Testing of on-board charger and AC charging processes

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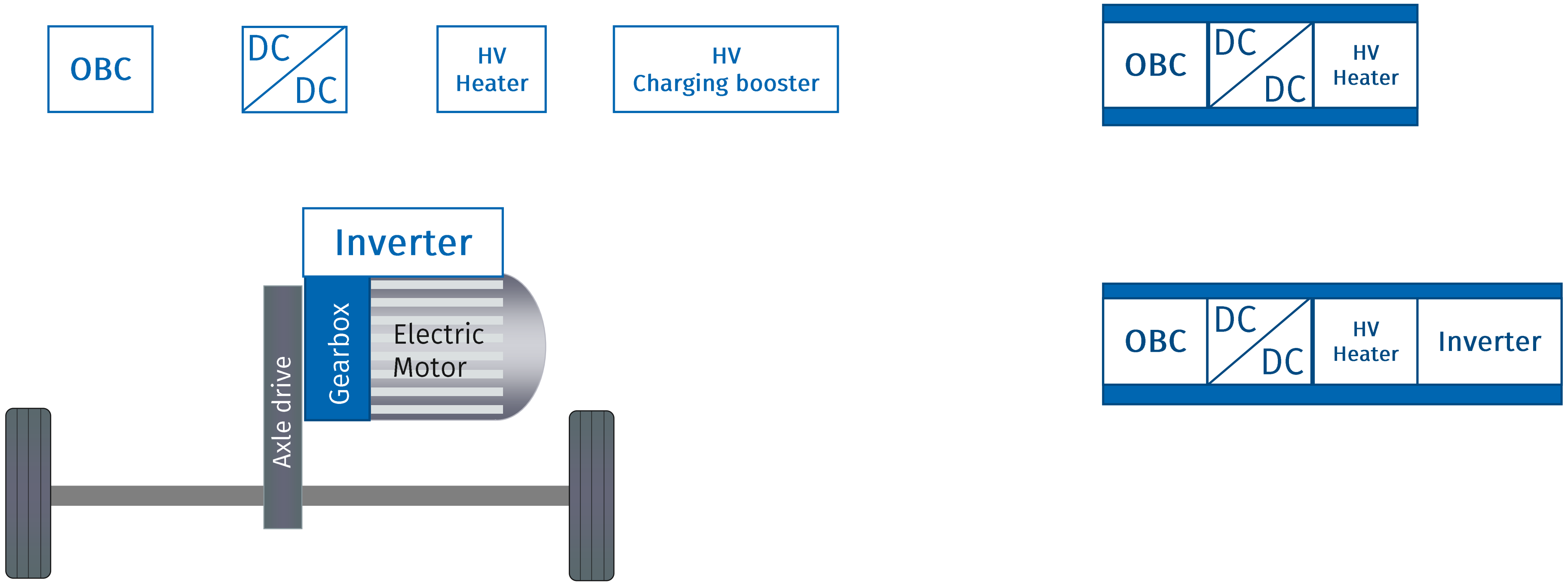
Innovative Measurement and Data Technology

Developments in on-board charger

- New generations of on-board charger (OBC) are being incorporated into vehicle series
- Higher integration, new semiconductor technologies, higher performance, less weight/volume, lower costs
- Trend towards integration of various power electronics

➡ **More complex testing and verification**



Challenges in AC charging and testing the OBC

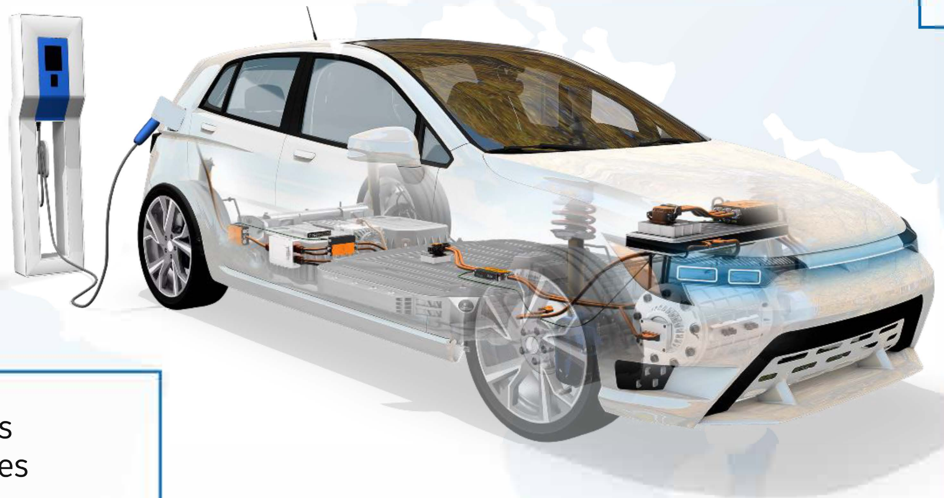
Verify impacts on the public power grid with regard to power quality criteria

(EN50160, IEEE 1159, IEC61000-2-2, IEC 61851-21-1, ...)

Analysis of power quality problems such as unbalances, transient over-voltages and frequency fluctuations

OBC interoperability testing is complicated by large variances

(countries, charging station providers and types)



Verification of OBC efficiency and charge cycle power loss

Verification of bi-directional operation to recover energy from the vehicle battery

Waveform, analyze harmonics up to the 40th harmonic with regard to harmonic disturbances

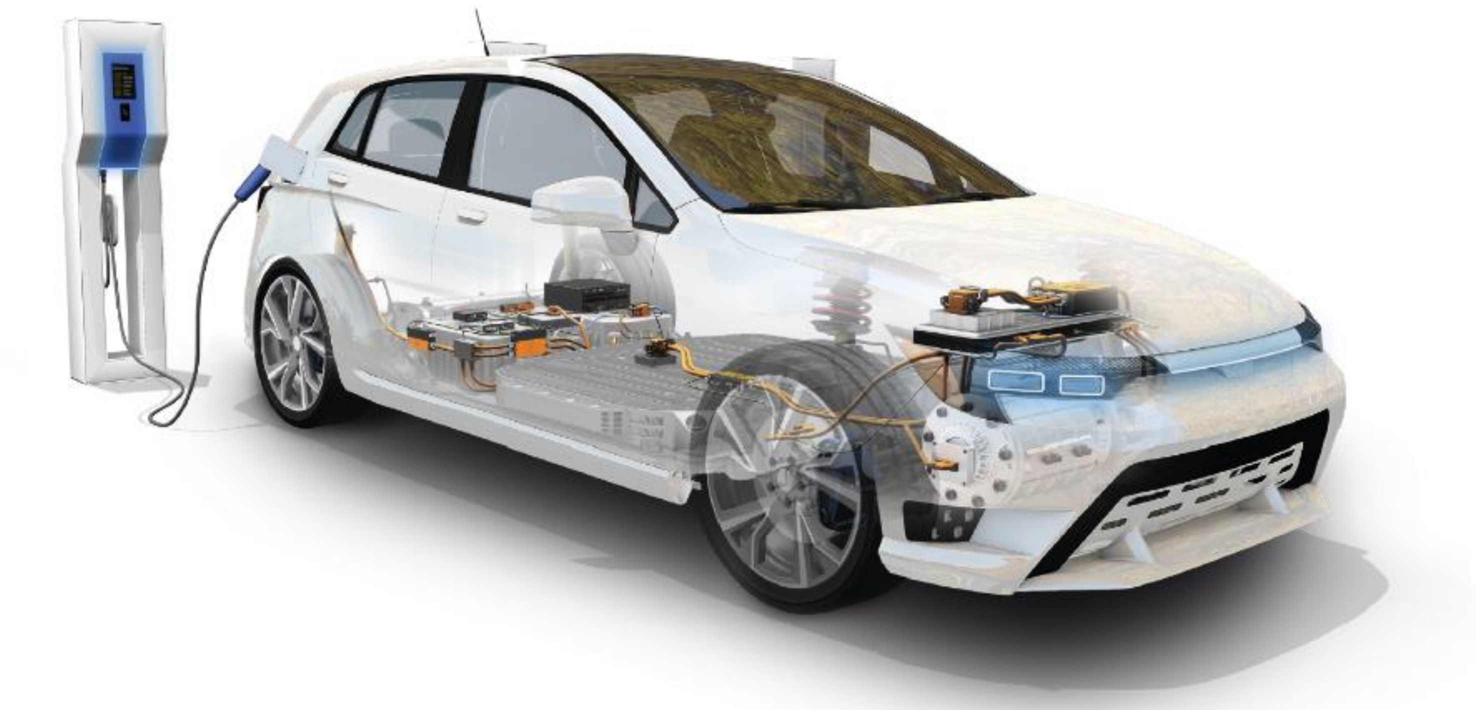
Investigation of fast processes, inrush currents, voltage dips, flicker phenomena

