Testing of on-board charger and AC charging processes

CSM web seminars

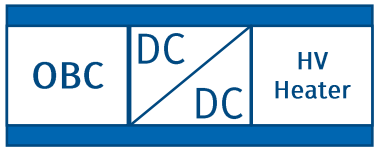
CSM Xplained
measurement technology

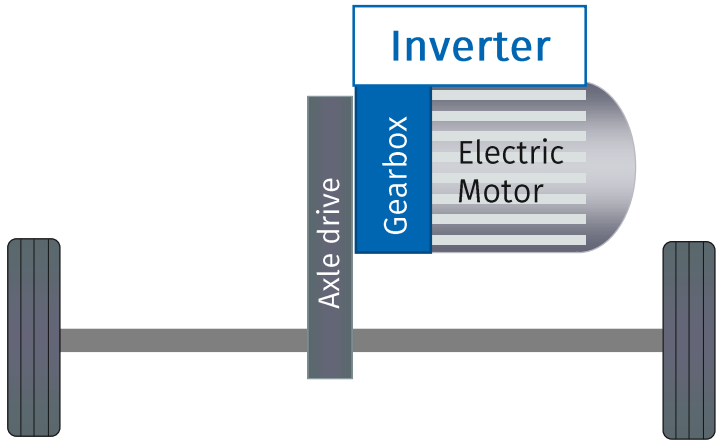
Innovative Measurement and Data Technology

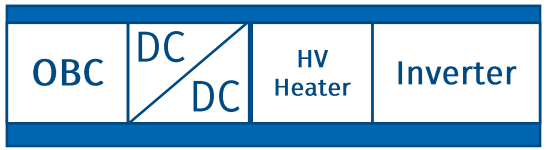
Developments in on-board charger

- 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

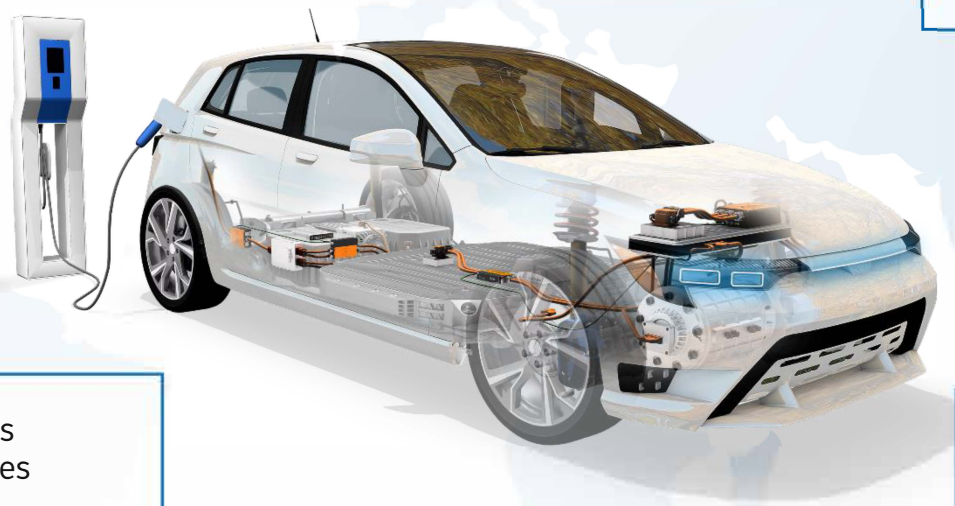
Verification of OBC efficiency and charge cycle power loss

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

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

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

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



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

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

OBC interoperability testing is complicated by large variances

(countries, charging station providers and types)

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

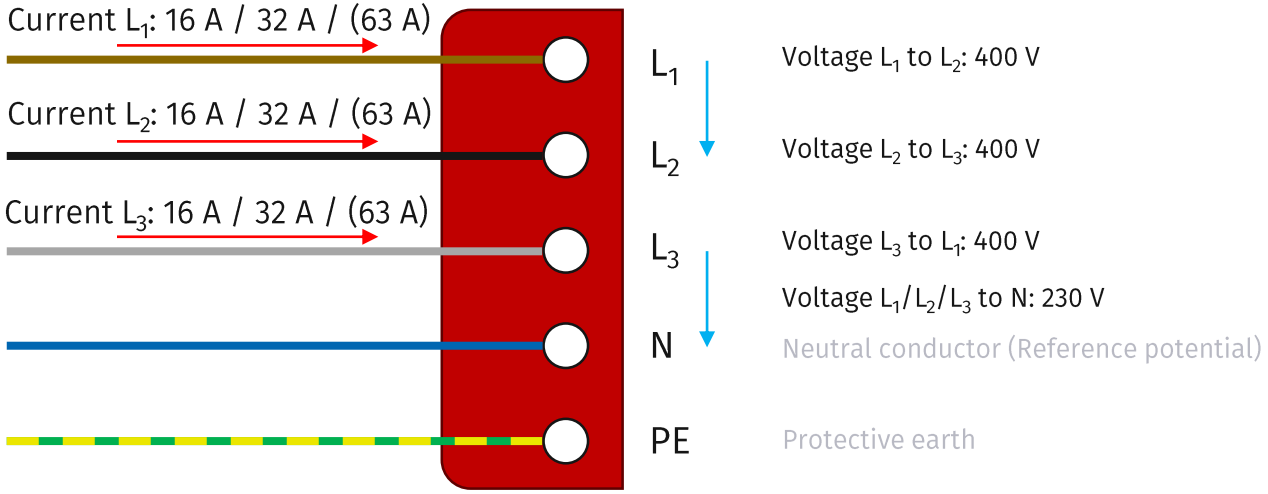
Type 2
AC Plug

Tesla
AC/DC Plug

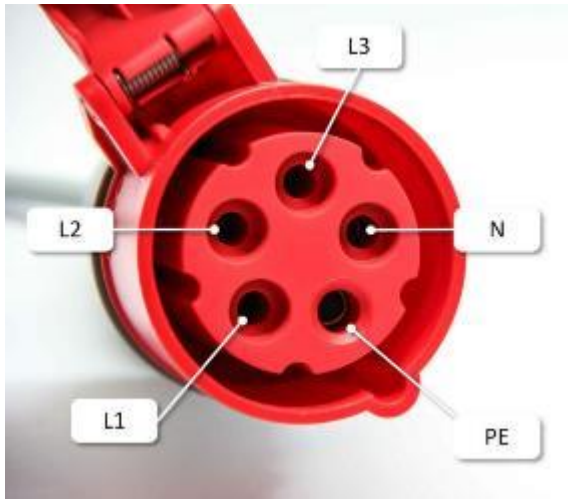
Three-phase AC Power socket and charging cable

- Example: Charging at CEE power outlet

  Home, hotels, workshops, agricultural area, etc.



