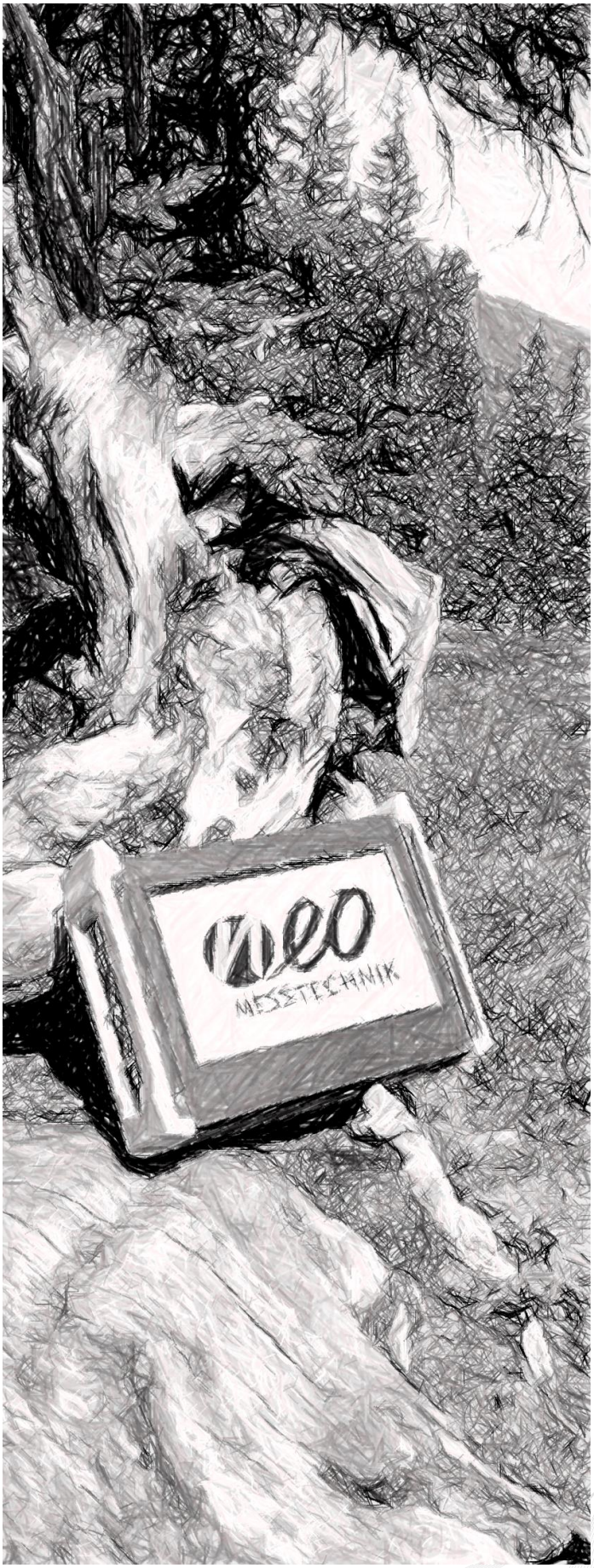

Application Note

Electric Vehicle Charging Station

Power Quality & Efficiency Analysis

Introduction

The reason of charging problems can have different sources. The PQA 8000H instrument allows to quickly analyze & troubleshoot the charging process of electric vehicles. Whether the problem is related to the charging station, the charging cable, the electrical installation, the electric vehicle itself or any other electronic equipment close-by …. the PQA 8000H will find the reason.

Keywords:
#PowerQuality #Supraharmonics #Unbalance #CP-Signal #PLC #Efficiency #PQSpreading #PQA8000H