Precise synchronization (PTP) of measurement and control unit communication

Fast measurement technology is required for the AC charging process analysis

AC Charging

- AC charging stations do not always have a permanently attached charging cable
- Electric car owners use their own charging cable, which they keep protected in their vehicle
- Different charging options: Socket, high-voltage socket, wallbox, AC charging station



Type 1
AC Plug

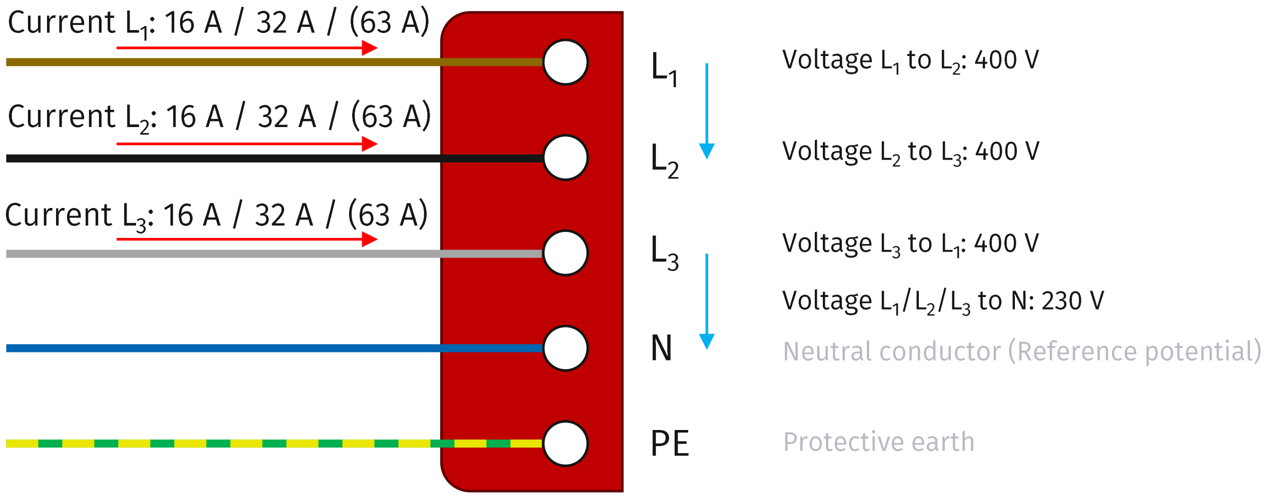
Type 2
AC Plug

Tesla
AC/DC Plug

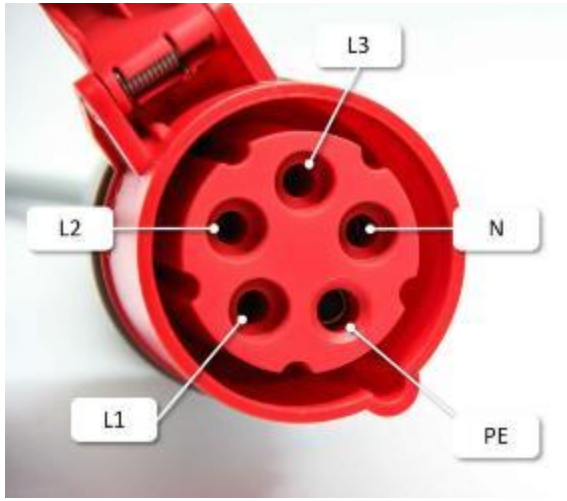
Three-phase AC Power socket and charging cable

- Example: Charging at CEE power outlet

  Home, hotels, workshops, agricultural area, etc.



