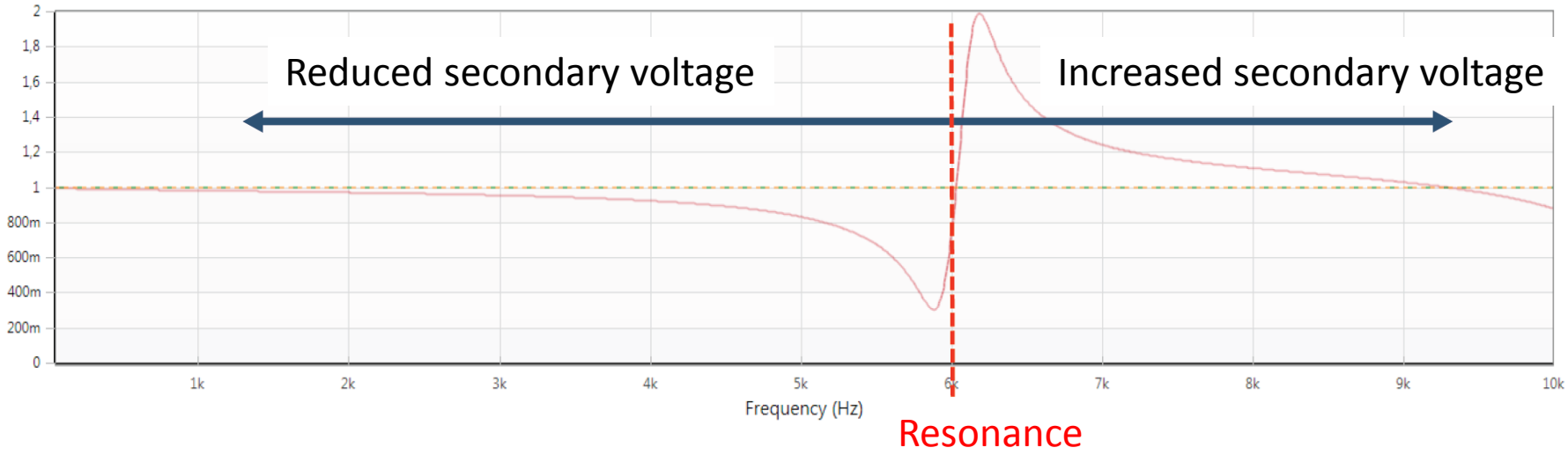
Double-fed asynchronous machine:

- Easy regulation, low losses
- Wearing parts



Wind plants Voltage Transformers

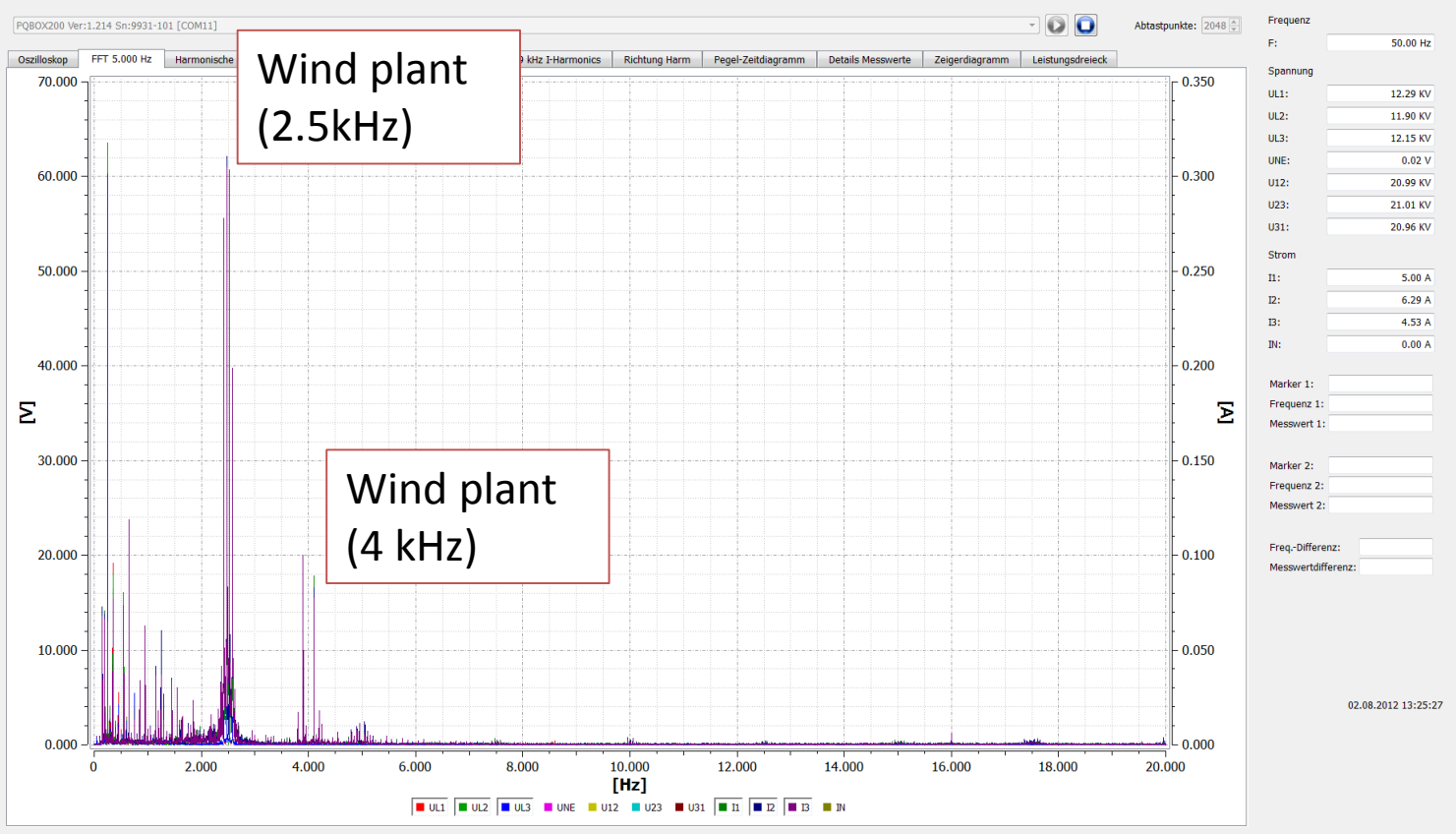
- Construction of standard VT‘s leads to resonance in single-digit kHz range
- At this point, amplitude error is about 100 % to 300 %,
  Phase error from 80° to 160°
- Rule of thumb: higher voltage -> lower resonance frequency