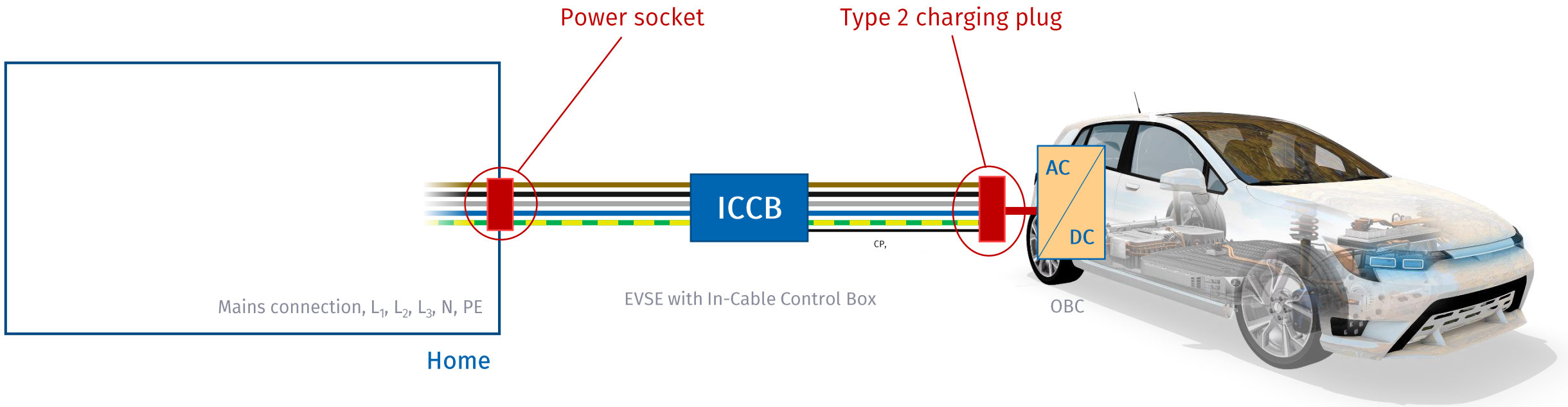
Power socket



AC charging process with charging cable and sockets

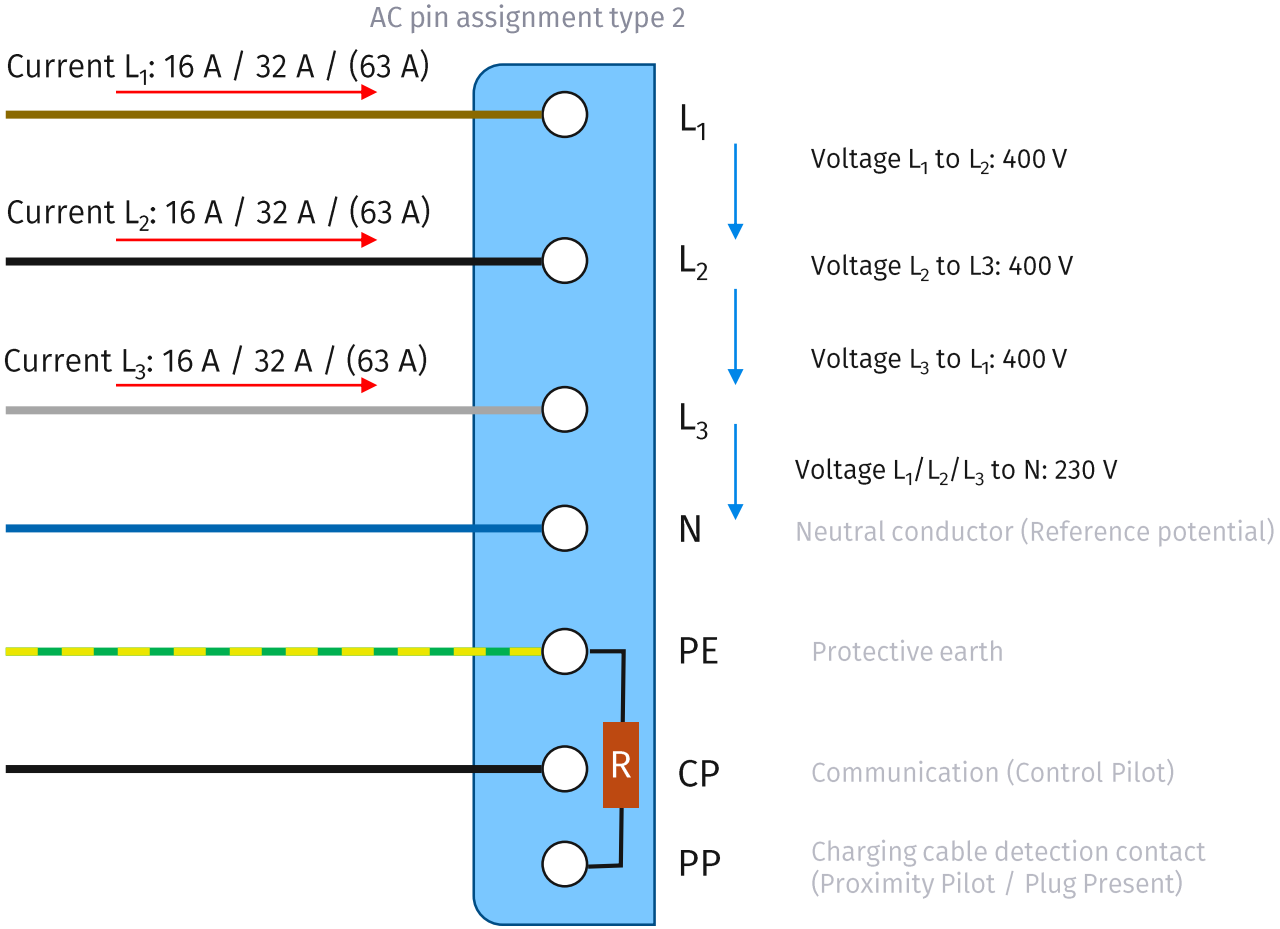
- Charging cable with a control box to control the charging process

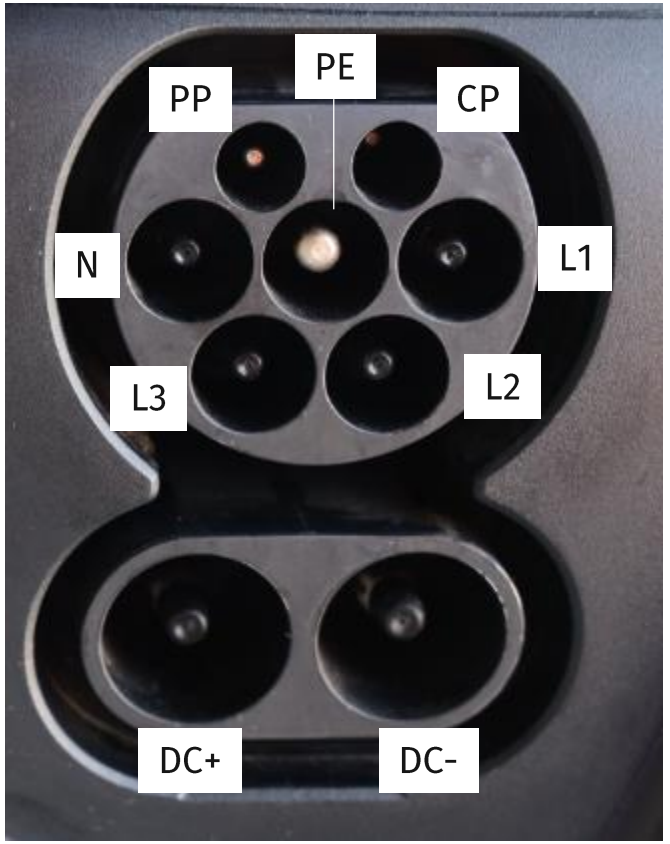
  EVSE (electric vehicle supply equipment)



CCS/Combo type 2 charging socket in an electric vehicle

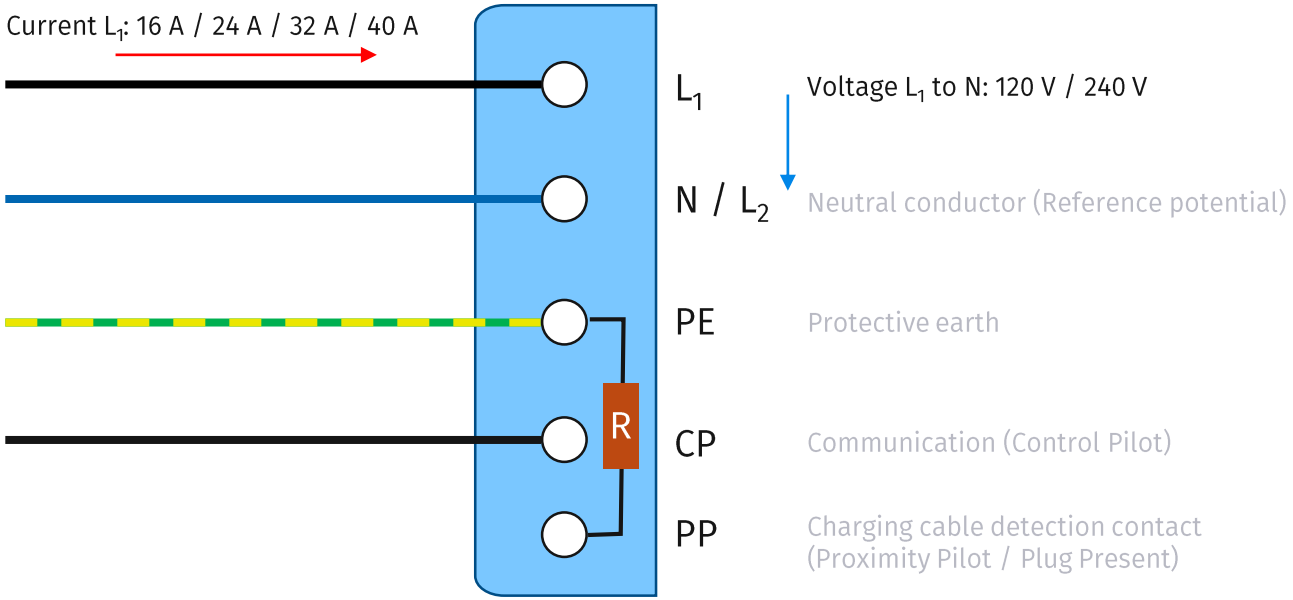
Example: Wallbox and AC charging station