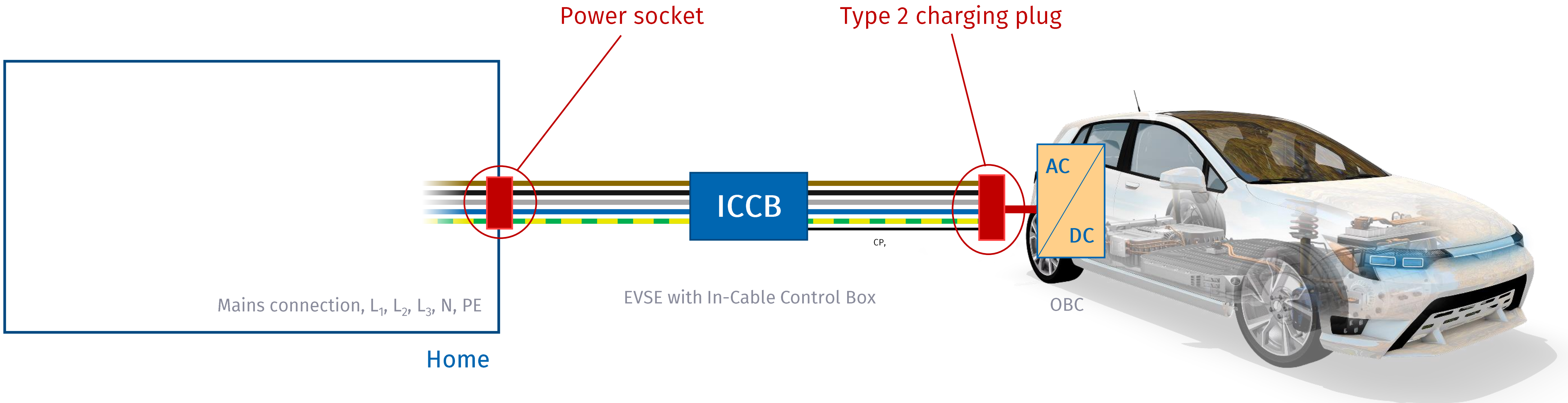
Power socket



AC charging process with charging cable and sockets

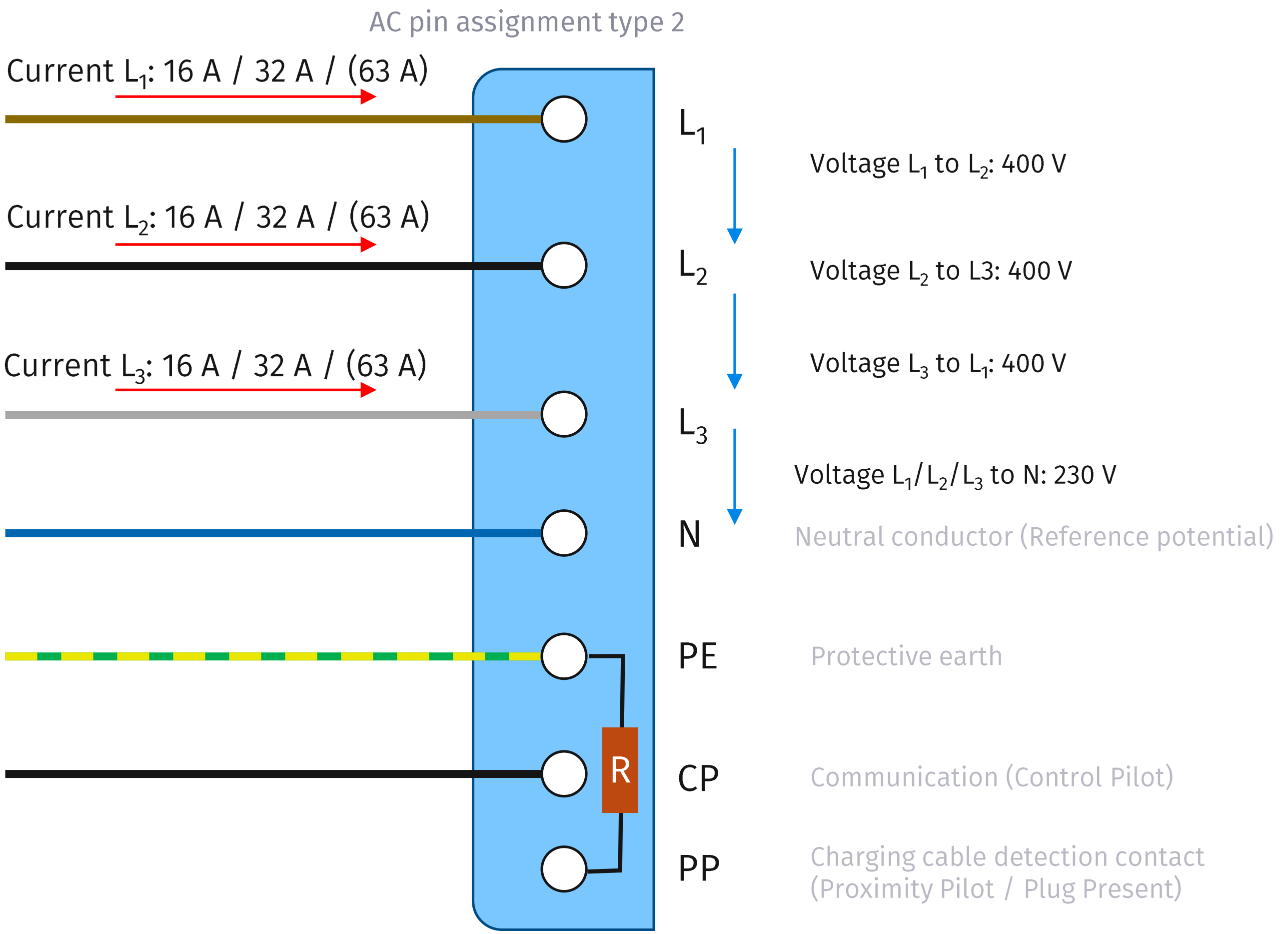
- Charging cable with a control box to control the charging process

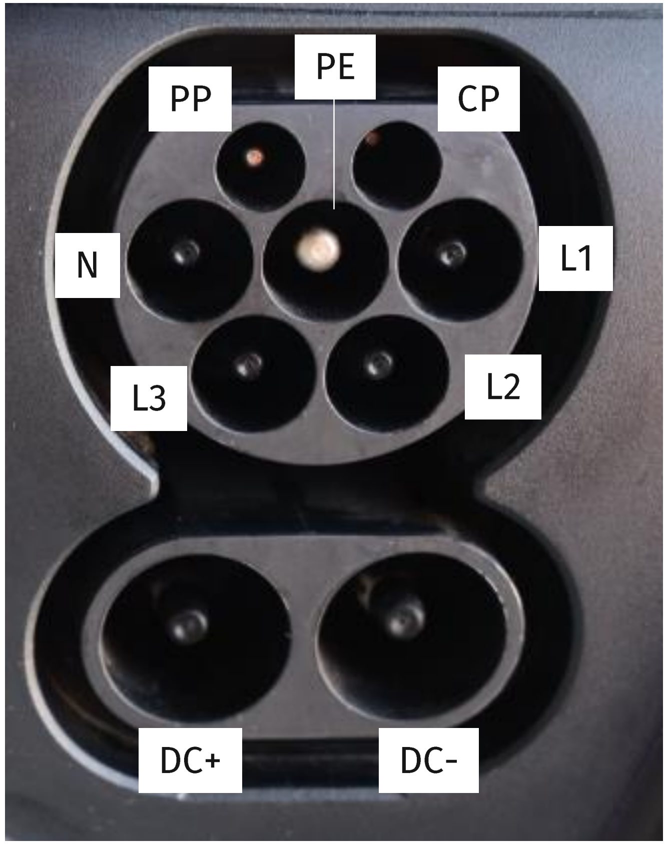
  EVSE (electric vehicle supply equipment)



CCS/Combo type 2 charging socket in an electric vehicle

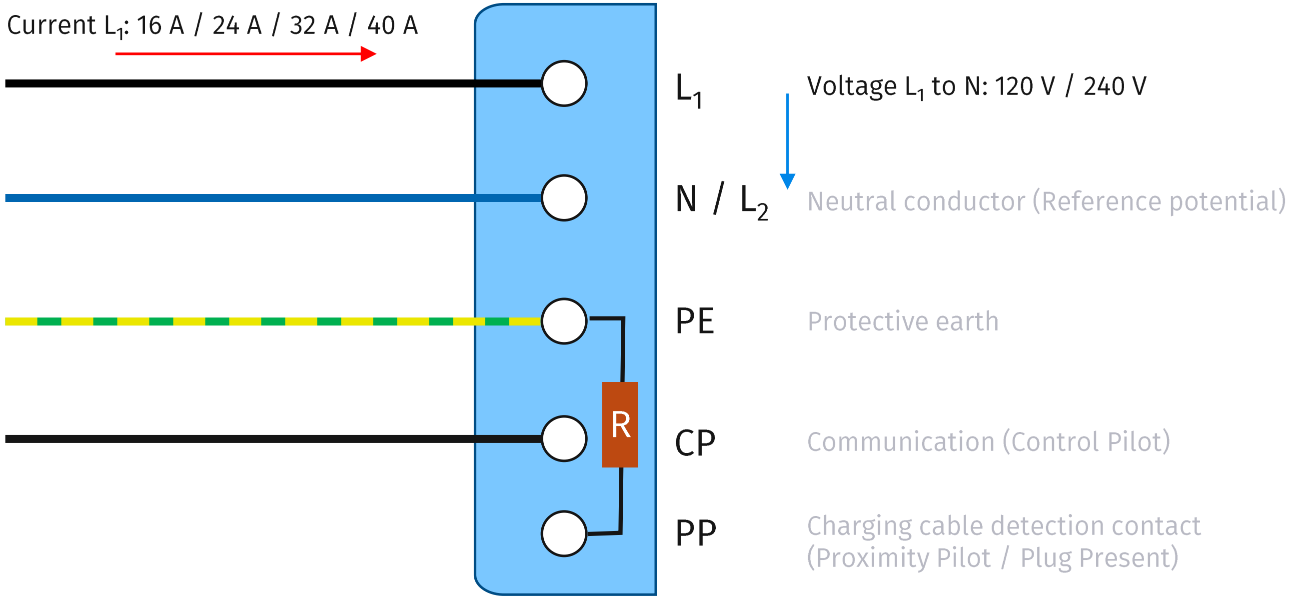
Example: Wallbox and AC charging station