Source MBS

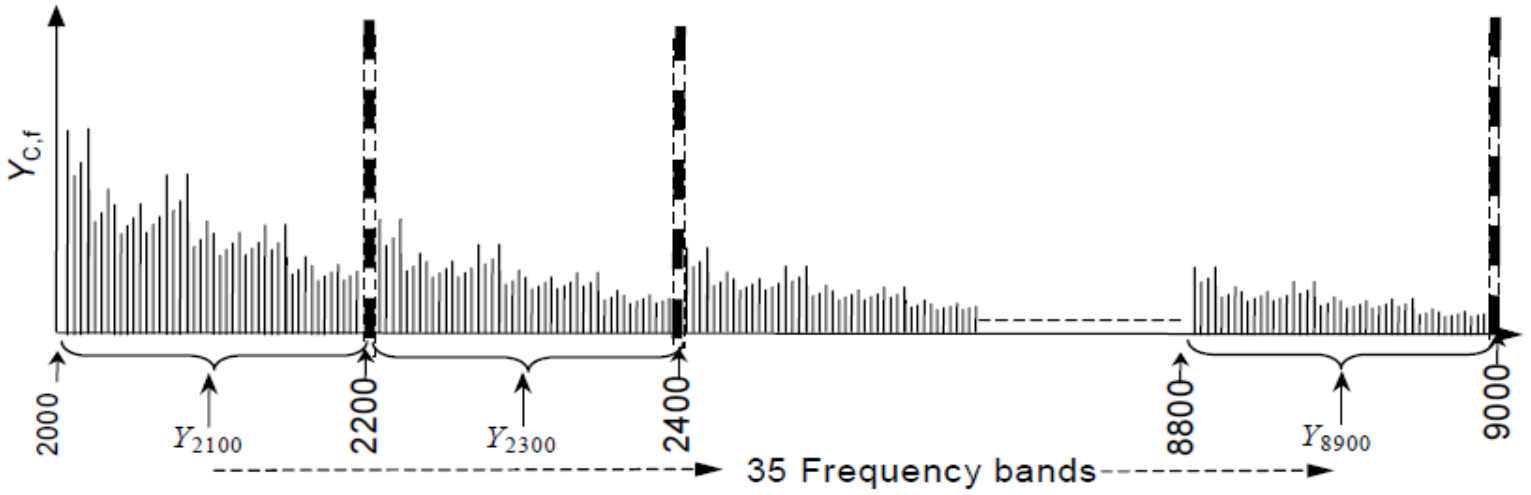
Wind plants Evaluation of harmonics

- Evaluation of frequency bands between 2 and 9 kHz according to DIN EN 61000-4-7
- VT behaviour is important!!