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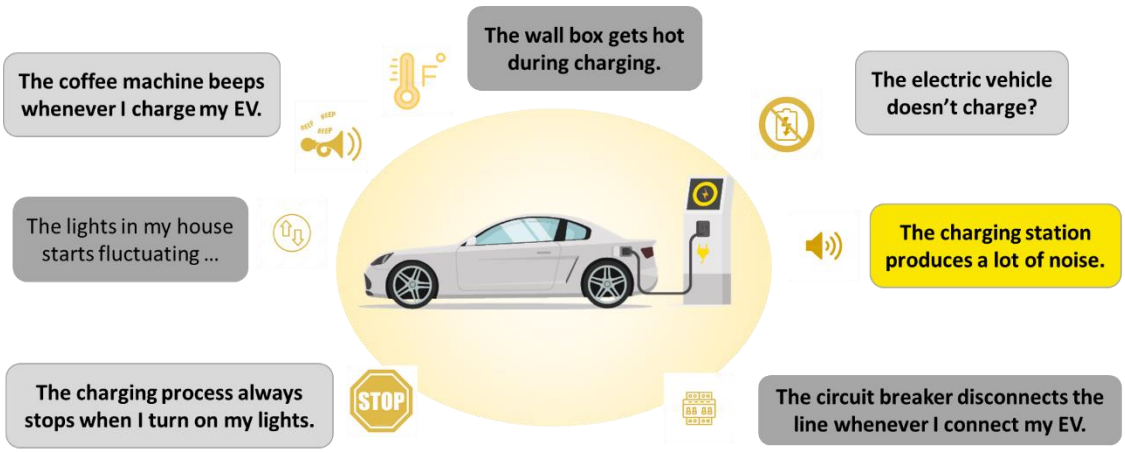
Electric Vehicle Charging Station

Power Quality & Efficiency Analysis



Problem? Solution!

The reason of charging problems can have different sources. The PQA8000H instrument allows to quickly analyze & troubleshoot the charging process of electric vehicles. Whether the problem is related to the charging station, the charging cable, the electrical installation, the electric vehicle itself or any other electronic equipment close-by – with the PQA 8000H, **you** will find the reason.

PQA 8000H. Easy answer. Simple measurement set-up. Intuitive Software. Powerful Measurement and Analysis. Troubleshooting simply can't be made any easier.

Contact NEO Messtechnik

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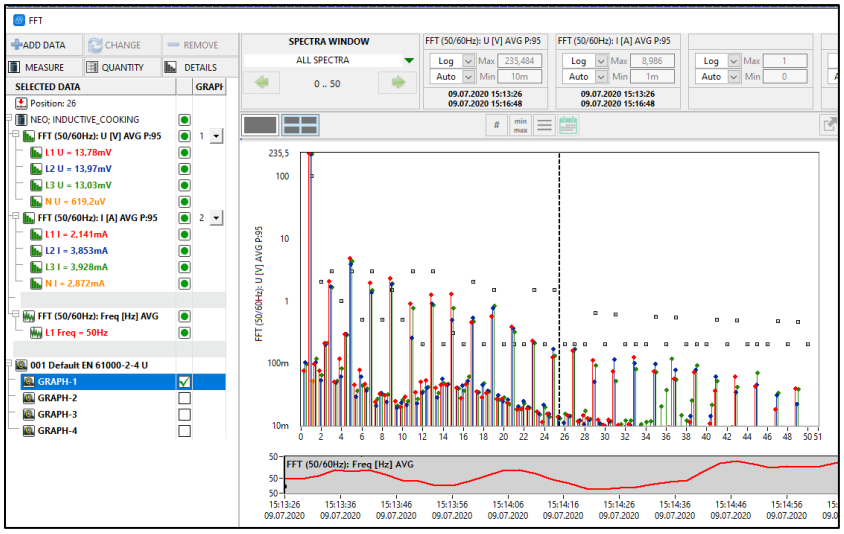
Measurement

Harmonics

The low-frequency emissions of EV charging stations are limited in different standards (e.g. IEC 61000-3-2, -3-3, 3-11 etc.). Harmonic emissions are depending on charging state, charging power and charging pattern. Therefore, the emission of certain harmonics can change significantly as some chargers use different switching frequencies during the whole charging process.