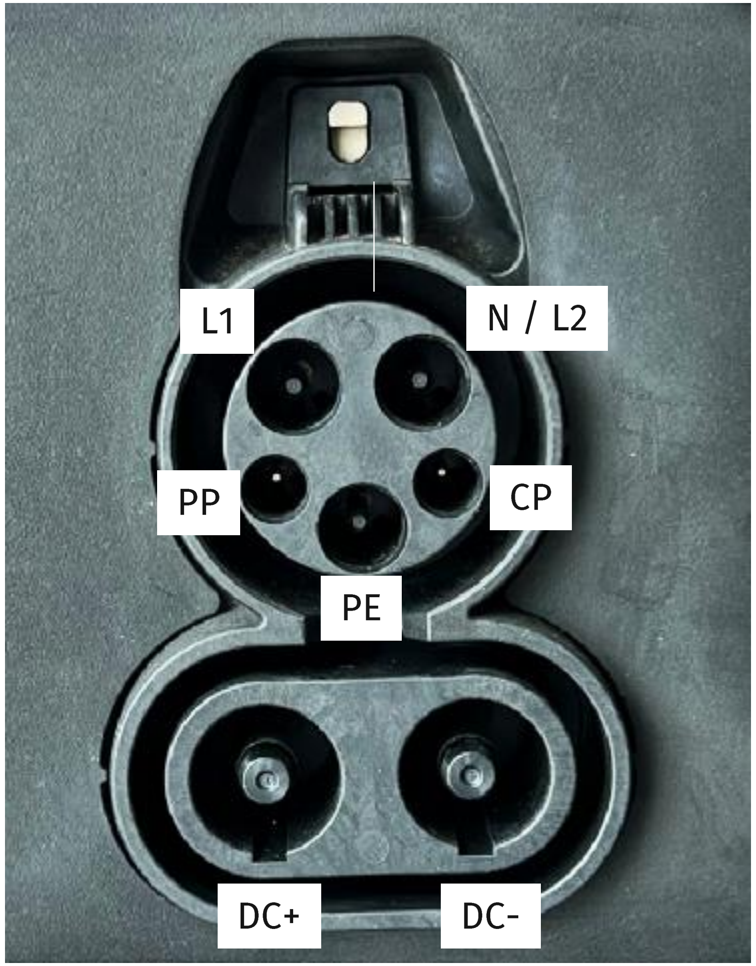




CCS/Combo type 1 charging socket in an electric vehicle

AC pin assignment type 1 SAE J1772





Split-phase AC power socket and charging cable

- Example: charging on NEMA 14-50 power outlet

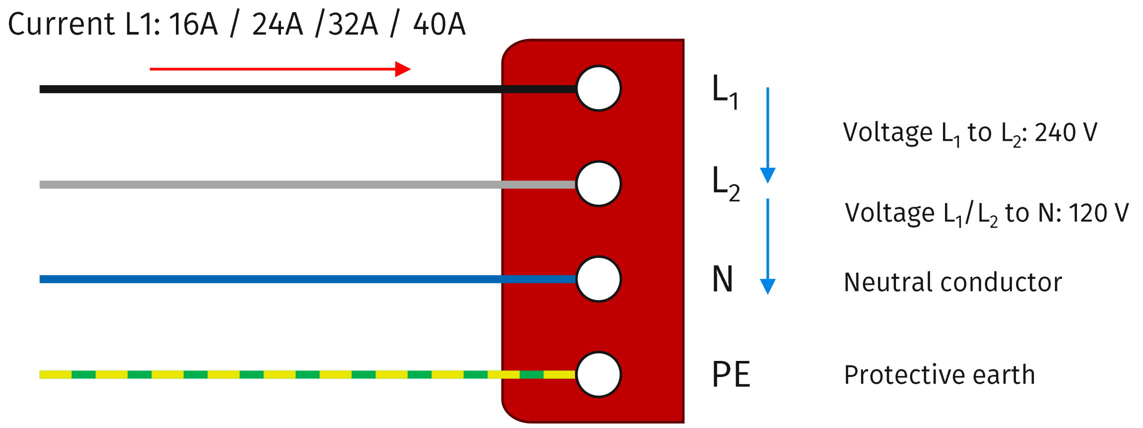
  Home, hotels, RV parks, workshops, agricultural area, etc.