Wind plants Evaluation of harmonics

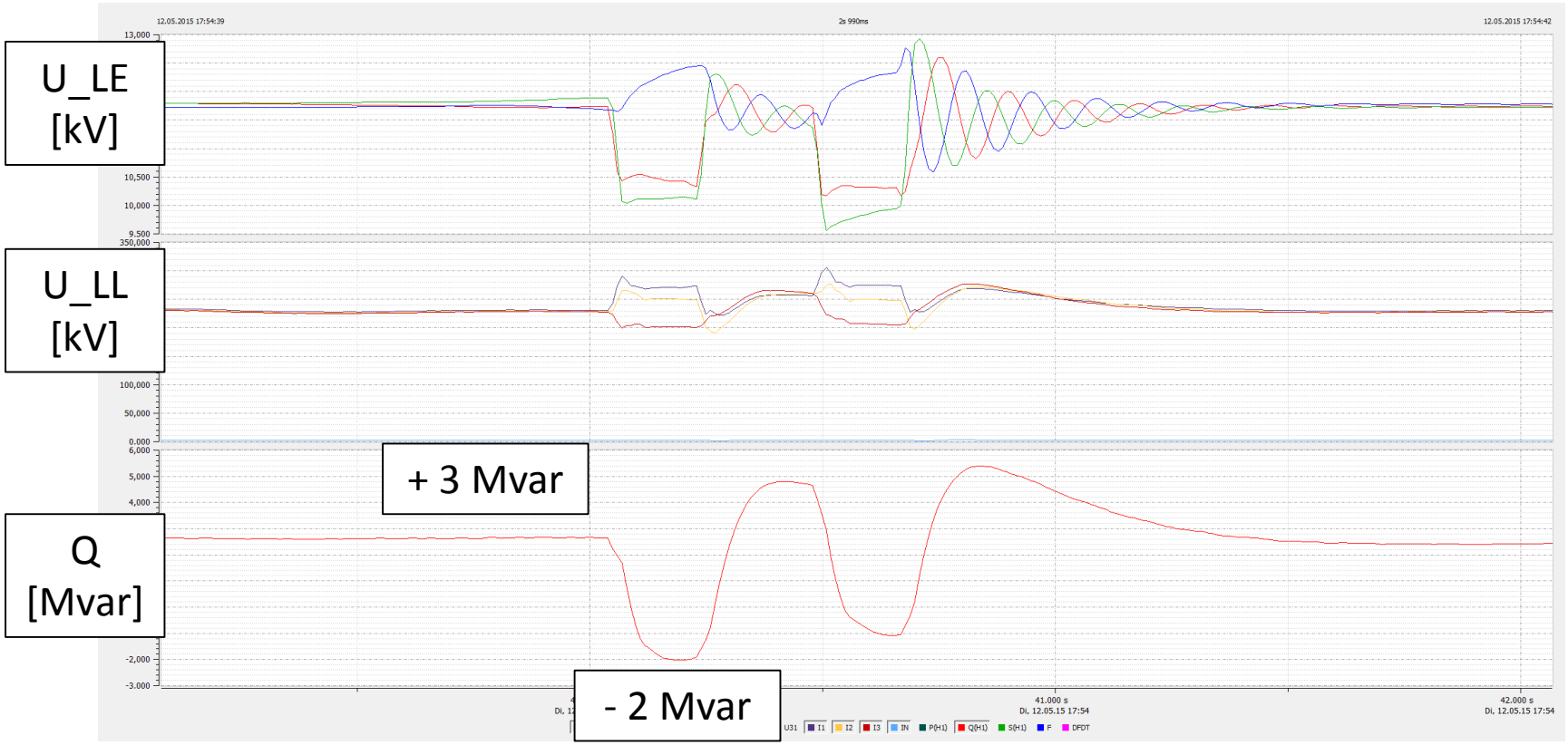
Frequency range (50Hz system)	Compatibility level (% of nominal voltage)
2 kHz to 3 kHz	1.4 %
3 kHz to 9 kHz	1.4 % to 0.65 % Decay logarithmically with logarithmically increasing frequency



Wind plants Dynamic grid support

- Systems are not allowed to disconnect from the power grid in case of overvoltage or undervoltage events.
- They have to support the grid voltage by feeding in reactive power during a grid fault. → protection devices
- Generation plants must be designed to withstand several successive network faults.

Wind plants Dynamic grid support



- Grid fault measured at a 8 MW wind power plant with PQ Box 200 (1/2 cycle data)