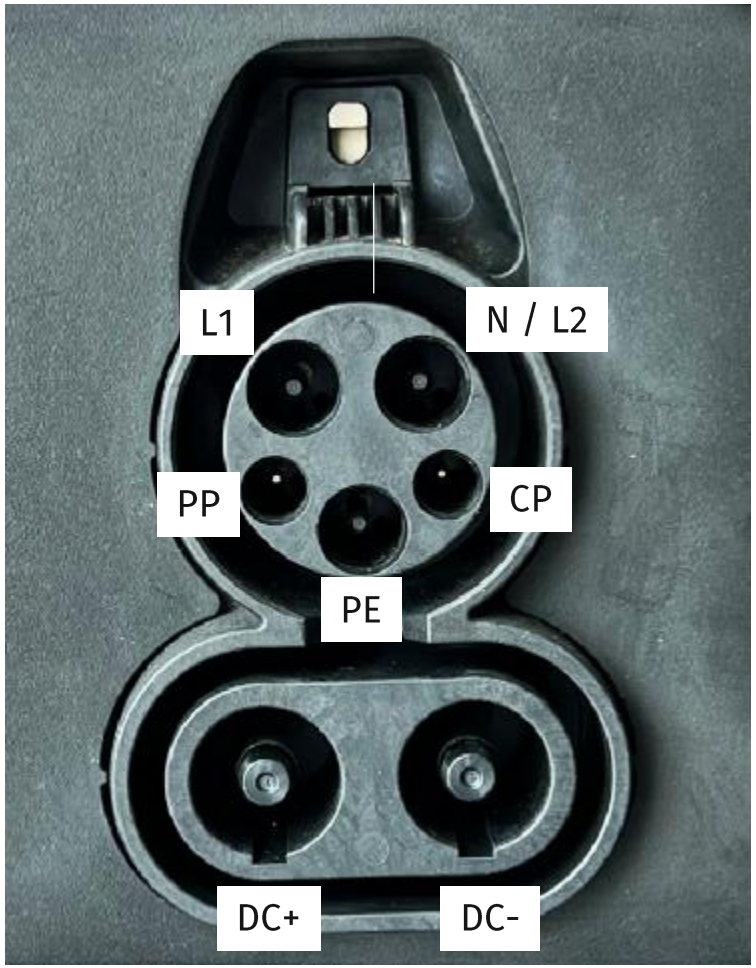


CCS/Combo type 1 charging socket in an electric vehicle

AC pin assignment type 1 SAE J1772



L_1	Voltage L_1 to N: 120 V / 240 V
N / L_2	Neutral conductor (Reference potential)
PE	Protective earth
CP	Communication (Control Pilot)
PP	Charging cable detection contact (Proximity Pilot / Plug Present)



Split-phase AC power socket and charging cable

- Example: charging on NEMA 14-50 power outlet

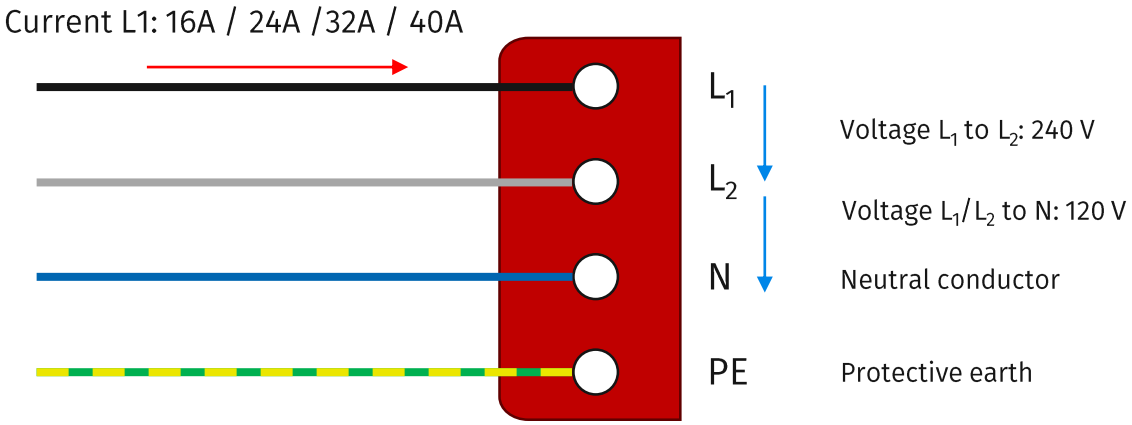
  Home, hotels, RV parks, workshops, agricultural area, etc.