The THD_I calculation gives a relative value from harmonic currents compared to the fundamental current. Nevertheless, only THD_I and THC measurements are not sufficient as certain harmonics often are exceeded, while the total harmonic currents are low. A low THD_I value for one charger doesn't necessarily mean that emissions are better than for a charger with higher THD_I. A typical example is that the 15th Harmonic current is very high and can cause problems. Typical problems of high harmonic currents are:

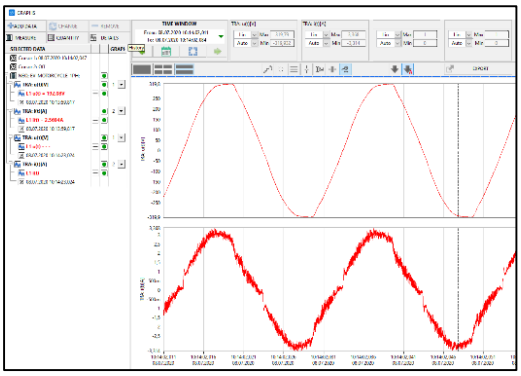
- Thermal stress and ageing of components
- Reduced torque and reduced efficiency
- Audible noise
- Resonances
- EMC



The NEO advantage – PQA 8000H investigation possibilities

- Harmonics Calculation for U, I, P, Q, S, phi
- THD, TDD, PWHD
- Interharmonics
- Harmonic Trigger Analysis
- Waveform and FFT Analysis

Noise



Noise emissions of electric vehicle charging stations are mainly caused by higher-frequency emissions (Supraharmonics). Some electric vehicle charging stations change switching frequency during the charging process which results in different noise perception.

Supraharmonics up to 500 kHz

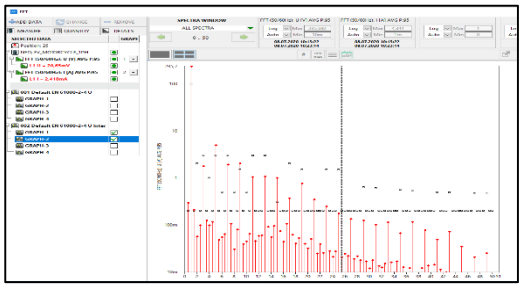
EV charging station inverters cause higher-frequency emissions (2 kHz - 150kHz or even above) that are not yet limited because of a gap in standardization, and cause the following issues:

- Noise
- Damping of PLC signal
- Thermal stress and ageing to electrical equipment
- Interference of other electrical equipment

PQA 8000H – Measurement of

- Higher Frequencies up to 9kHz in 200Hz bands
- Supraharmonics up to 500kHz in 2kHz bands for voltage and current
- Harmonics (5Hz band) up to 3000th order
- Waveform and FFT analysis

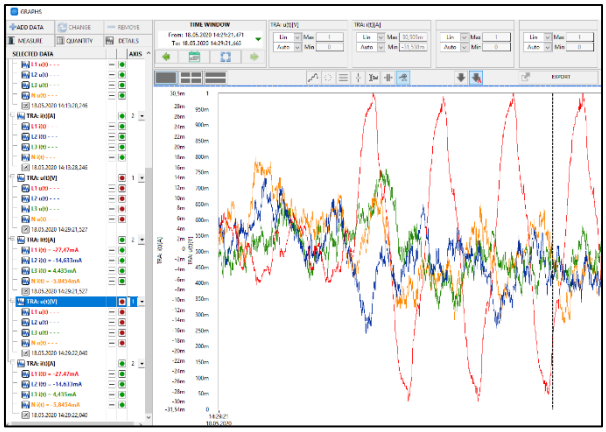
Power Quality Mitigation



Mitigation of some Power Quality parameters very often increases the penetration of other Power Quality parameters. A typical example is using higher switching frequencies of inverters - while reducing lower-numbered harmonics, the higher frequency emissions often increase. Therefore low- and high-frequency emissions should always be monitored at the same time.

In-Rush Current

High In-Rush currents can cause voltage drops which can affect other electronic equipment and PQ problems. Typically, requirement by standards and grid codes is that the resulting voltage drop shall stay below 4%.



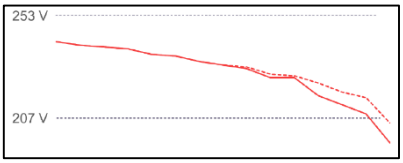
Example: A delivery company complained that their electric motorcycles are never charged during night-charging. Finally, the reason was found in LED lighting in the parking garage. The big In-Rush current of LED lights caused voltage drops and the chargers stopped (zero-cross).

PQA 8000H investigation possibilities

- Waveform Analysis of In-Rush current (up to 1MS/s per channel)
- Measurement of Voltage drop (1/2 perio)
- Trigger and Disturbance Record

The following graph shows that data transmission is done with modulated signals of up to 490 kHz. However, PLC data is distorted and shows lack of reliability under certain circumstances or time spans which we will further discuss in this article.