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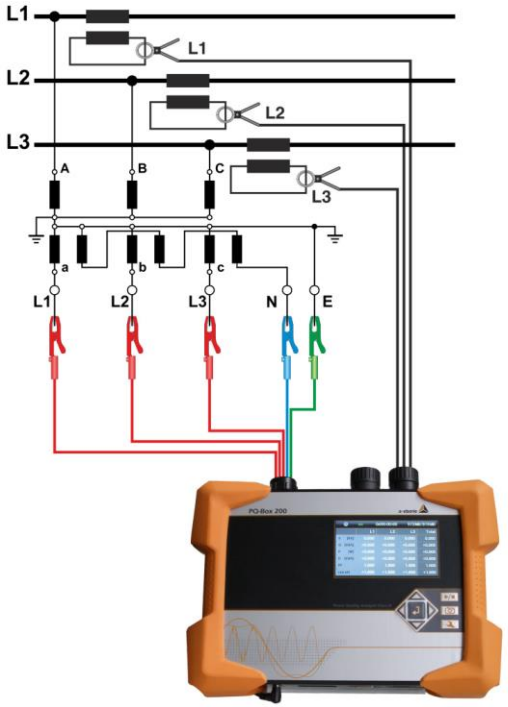
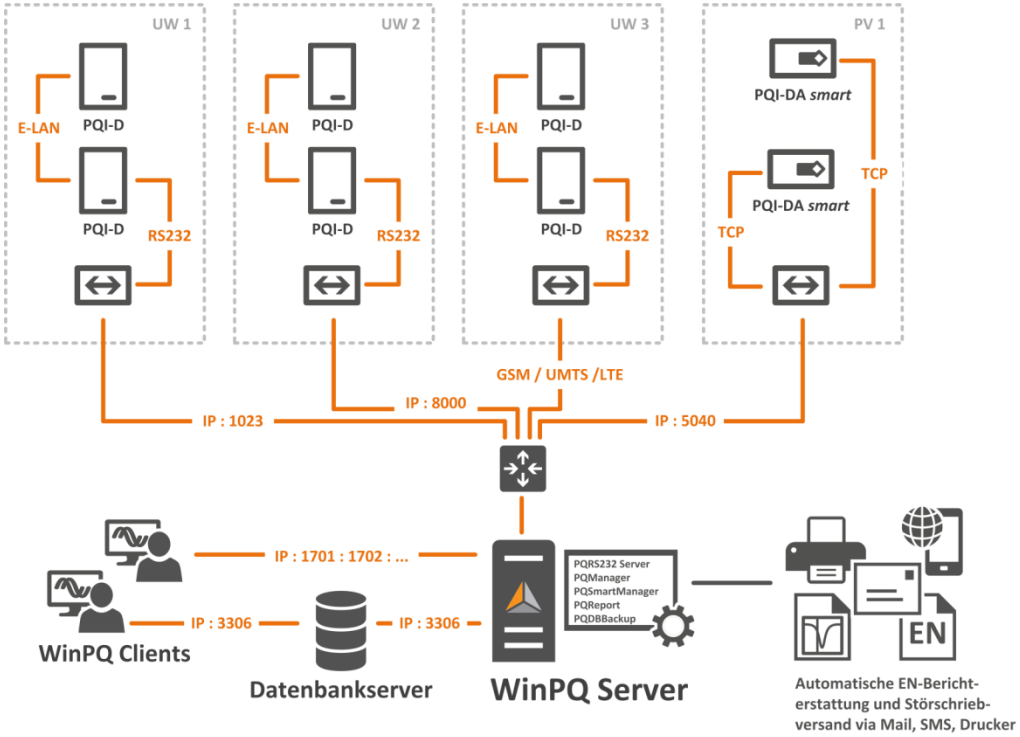
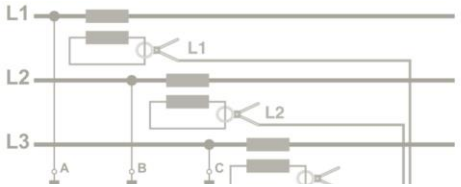
PQ Monitoring Troubleshooting vs. Monitoring