EVSE with In-Cable Control Box

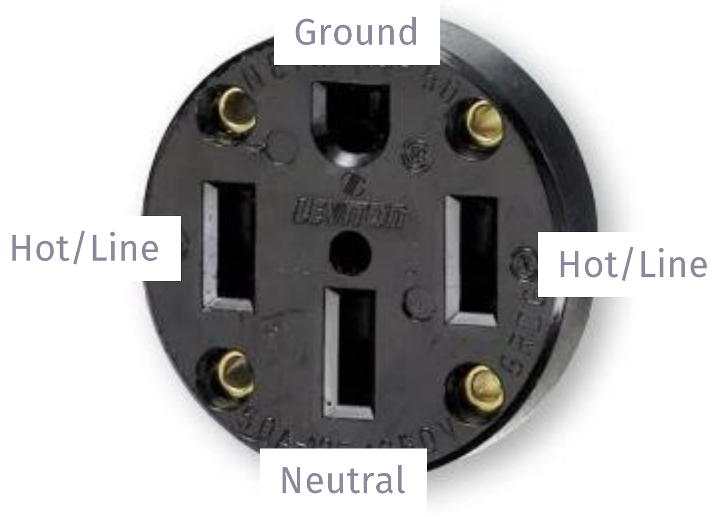
SAE J1772

NEMA 14-50 plug

AC pin assignment NEMA 14-50

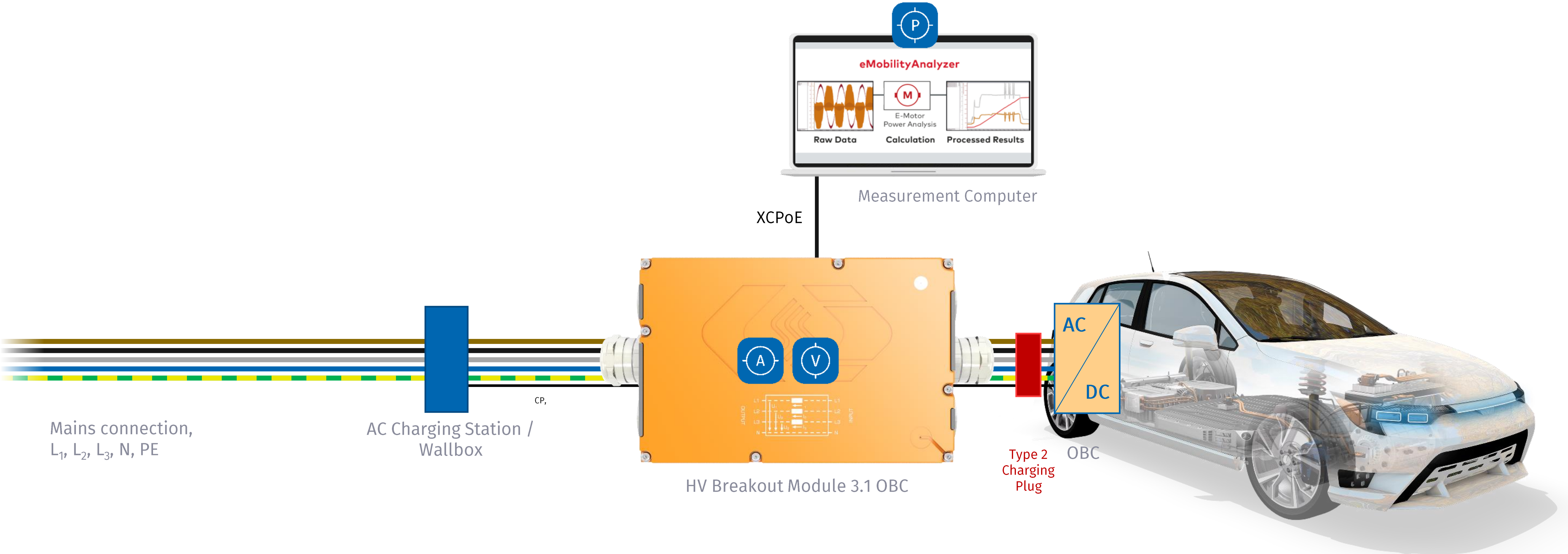


Power Socket NEMA 14-50



Verify on-board charger and AC charging processes

- Measurement between charging station and electric vehicle with an HV Breakout Module 3.1 OBC



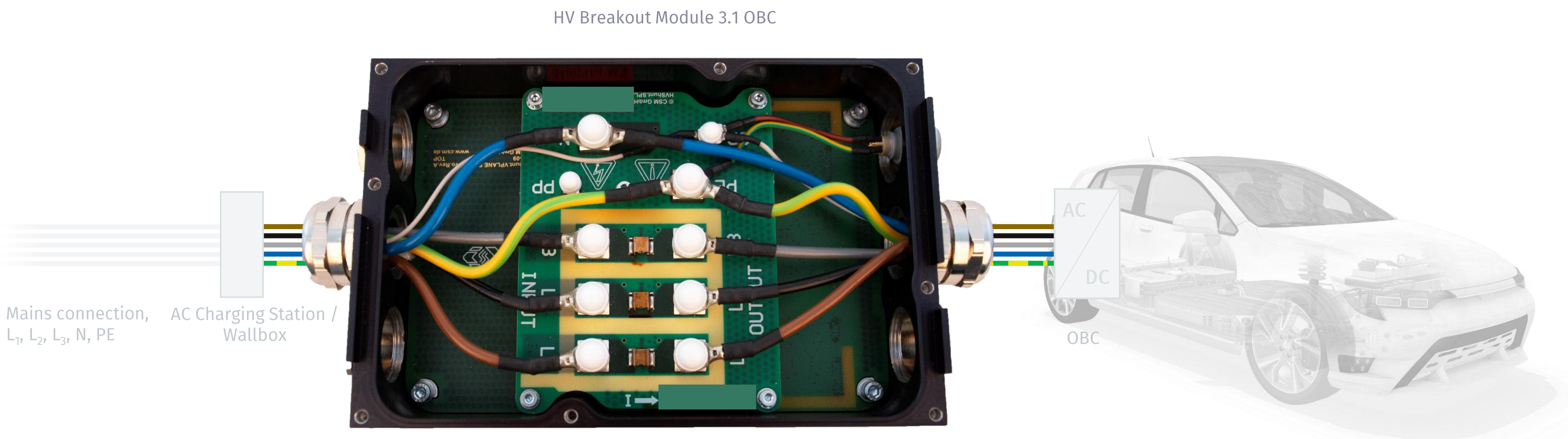
Breakout Module HV BM 3.1 OBC

HV BM 3.1 OBC
on www.csm.de

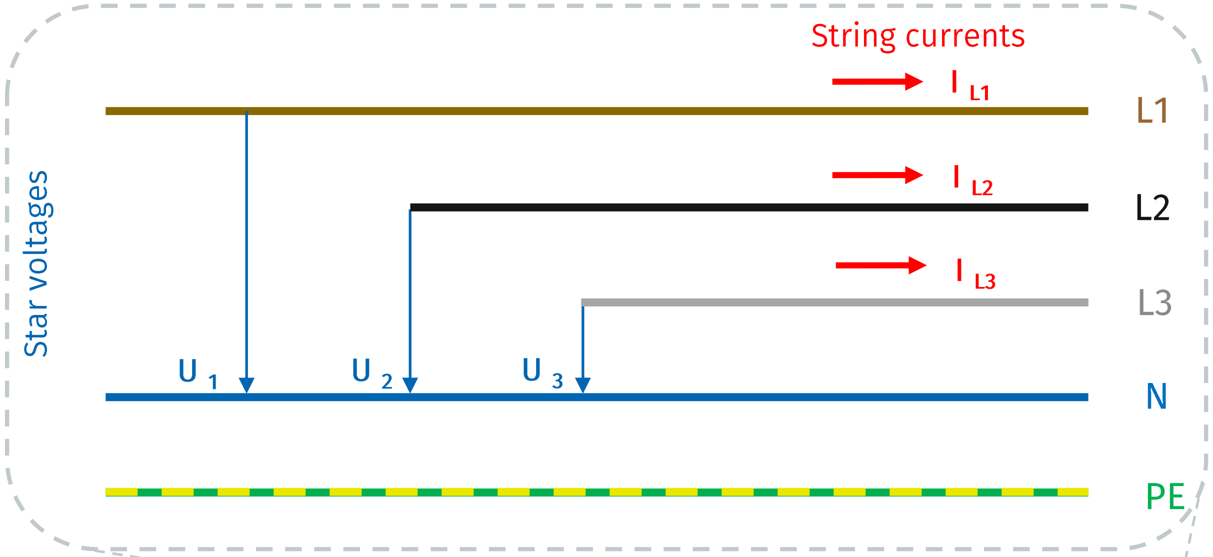
- Measurement of star voltages U1, U2, U3 against N and phase currents (I) I_1, I_2, I_3 in HV applications
- Nominal voltages up to 707 V_{rms} (measurement range up to ±1,000 V)
- Currents up to ±88 A_{rms}, ±125 A (peak)
- Interfaces: GBit/s XCP-on-Ethernet, ECAT, CAN
- Measurement data rate up to 2 MHz per measured value
- Optional calculation of power and RMS values
- Simultaneous data output via CAN with up to 5 kHz
- XCP-Gateway: connection of CSM ECAT and CAN measurement modules