EVSE with In-Cable Control Box

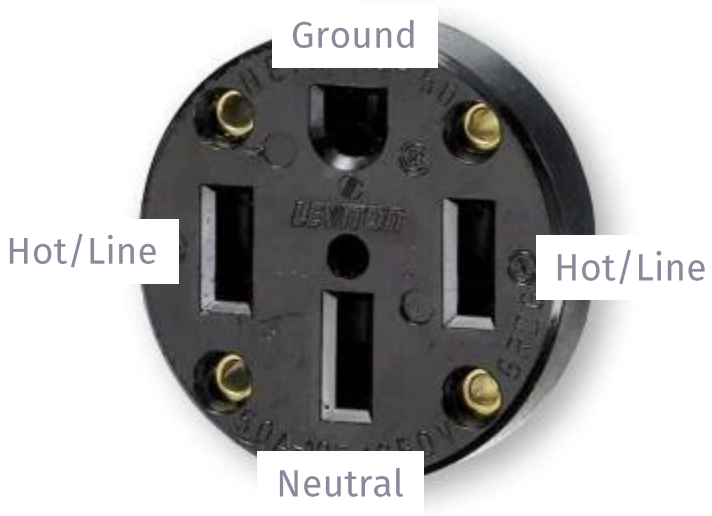
SAE J1772

NEMA 14-50 plug

AC pin assignment NEMA 14-50

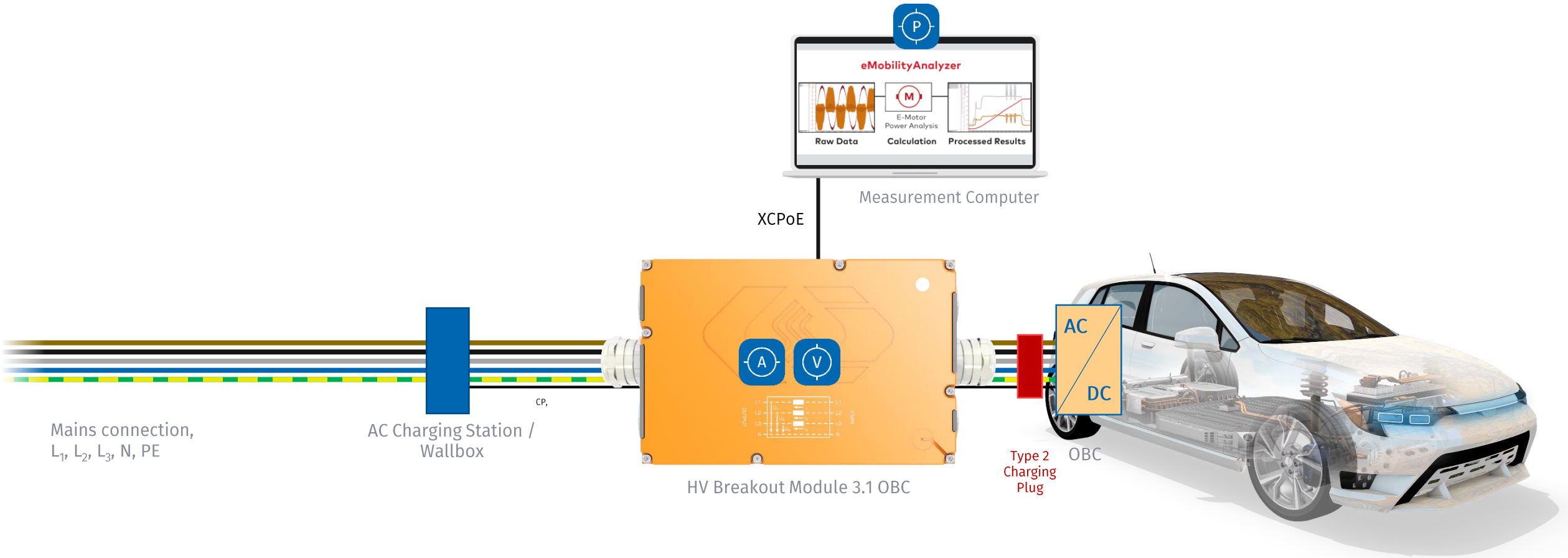


Power Socket NEMA 14-50



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

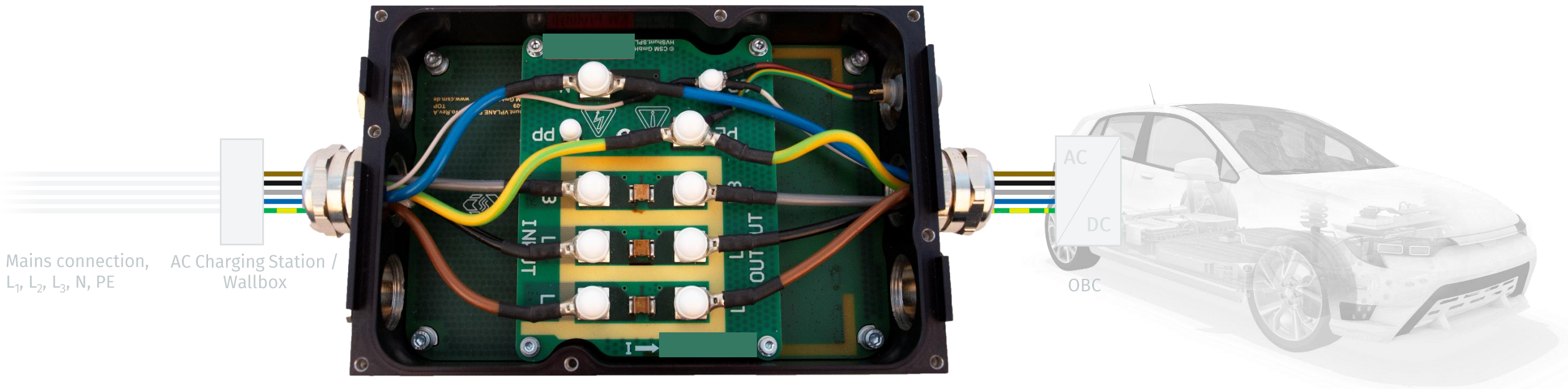
HV BM 3.1 OBC
on www.csm.de

- 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

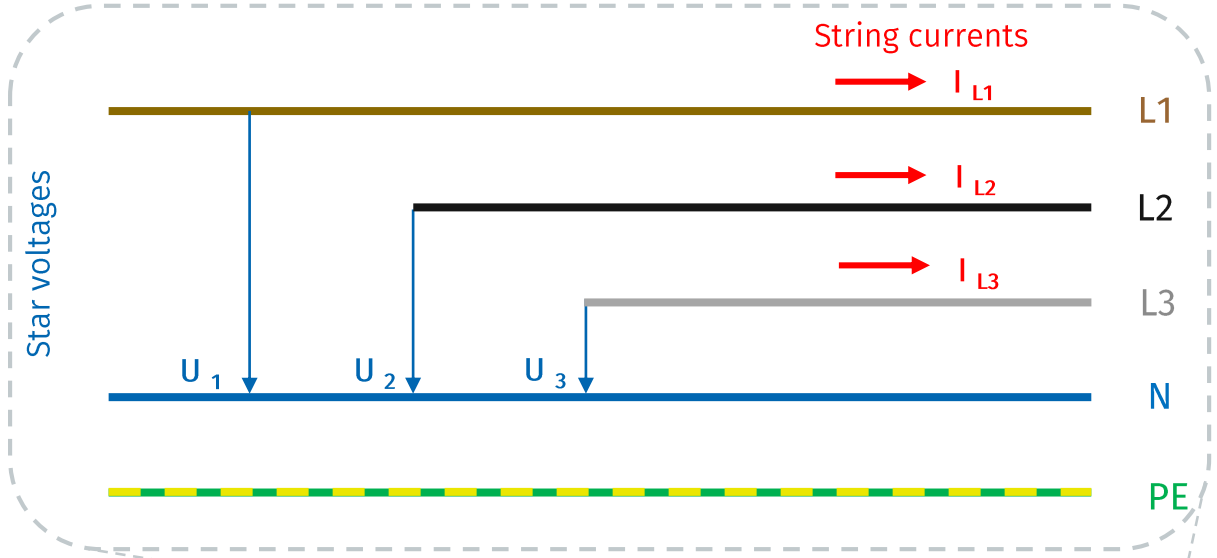
Breakout Module HV BM 3.1 OBC

- 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

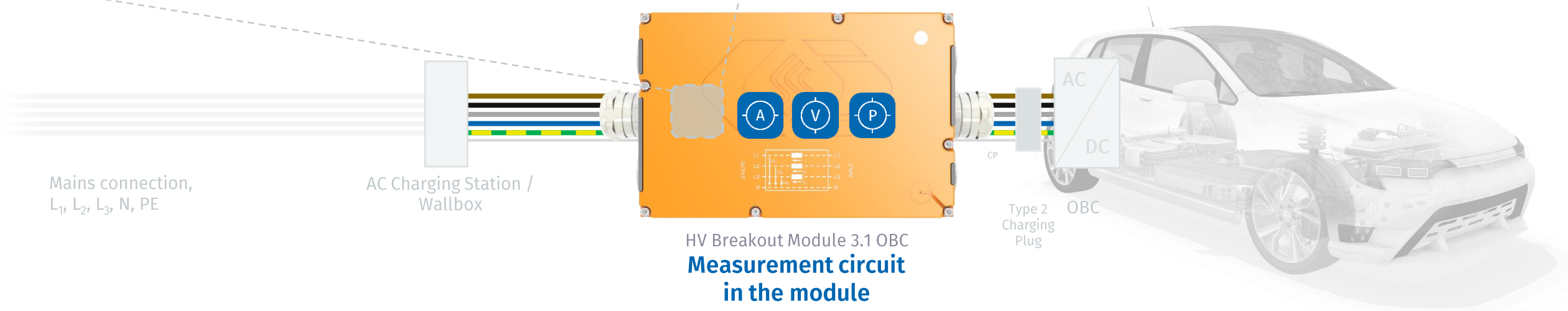
HV Breakout Module 3.1 OBC



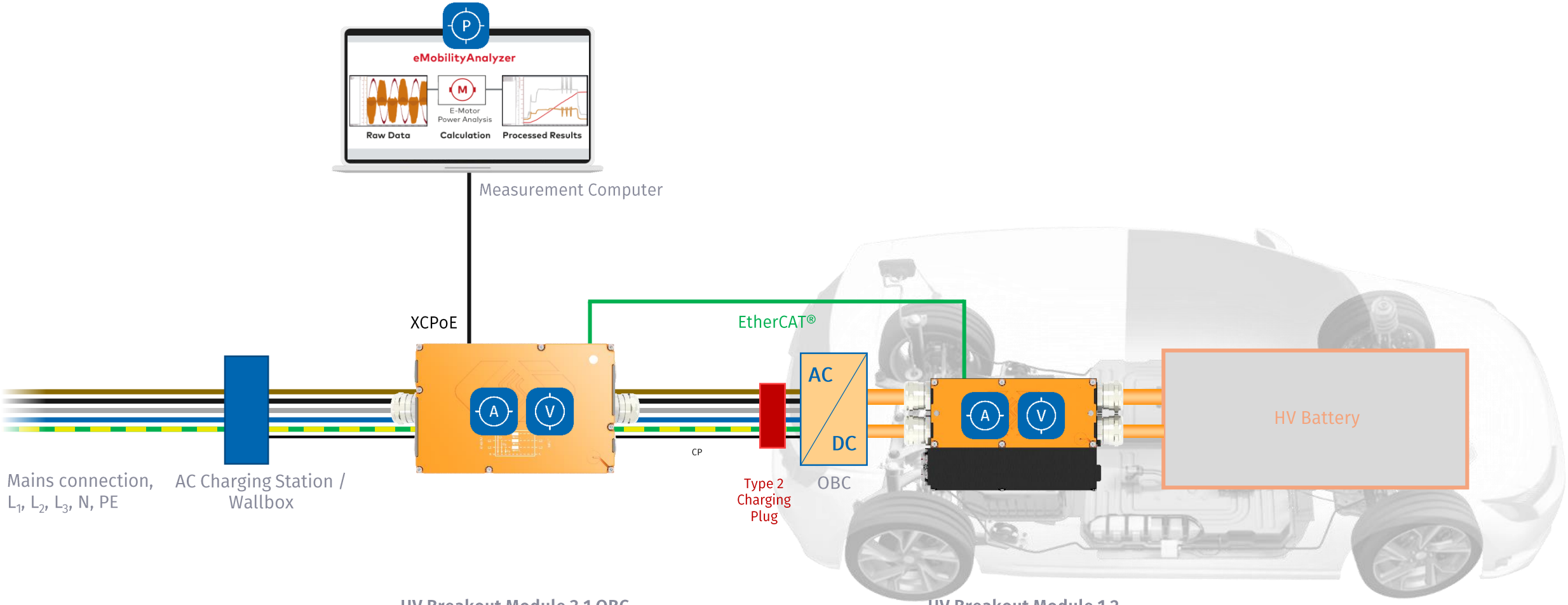
Measurement circuit in the HV BM 3.1 OBC