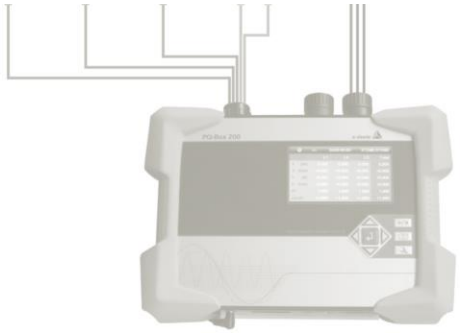


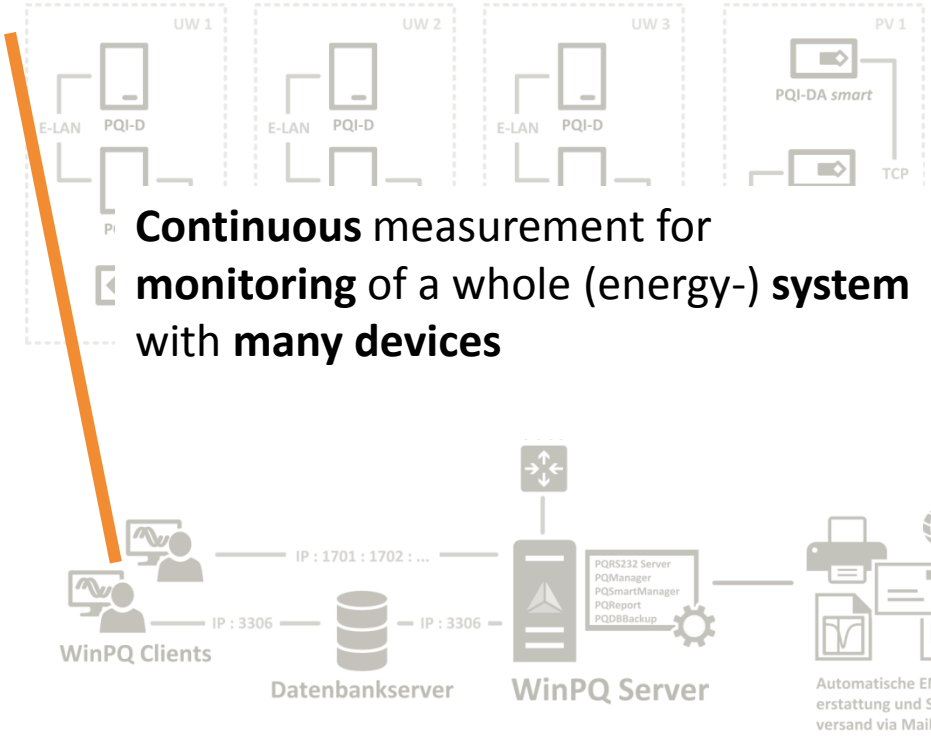


PQ Monitoring Troubleshooting vs. Monitoring



Temporary Measurement and **fault detection** with **one single device**





Continuous measurement for **monitoring** of a whole (energy-) **system** with **many devices**

Different requirements on Hardware and Software

PQ Monitoring Pros & Cons

Mobile Devices

- Pros:

The device can be installed at **any measuring location**. Usually directly at the location of the last fault.

Flexible usage.

- Cons:

Measuring instrument is usually **installed after a fault happened** at the measuring location. Depending on the frequency of the fault, the reason for a previous fault can no longer be traced.

Fix installed Power Quality devices

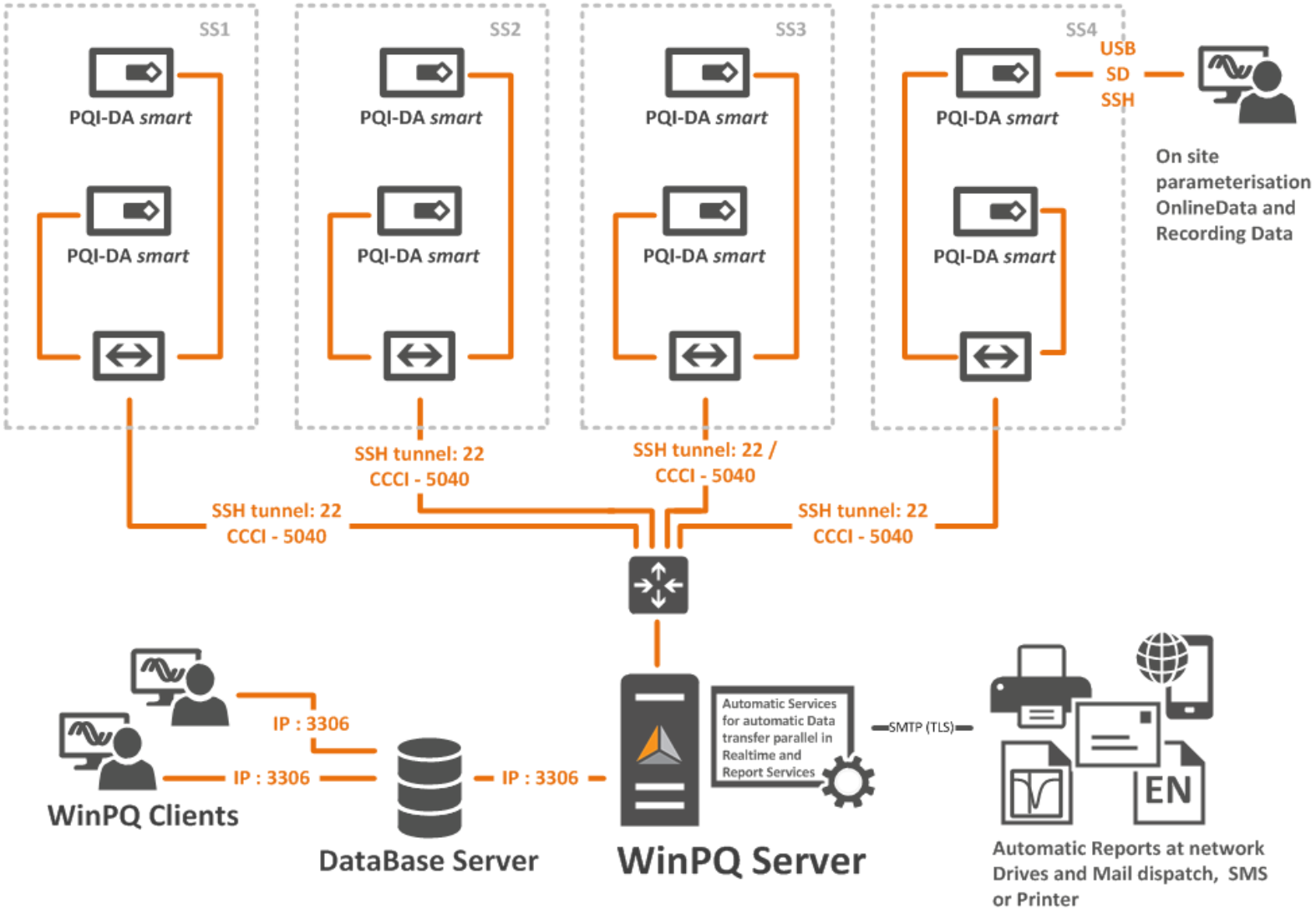
- Pros:

In case of a system failure, **all measurement data is available** in retrospect. The cause of the malfunction can be traced **at any time**.

- Cons:

Costs - It is not possible to have a permanently installed device at all possible measuring points.

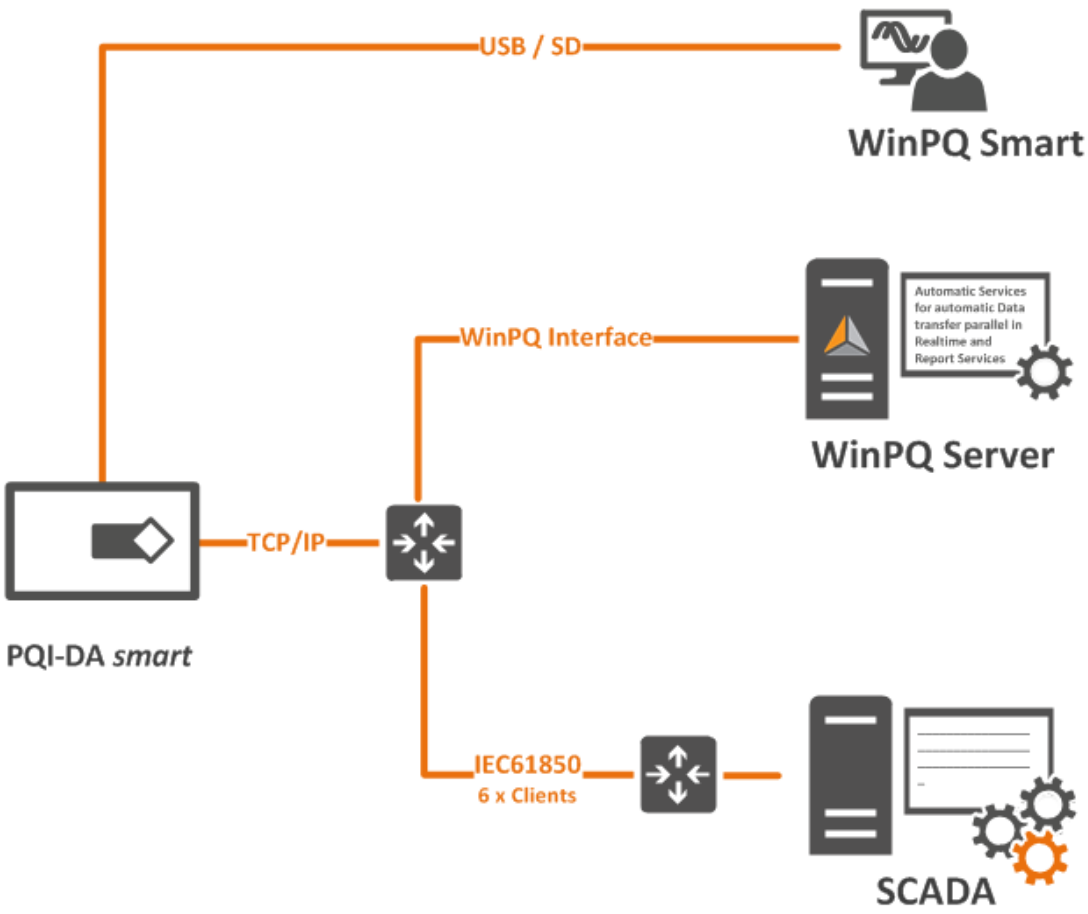
PQ Monitoring System solution



PQ Monitoring How it works

1. **Data Storage & DataTransfer**
   PQI-DA smart stores the data in its fast memory (up to 140 weeks). The WinPQ System downloads the Data from the measuremen devices parallel
2. **Data Management**
   Calculation and Evaluation of the PQ Data for Reporting and Disturbance Data – Generating Alarms
3. **Alarm-Management / Reporting**
   Reporting of Distubances e.g. via E-Mail, SMS or **cyclic Exports and Reports** via **Report-Management**
4. **DataBase**
   The Data is stored completely in this DataBase
5. **Visualisation / Analyses and Interactive Reporting**
   Possible direct on the Server or on Clients via Remote Connection (RDP) / Terminal Server solution (RDP) or via local WinPq Client Installation