Voltage Level



Using long extension cables or too low diameter of electrical installation often causes a too low voltage level. The charger won't start charging or will abort after a short time.

Unbalance

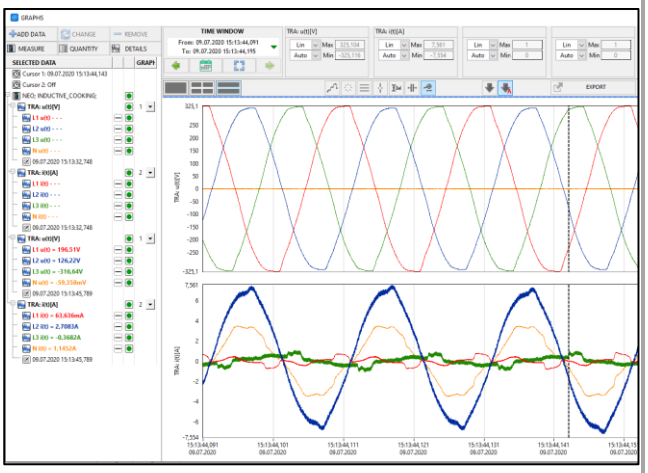
Due to the high charging power, EV charging processes can lead to unbalance of the three phase system. Different voltage levels on the three phases and a shifted neutral point, as well as high neutral currents can occur. Unbalance will increase heating of electrical equipment and shorten their life-time.

Especially single-phase chargers can have a huge impact, while three-phase chargers can also have an effect as they are not perfectly balanced or sometimes only use two-phases for specific charging states. Sometimes one phase is generally not activated for the whole

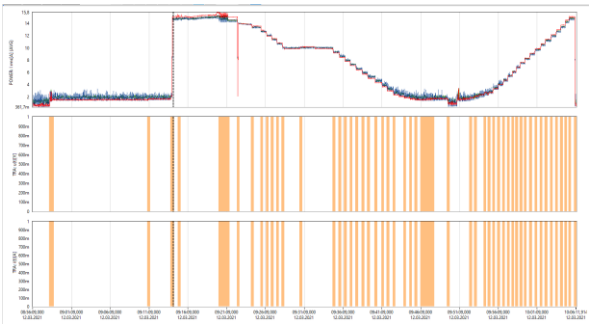
charging process, other charging strategies use the three phases at different times which again leads to temporary unbalanced systems.

PQA 8000H investigation possibilities

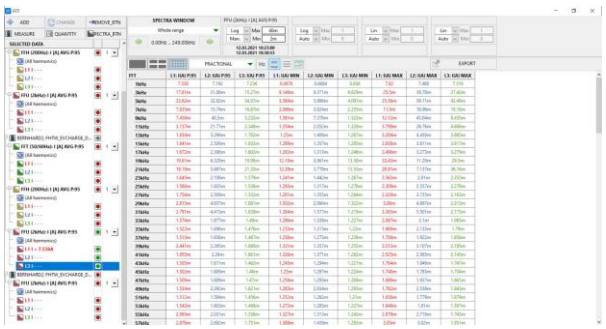
- Waveform Analysis of Unbalance
- (up to 1 MS/s per channel)
- Unbalance ratio
- Positive, negative, zero-sequence system for U, I, P, Q