- 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



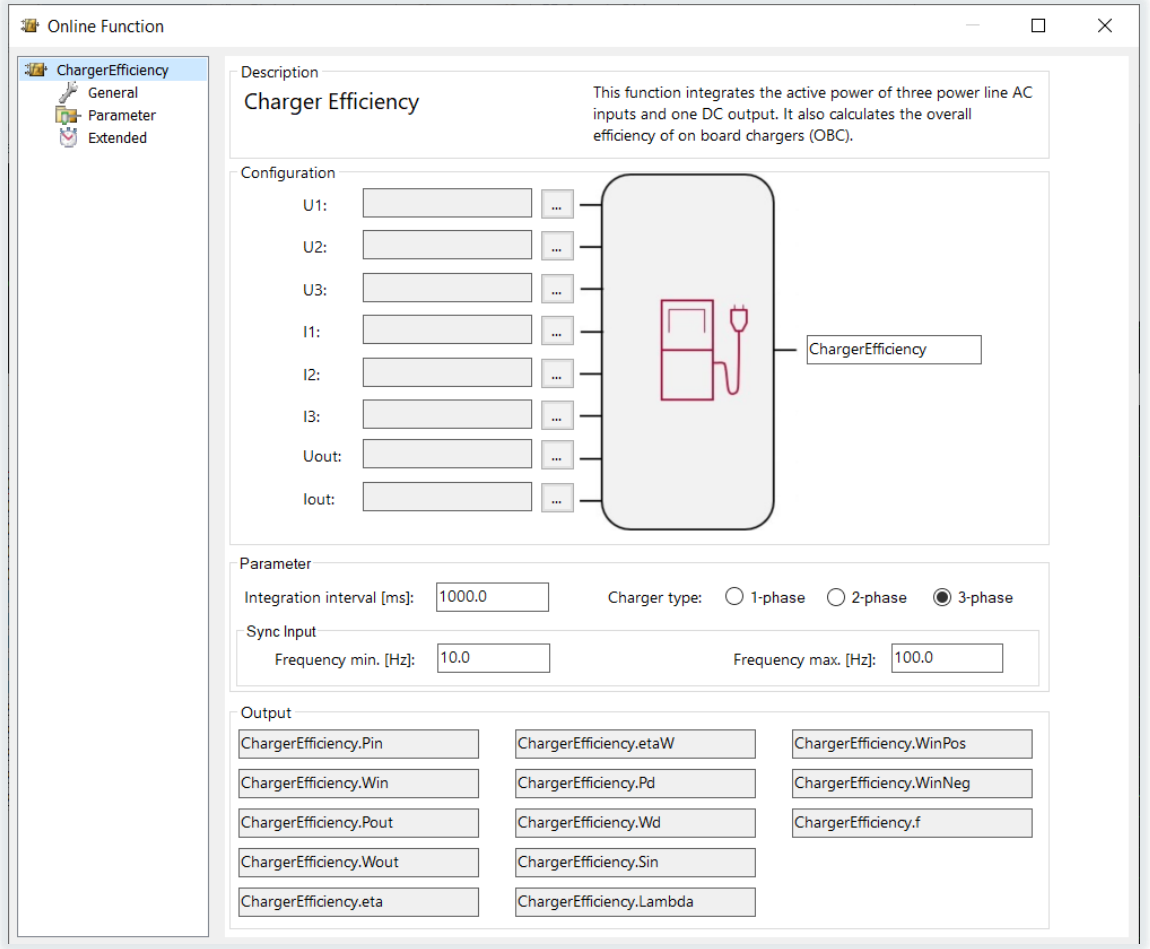
Verify OBC efficiency with Vector CANape and eMobilityAnalyzer



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.

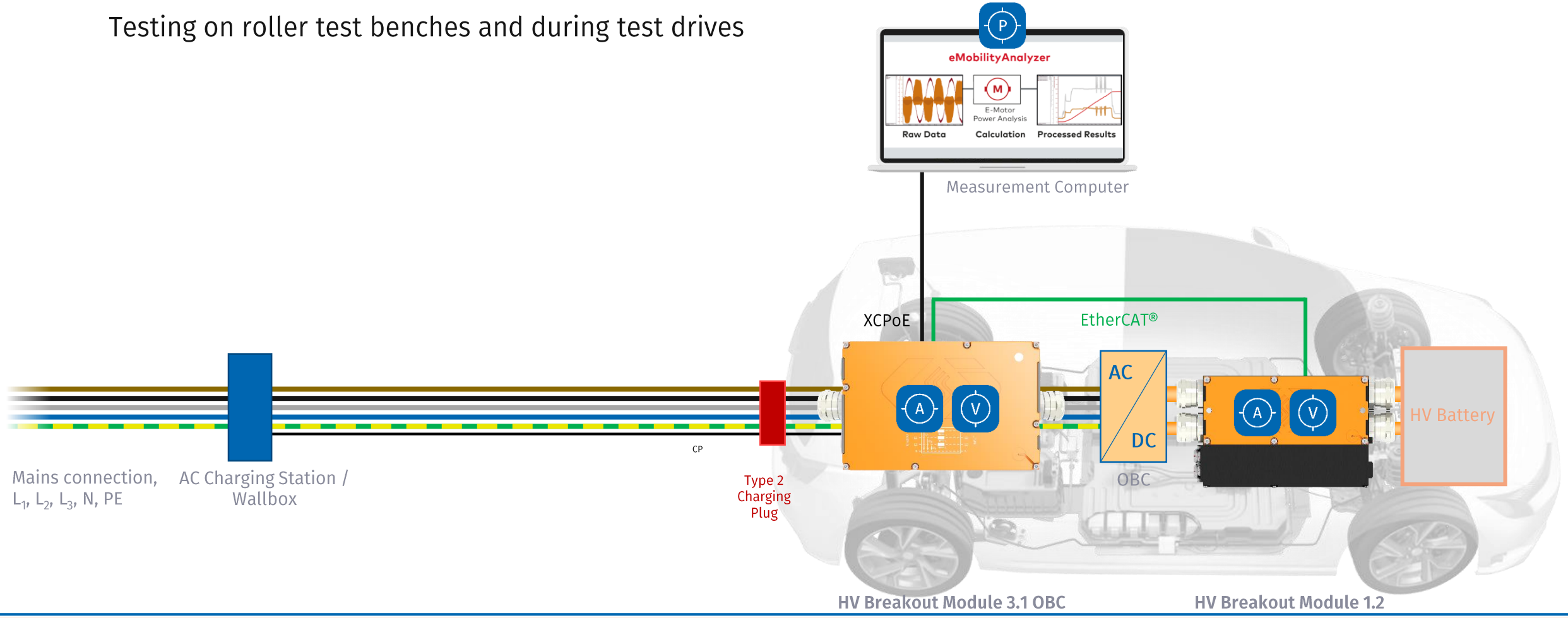
- AC input voltages, currents, waveforms
- DC output voltage, current
- Frequency
- Signal events
- On-board charger input power
- On-board charger output power
- On-board charger efficiency
- On-board charger total energy provided to HV battery and overall efficiency
- Charging cycle power loss



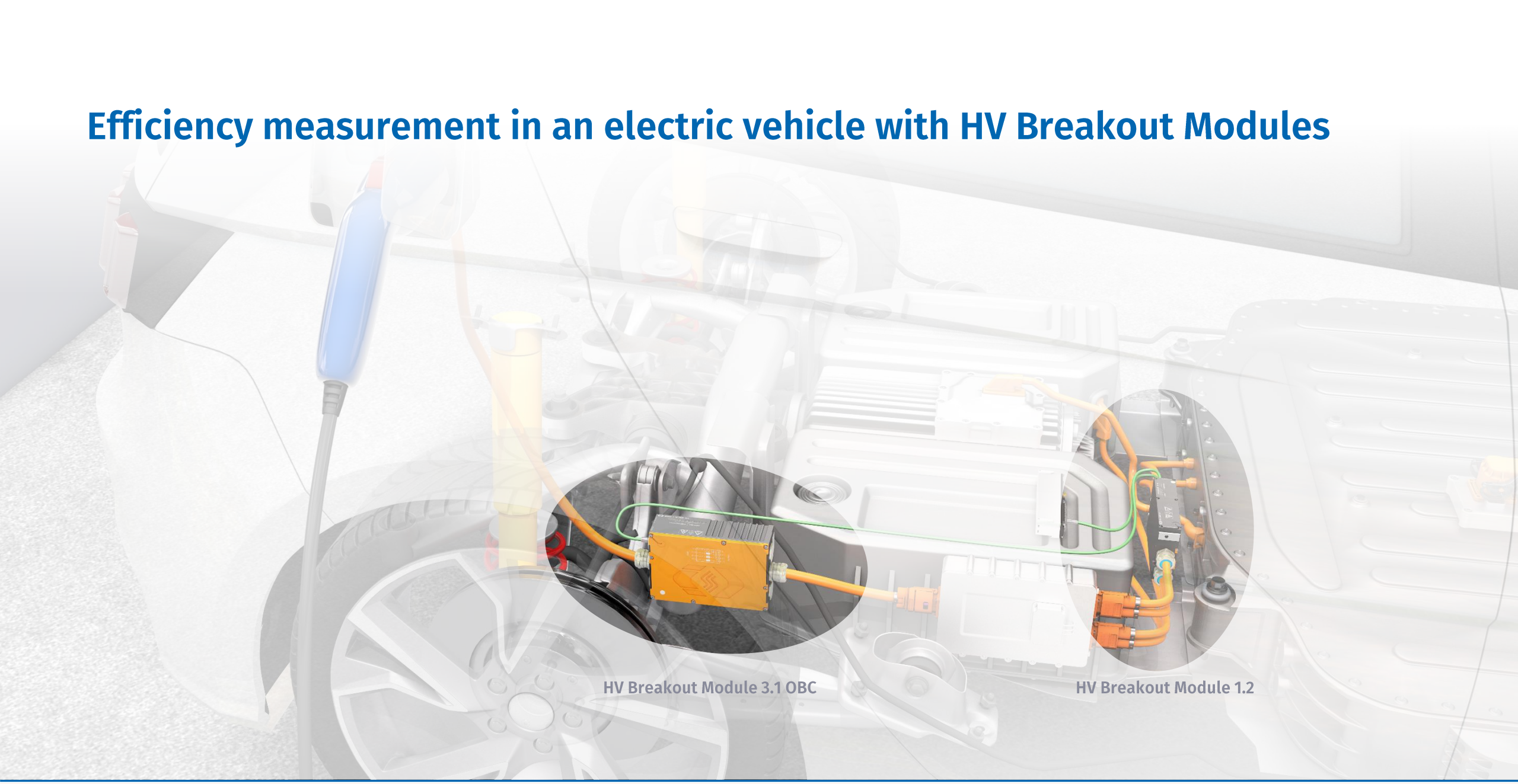
HV BM 3.1 OBC installed in the test vehicle