PQ Monitoring How it works



WinPQ Smart / SD – Card:
Quick View into Device / Parameterisation / Online DATA /
On site parameterisation OnlineData and Recording Data

WinPQ Server:
EN- Statistics / distubance Recording / PQ Monitoring / TOP DOWN Principle!
Automatic Data Storage of individual measures – **LEAK FREE and Paralle**l for each Device!
Automatic Reports at network Drives and Mail dispatch, SMS or Printer

SCADA over IEC61850
Monitoring / Visualisation / Trigger / Disturbance Recording of Many Measures (2800)

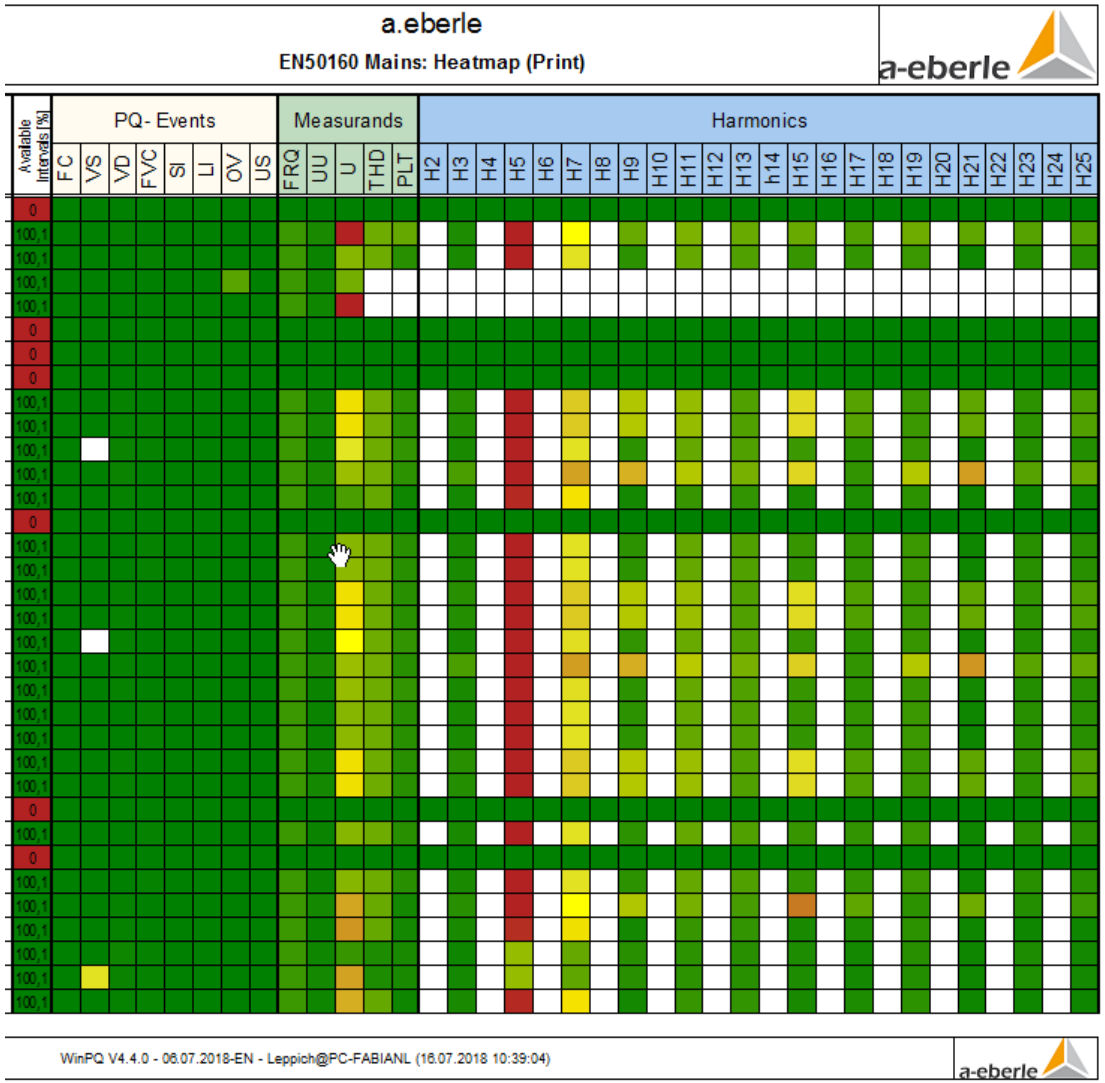
Long Time DATA:
Frequency /Voltage / Current / Power / Energy / U – Harmonics / I- Harmonics in different DataClasses
EVENTS:
DIPS/Swells, Interruptions, Counter