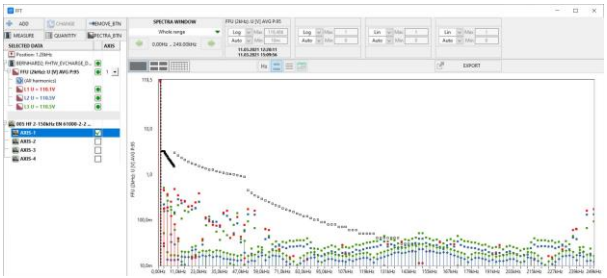
Charging Power & Charging Profile



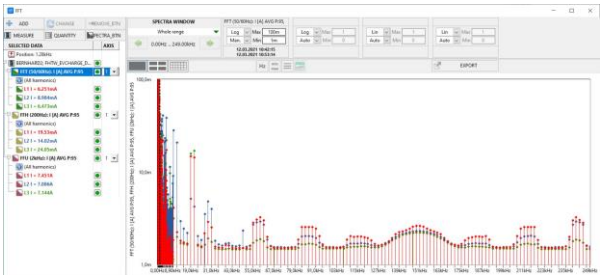
Min, Max, Quantile



Limit Comparison

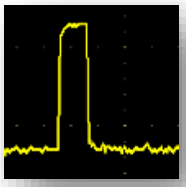


Wideband Frequency Analysis



CP Signal Analysis

Sometimes the communication between electric vehicle and charger causes problems. Waveform and RMS analysis of the PWM modulated CP signal shows if set point settings are fine and if the signal quality is sufficient. Sometimes oscillations and distorted PWM signals causes charging problems.



- Measurement of CP Signal with high sampling rate
- RMS calculation for Set-point evaluation
- Waveform Analysis for EMC and disturbance analysis

PLC Communication

Charging problems can be related to software problems of the vehicle, charging station or failed communication. Analyzing and simulating the charging communication vial PLC signal allows the determination of these problems and is an optional feature of the PQA8000H.

Earth Fault

In some countries, depending on the electrical grid system, problems can occur through earth faults, a typical example could be street lights. Detecting these earth faults can be easily done with the PQA8000H together with dedicated current sensor equipment.

Flicker

Charging patterns of chargers can cause fluctuating lights at houses, potentially leading to headache and other damages that can be traced down by Flicker measurements.

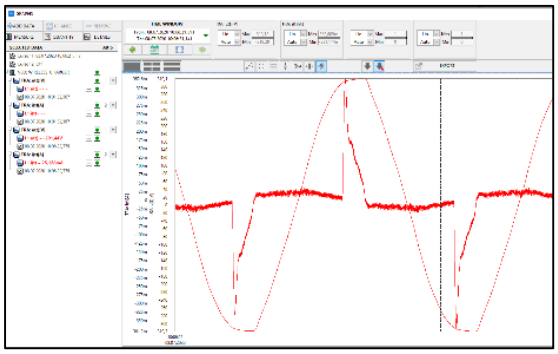
Efficiency Analysis

Charging power typically goes up to 43 kW for AC charging and up to 200kW (or even more in the future) for DC charging. Bad design of chargers can lead to bad efficiency of the charging process. Already small losses can add up to significant costs.

PQA 8000H investigation possibilities

High accurate inputs, sampling rate and channel-by-channel isolation allows AC and DC measurement for highest-precision efficiency analysis.

- Active, reactive apparent power, cos phi, PF, harmonic power, etc.
- Efficiency, Energy calculation



Power Quality Spreading and Mitigation

Multiple EV charging stations and their respective emissions do not necessarily have to add up and increase the total emission amount. Field tests showed that EV chargers can as well be the sink of higher frequencies generated by PV inverters or other EV charging stations.

Having said that, it is well known that while individual charging stations fulfill the emission requirements, the tolerance limits are often exceeded by multiple charging stations. Therefore, for each location, individual measurements have to be carried out to determine the effect of multiple charging stations due to different grid conditions (frequency dependent grid impedance, short circuit power etc.).

PQA 8000H investigation possibilities

The determination of the effect of multiple EV charging stations connected to the same point requires multi-channel and synchronized measurements. In addition, phase angle information of Harmonics and Higher-Frequencies are needed to determine their spreading or damping impact

Measurement System

PQA 8000H Portable Power Quality Analyzer

- *4x Voltage Measurement up to 1600V DC / 0.05% accuracy*
- *5x Current Measurement via High-Bandwidth Rogowski Coils 300A*
- *1x CP-Signal Measurement with high-sampling (CCS)*
- *1x PP Signal input*
- *CAN Interface (CHAdeMO)*
- *GPS-Time Synchronization*
- *Sampling Rate: 1MS/s per channel / 18 bit resolution*

Accessories & Options

CP-Signal Sensor

easy non-invasive measurement of CP signal

AC Measurement Adapter

easy access of voltages and currents for CEE16A and CEE32 connector

CCS or CHAdeMO Measurement Adapter Box

Easy breakout for voltage, current, CP and PP signal measurement

AC Adapters

DC Current Sensor

up to 500kHz bandwidth

AC Current Sensor