Breakout Module HV BM 3.1 OBC

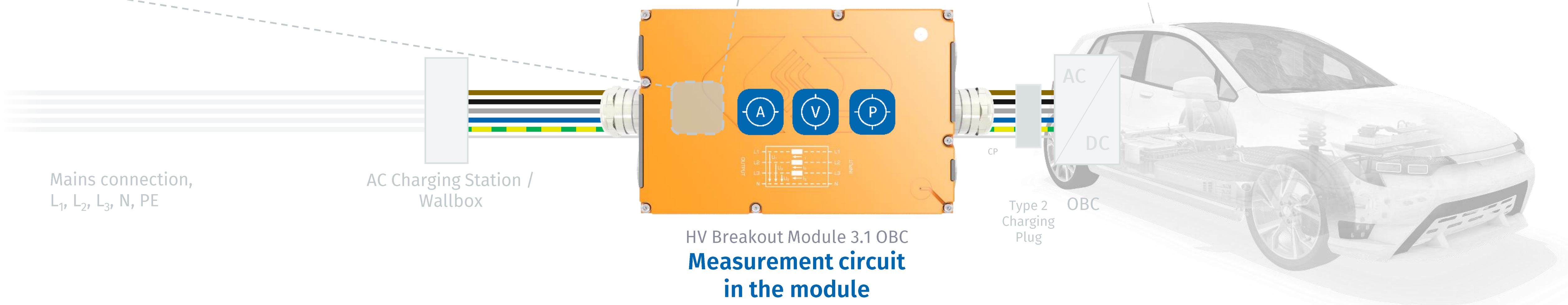
- Open HV BM 3.1 OBC with temperature-compensated shunt module for measurement of star voltages U_1, U_2, U_3 against N and phase currents (I) I_1, I_2, I_3



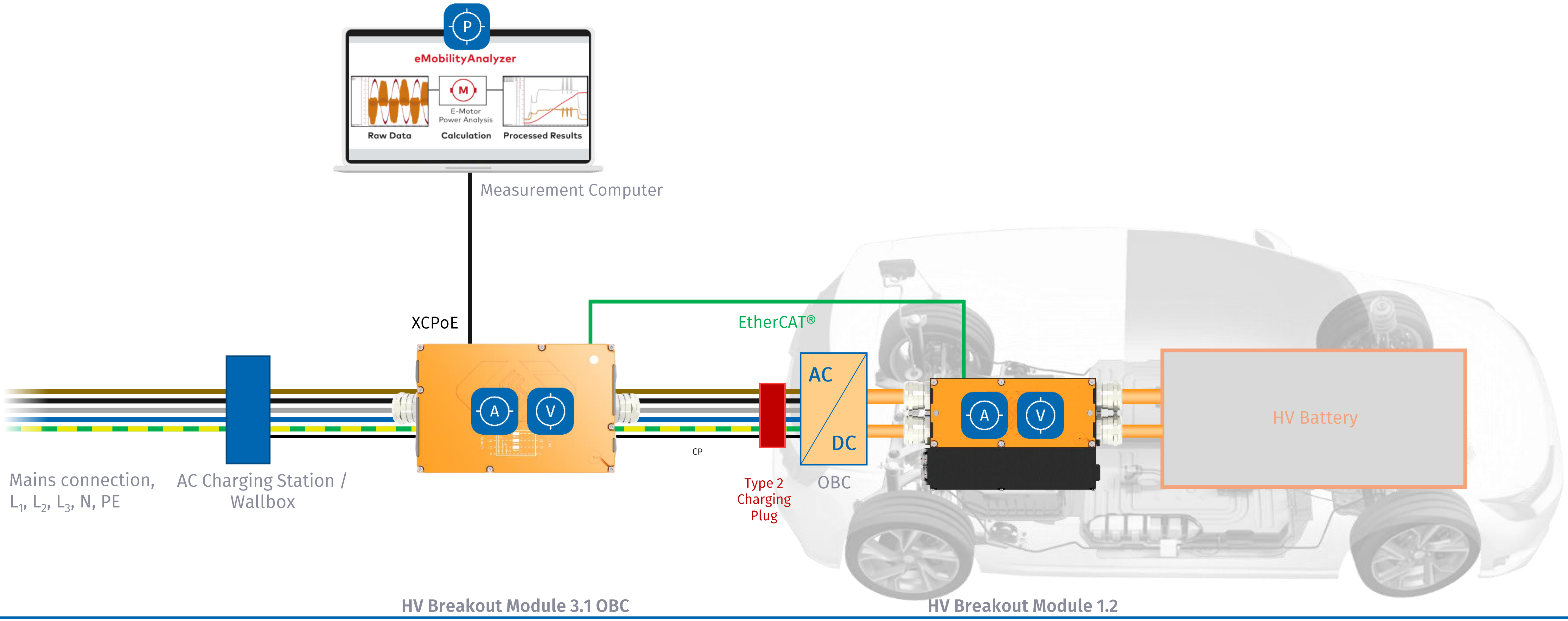
Measurement circuit in the HV BM 3.1 OBC



- In the four-wire 3-phase system, N is the common reference
- $P_{total} = P_1 + P_2 + P_3$
- Power calculation in the module



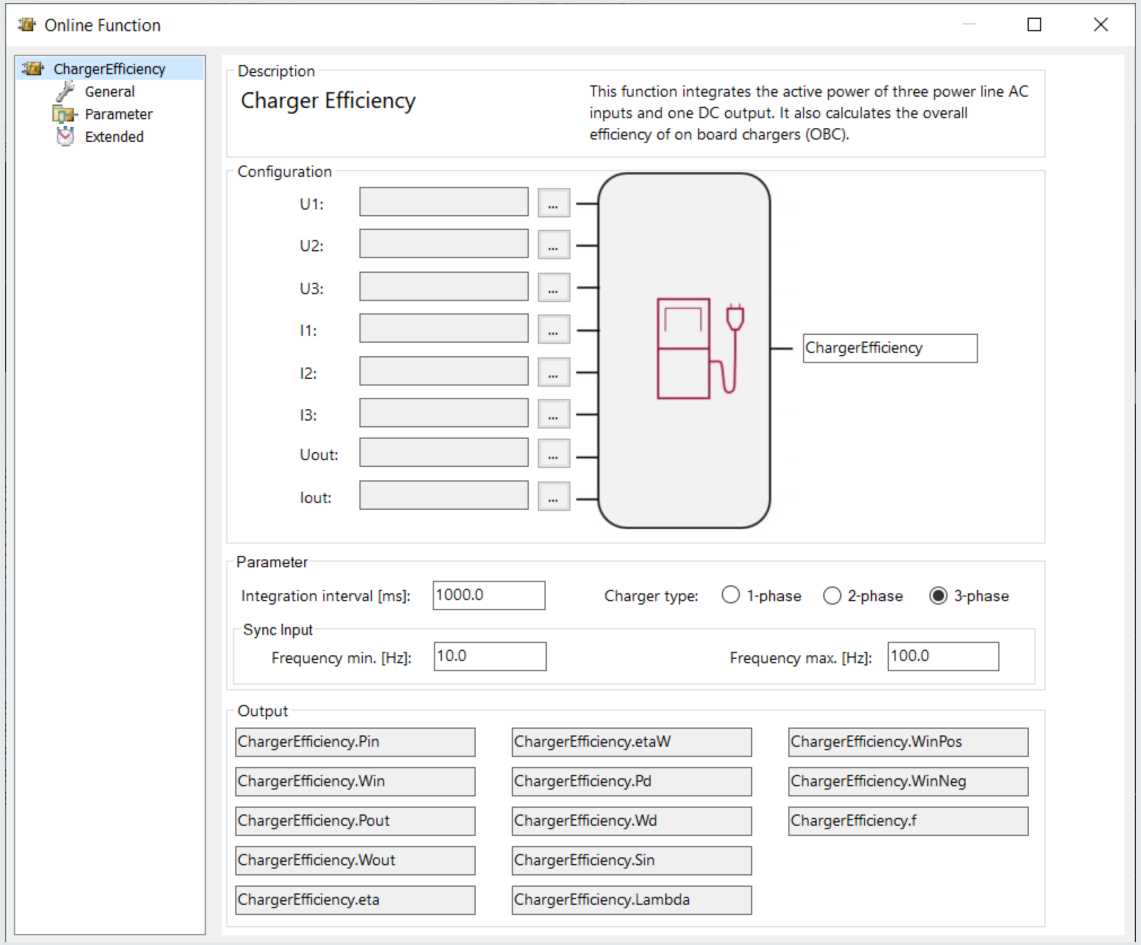
Verify OBC efficiency with Vector CANape and eMobilityAnalyzer



CANape - eMobility-Analyzer - ChargerEfficiency function

The function is used to determine the power parameters of an on-board chargerthat is supplied directly with single-phase to three-phase alternating current.