- Verification of OBC performance parameters and efficiency

  Testing on roller test benches and during test drives

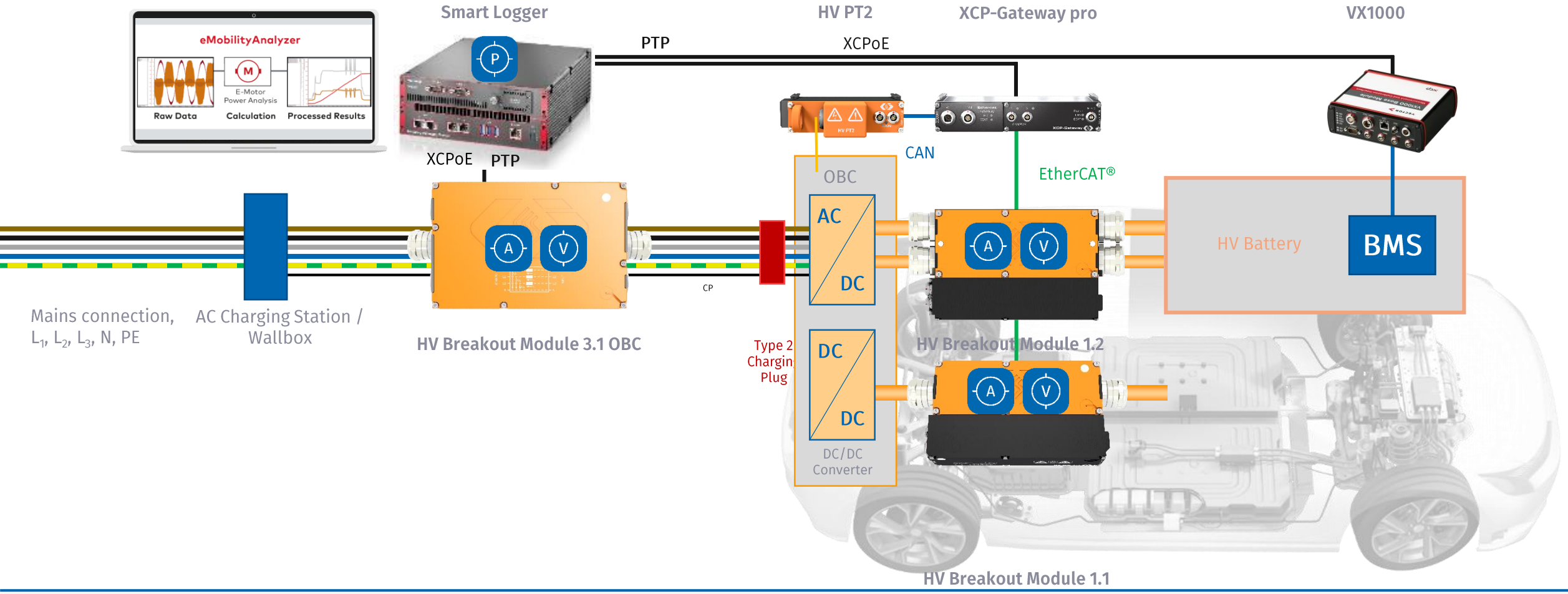


Efficiency measurement in an electric vehicle with HV Breakout Modules



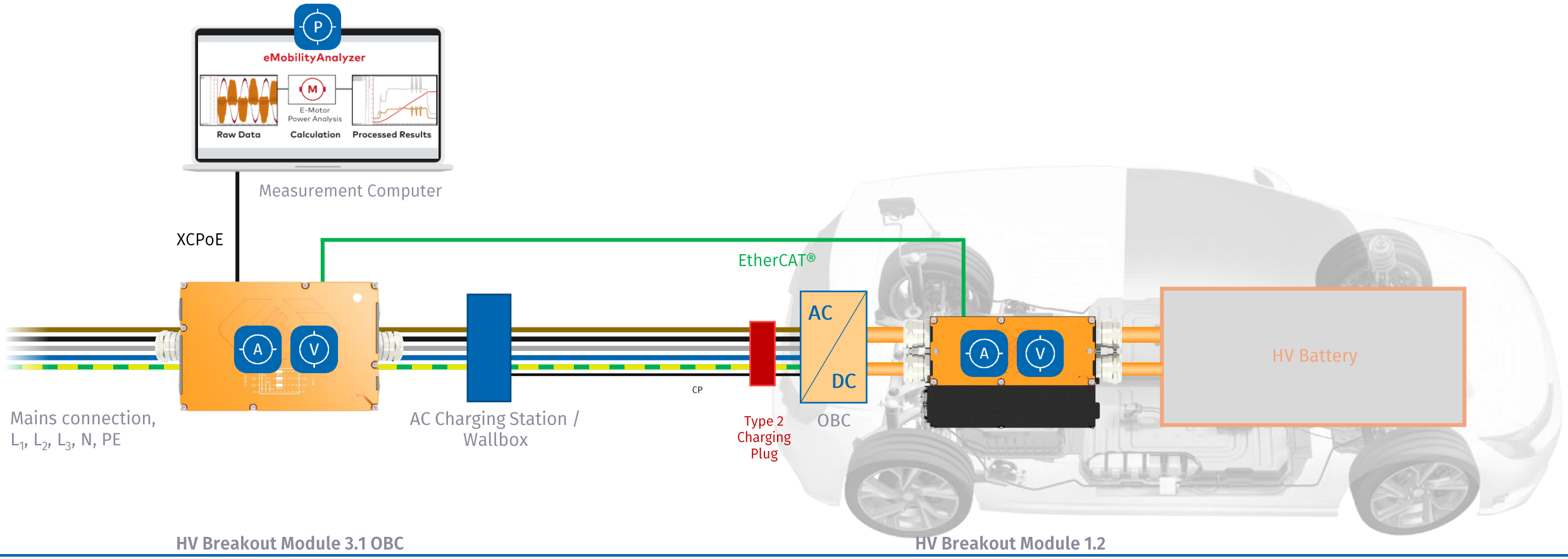
Testing integrated on-board charger

- 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

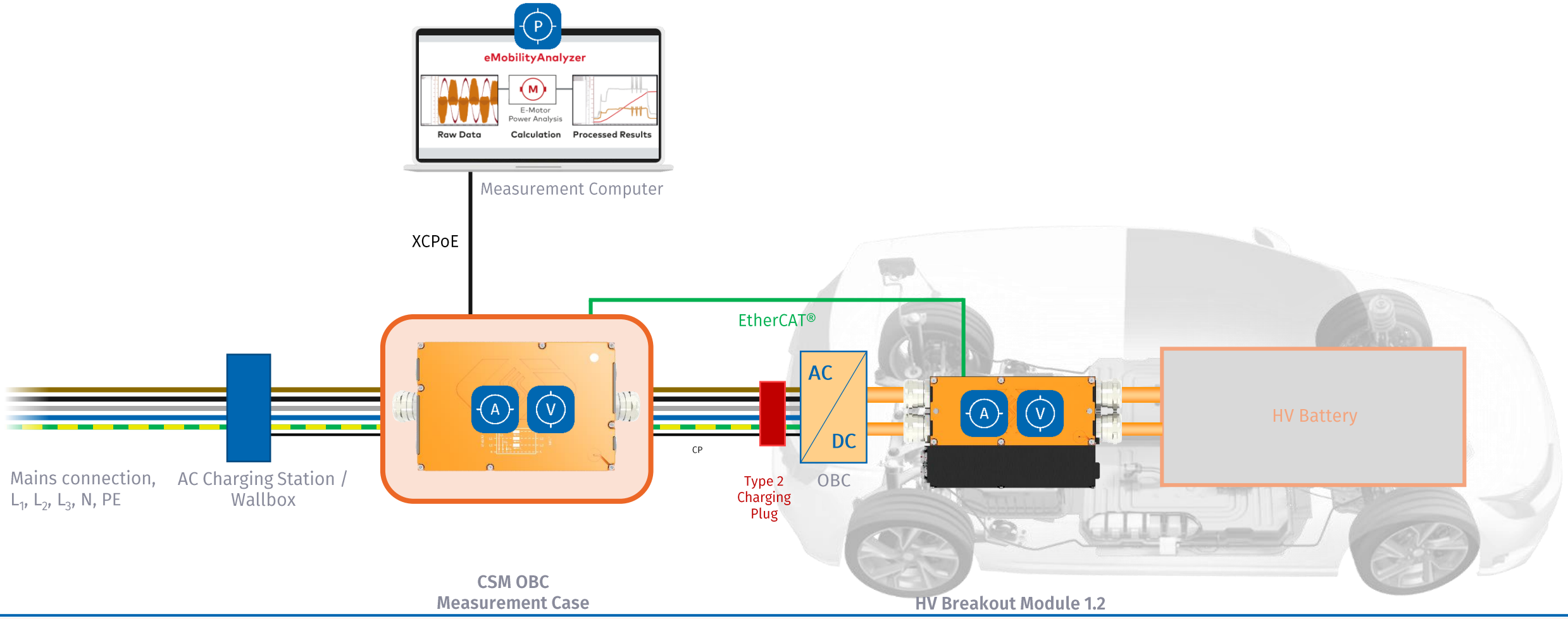
Country-specific power grid characteristics must be taken into account