Customizeable ICD - Profiles are Possible:
e.g. Angle of Harmonics during an Engineering

PQ Monitoring Evaluation

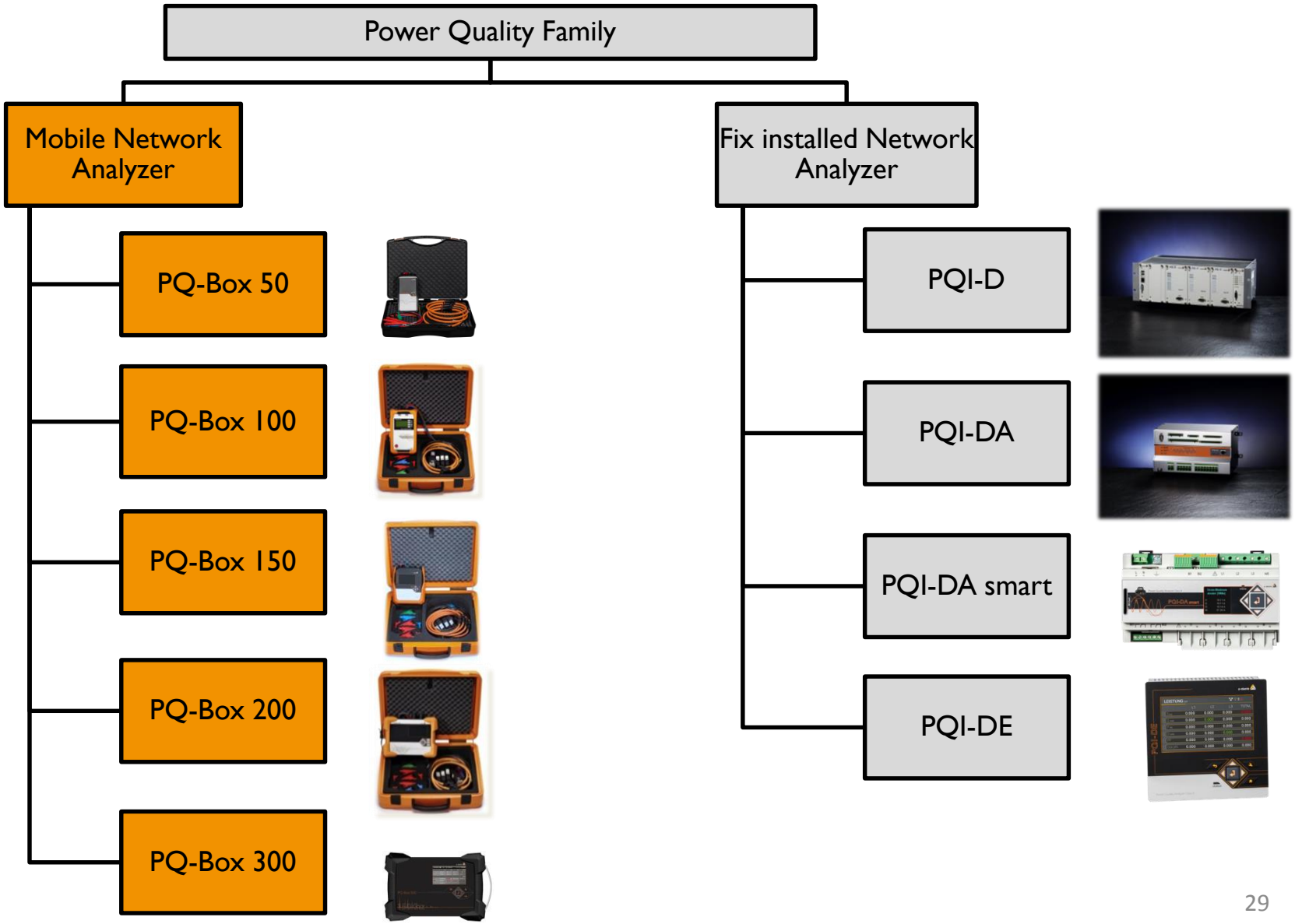
All Necessary PQ Parameters are continuously monitored by WinPQ! E.g. one Time per Week the Control Station can get a Report of more than billions of Measures by Email!

- Every row is representing one measurement spot
- RED: Threshold is reached
- GREEN: OK
- The System is creating such Report automatically and sends it automatically to the Control Station!



Power Quality Monitoring Solutions

RONNY STEINERT




PQ-Box 200
PQ-Box 300
CAT IV
REGSys
PQI-DA