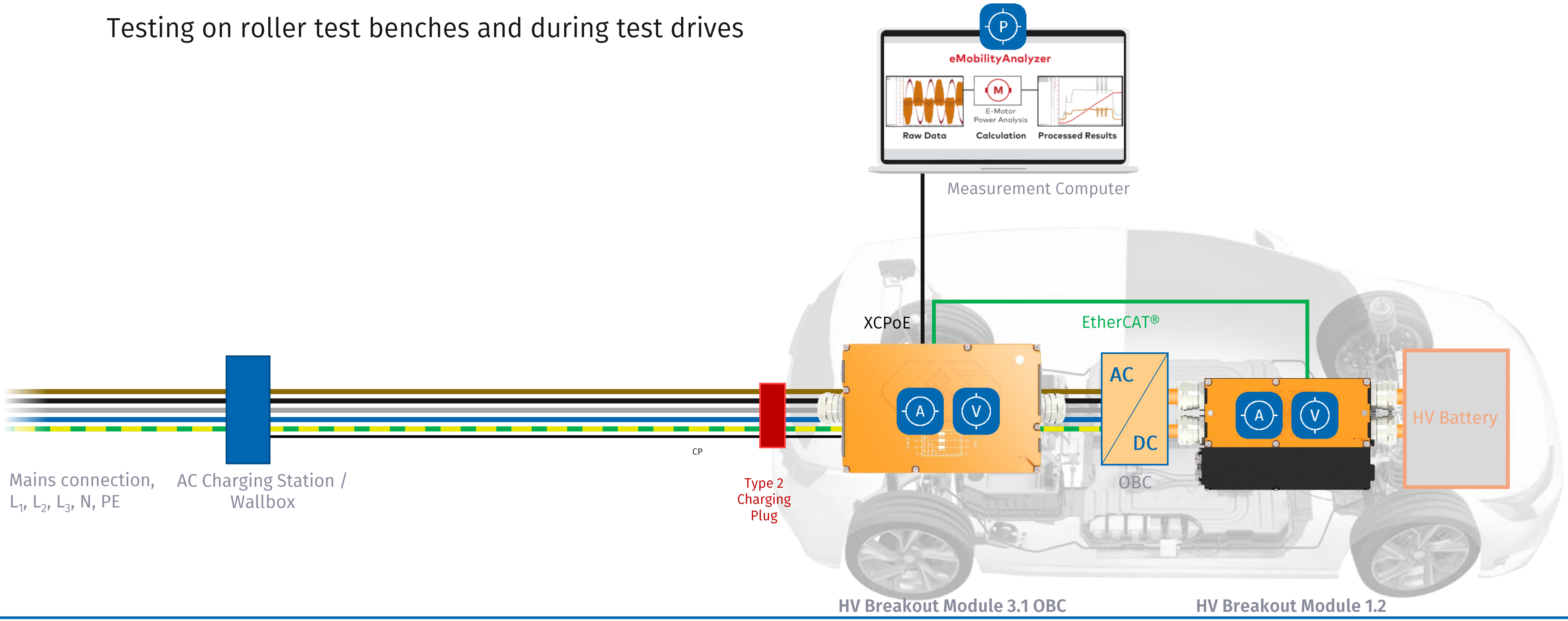
- AC input voltages, currents, waveforms
- DC output voltage, current
- Frequency
- Signal events
- On-board charger input power
- On-board charger output power
- On-board charger efficiency
- On-board charger total energy provided to HV battery and overall efficiency
- Charging cycle power loss



HV BM 3.1 OBC installed in the test vehicle

- Verification of OBC performance parameters and efficiency

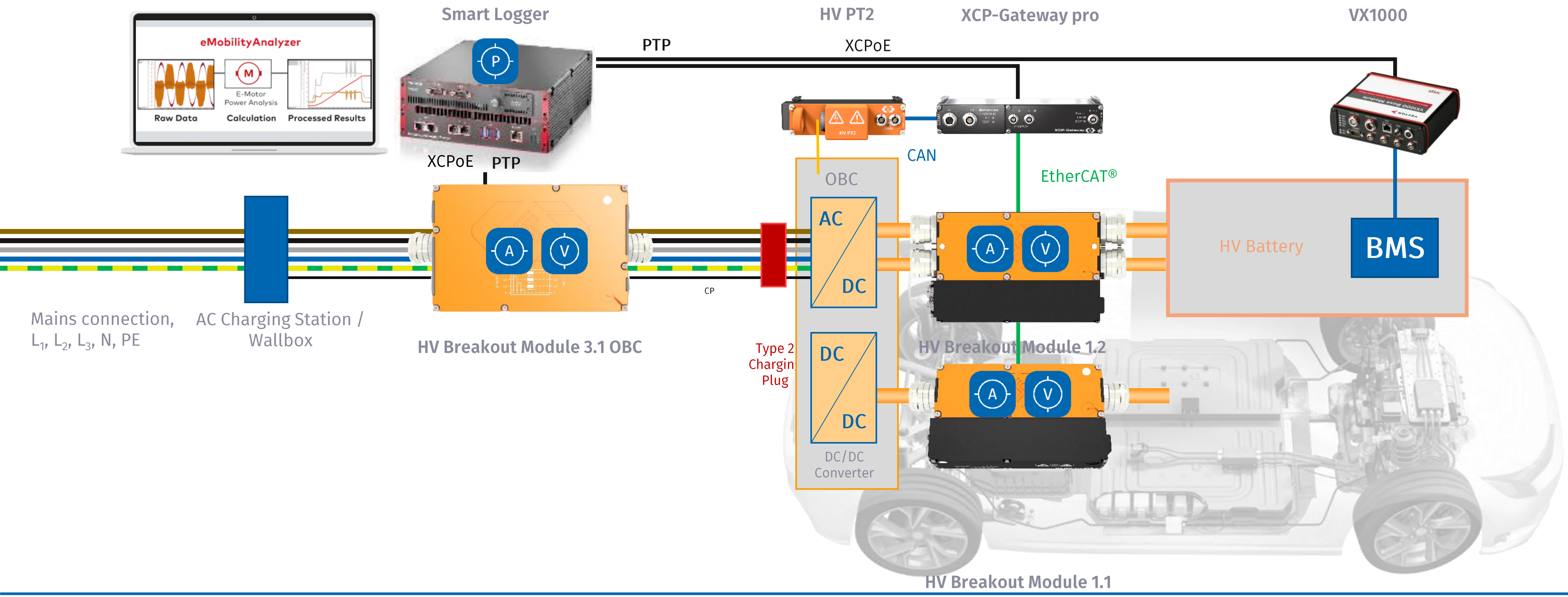
  Testing on roller test benches and during test drives