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

Testing on-board charger and AC charging processes with a measurement case

Read the use case on www.csm.de



On-board charger interoperability testing - worldwide

- AC charging stations USA up to 80 A
- AC charging stations 3-phase, 11 kW, 22 kW
- On wall boxes
- On three-phase and split-phase AC power sockets
- At mains sockets 1-phase charging up to 16 A, 3.7 kW

Power grids worldwide

- Different voltages and frequencies

Different systems

- Three-phase system
- Single-phase three-wire system
- Single-phase system

CSM OBC measurement case

- Compact for carrying as flight luggage
- Complete solution measuring case with adapter cables for connecting to electric vehicle and charging station
- Various adapter cables with different plug types

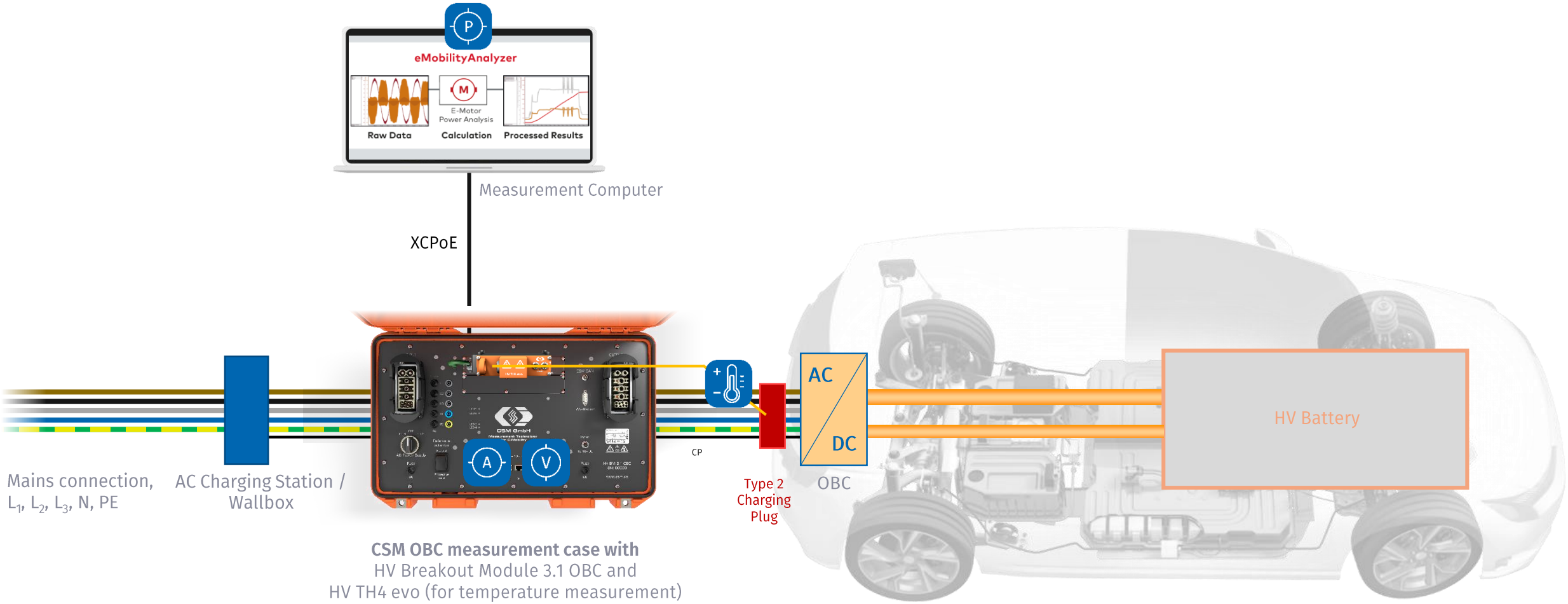
- Power supply for measuring case optionally or simultaneously via mains charging cable and from the vehicle battery

- Integrated HV BM 3.1 OBC Breakout Module
- Ethernet interface for connection to the measurement computer

CSM OBC measurement case

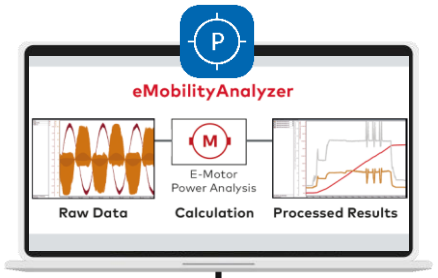
- Integrated GE switch for connecting the measurement computer and other Vector CSM measurement technology
  - Data logger
  - Vector interfaces
  - CSM XCP-Gateways from the vehicle
- Slots for further CSM measurement modules for additional measurements
- Measurement access mains side L_1, L_2, L_3, N, PE
- Reference potential switching for star voltage neutral conductor or PE conductor

Integrated HV TH4 evo measurement module for temperature measurement



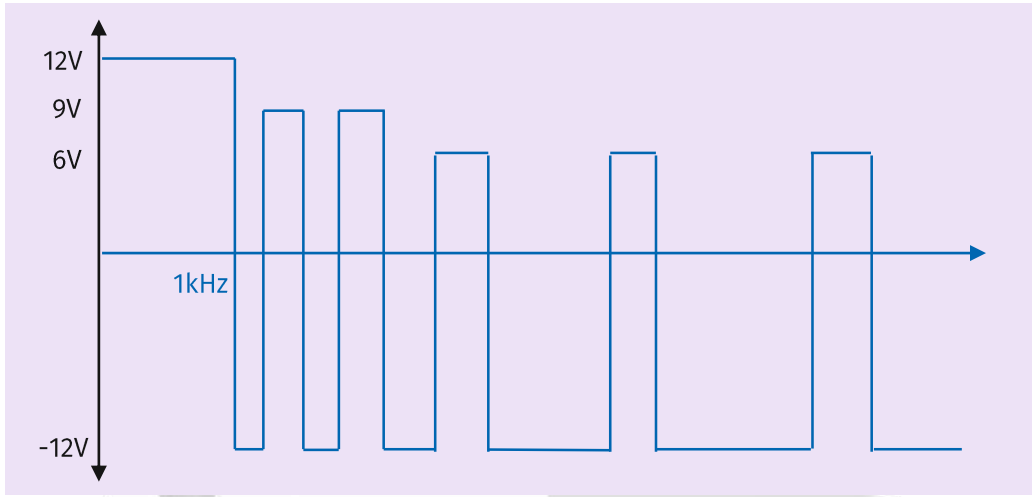
CSM OBC measurement case with
HV Breakout Module 3.1 OBC and
HV TH4 evo (for temperature measurement)

Integrated AD4 measurement module for measuring the communication signal at CP

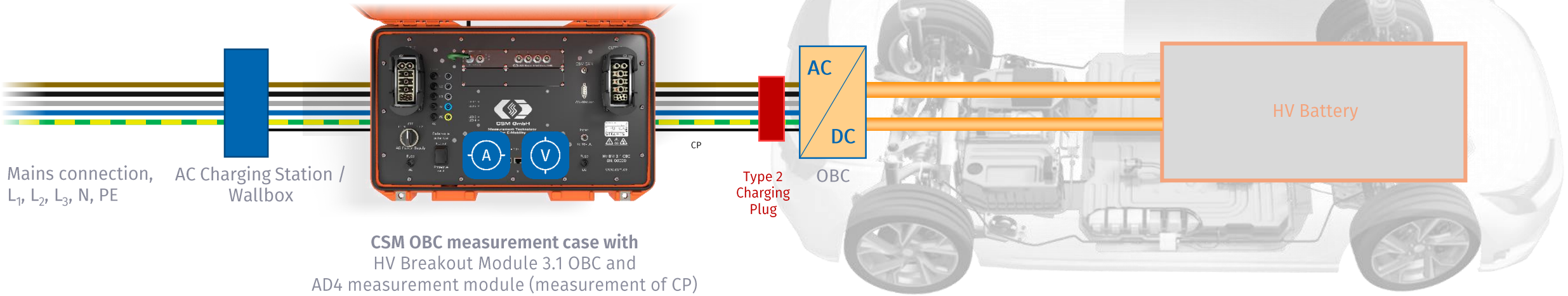


Measurement Computer

XCPoE



Control Signal (CP, Control Pilot)



Mains connection,
L_1, L_2, L_3, N, PE

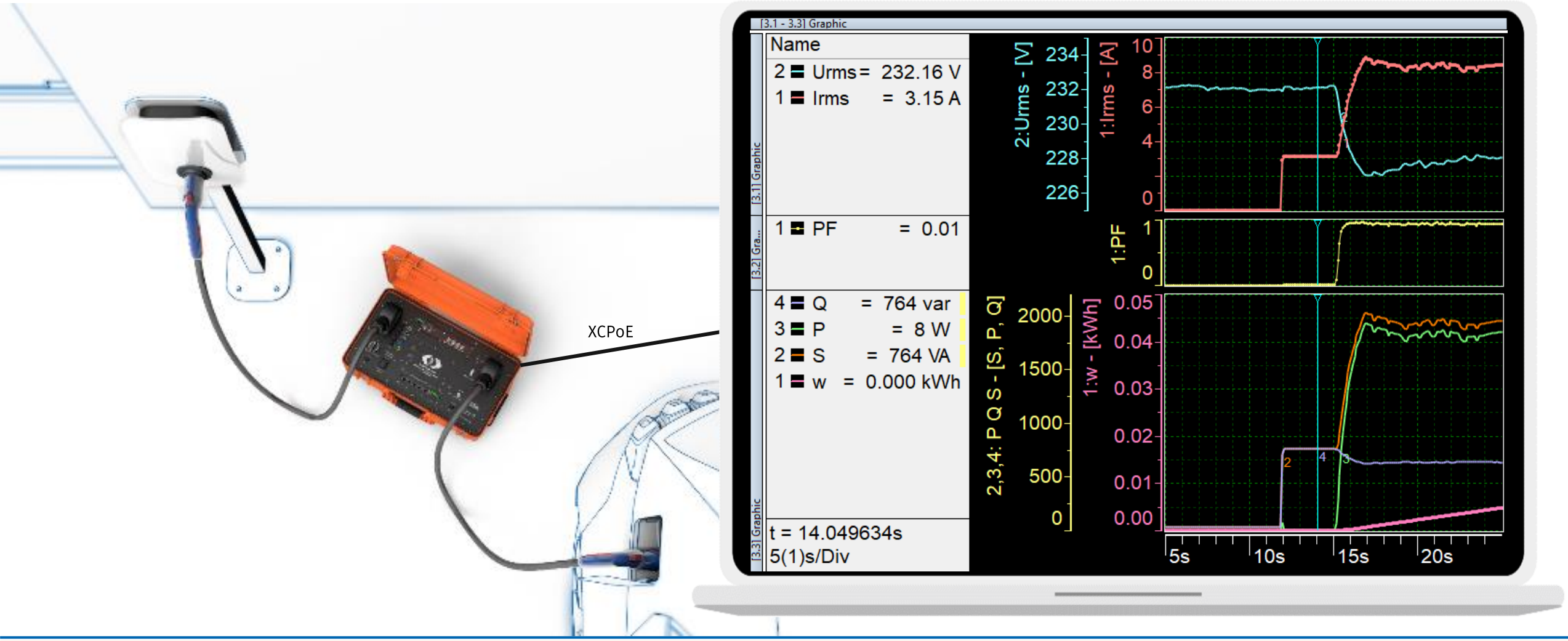
AC Charging Station /
Wallbox

Type 2
Charging
Plug

OBC

CSM OBC measurement case with
HV Breakout Module 3.1 OBC and
AD4 measurement module (measurement of CP)

Analyses with CANape and eMobility Analyzer



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

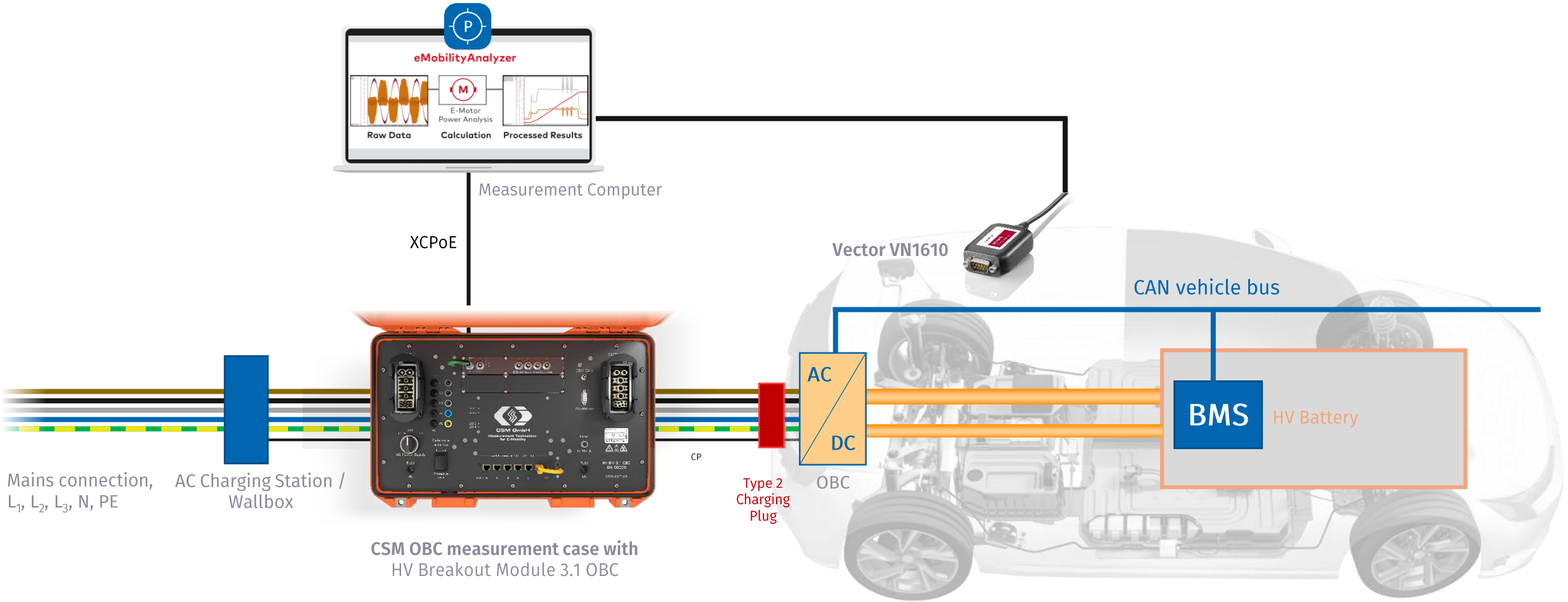
Frequency

- 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)

Additional measurement on the CAN vehicle bus



Measurement preparation OBC measurement case with electric vehicle

- The OBC measurement case is connected to the measurement computer via XCPoE
- The measurement case can also be powered by the vehicle battery
- The measurement computer is connected to the CAN vehicle bus

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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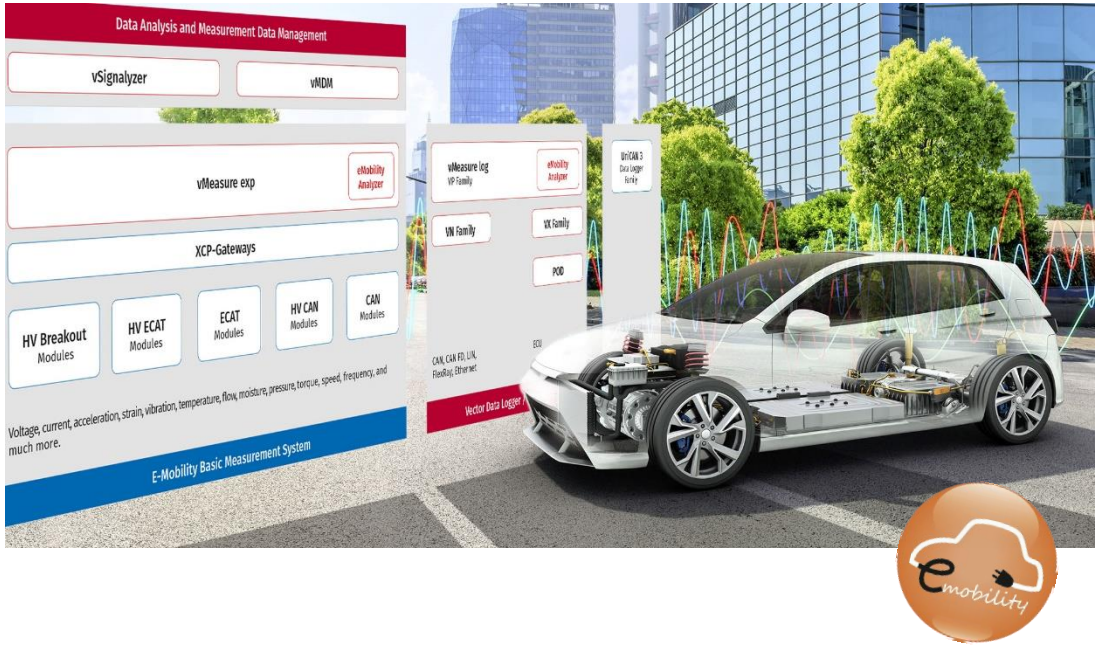

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