Efficiency measurement in an electric vehicle with HV Breakout Modules

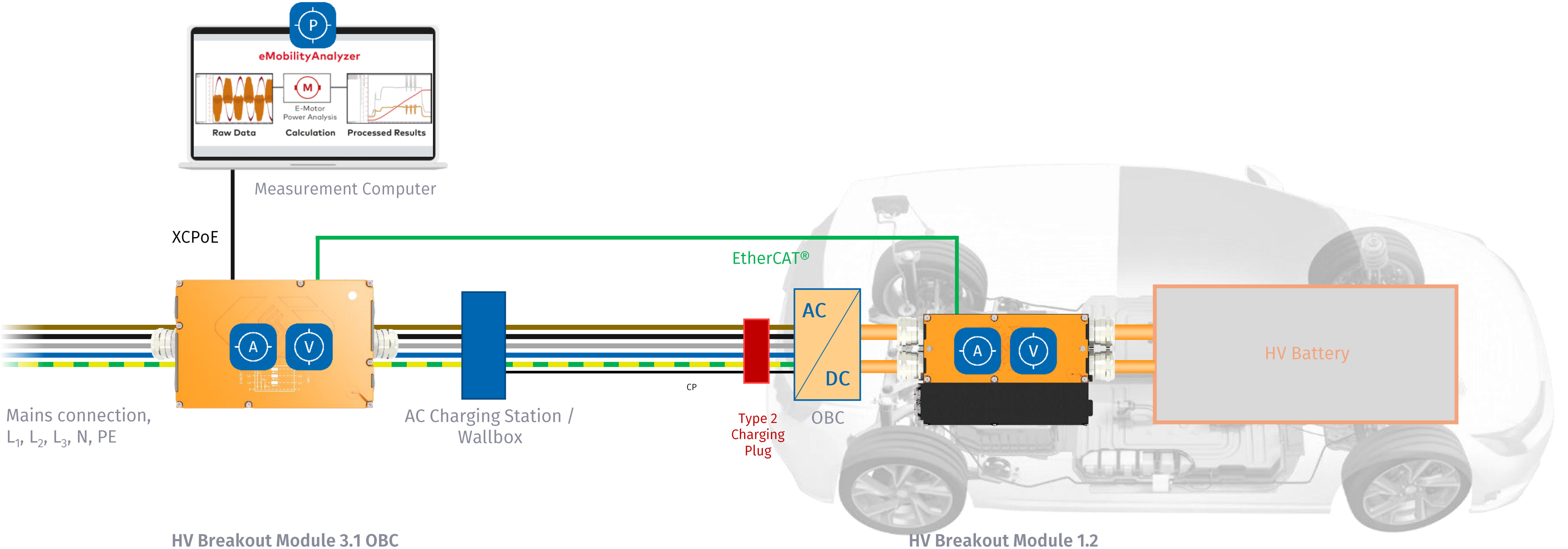
Testing integrated on-board charger

- Data recording with Vector Smart Logger
- Function test and verification



Verification of the grid side in front of the charging station

- Testing charging points and charging stations
- Verification of grid quality and repercussions of the charging station



Mobile testing of charging processes - interoperability testing

A fast and precise current, voltage and power measurement must be carried out

A power supply for the measurement device is required to measure the starting process

Charging cable **to the vehicle** must be connected with the appropriate plug

Charging cable **to the wallbox/charging station** must be connected with the appropriate plug

Country-specific power grid characteristics must be taken into account

A wide variety of wallbox models, charging stations and high-voltage sockets

The measurement device must be installed between the charging station and the electric vehicle in the charging cable in a **HV-safe** manner

Function analyses with the eMobilityAnalyzer

for investigating feedback effects, power quality problems, disturbance variables and harmonics

ChargerEfficency

- Analysis of the 3 AC charging phases: Currents, voltages, power, frequency, waveforms, stability, ...

Harmonics

- Performs a harmonic analysis of a signal in which the fundamental and higher harmonics are calculated in a specified time interval

Harmonic Power

- HarmonicPower is an extension of the Harmonic Analysis function for calculating the active power of the fundamental and the higher harmonics

Single Frequency Analysis

- This function performs a Fourier analysis for a single specified frequency

Frequency

- This function calculates the fundamental frequency and its rate of change

Fourier Analysis

- This function calculates the spectrum of a signal (CANape 22, vMeasure 8)

Summary

- The new HV BM 3.1 OBC and CANape make it easy to solve complex measurement tasks for testing on-board charger:
  - Check power quality and investigate system perturbations
  - Detect and analyze harmonics
  - Measure charging power loss
  - Determine OBC efficiency
- Interoperability problems during AC charging can be analyzed quickly and in detail
- Fast switch-on and switch-off processes and transient voltage changes can be investigated
- The CSM OBC measurement case allows a quick and easy measurement setup in the field worldwide
- Synchronized analysis of control unit, bus data and fast measurements up to 2 MHz

About CSM

CSM has been setting technological standards for decentralized measurement technology in vehicle development for over 35 years. Our CAN bus and EtherCAT® measurement devices support worldwide renowned vehicle manufacturers, suppliers and service providers in their developments.

Continuous innovation and long-term satisfied customers are our guarantee for success. Together with our partner Vector Informatik, we have developed an easily scalable and powerful E-Mobility Measurement System for hybrid and electric vehicles and are constantly expanding the areas of application. With our high-voltage safe measurement systems designed for fast and synchronous measurements and power analyses, we actively accompany the change to **E-Mobility.**

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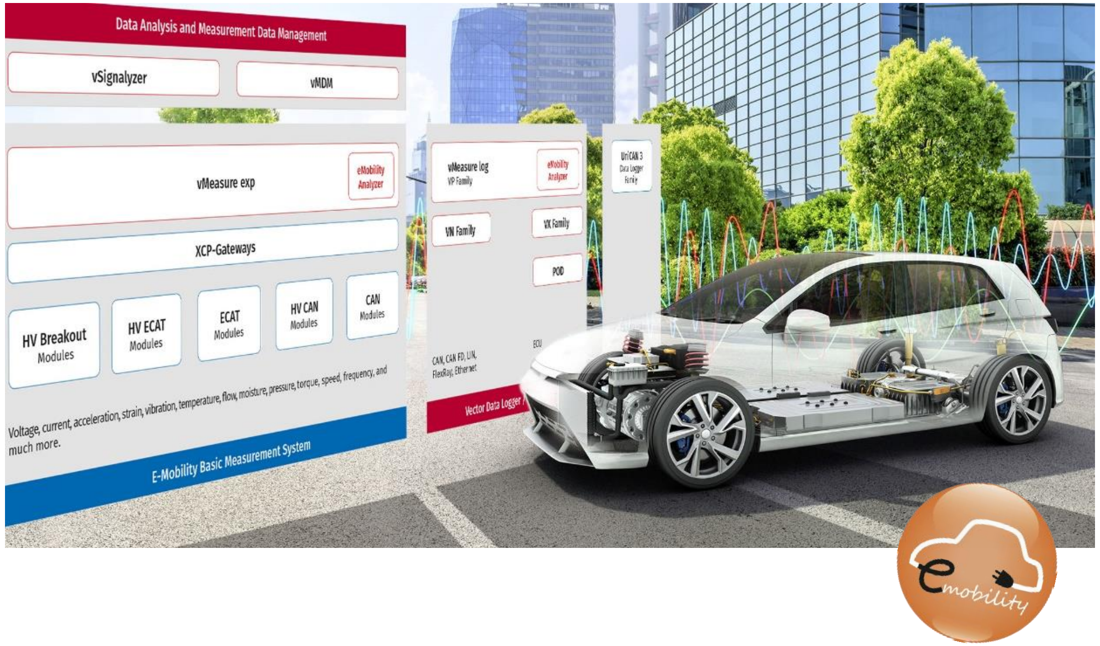

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