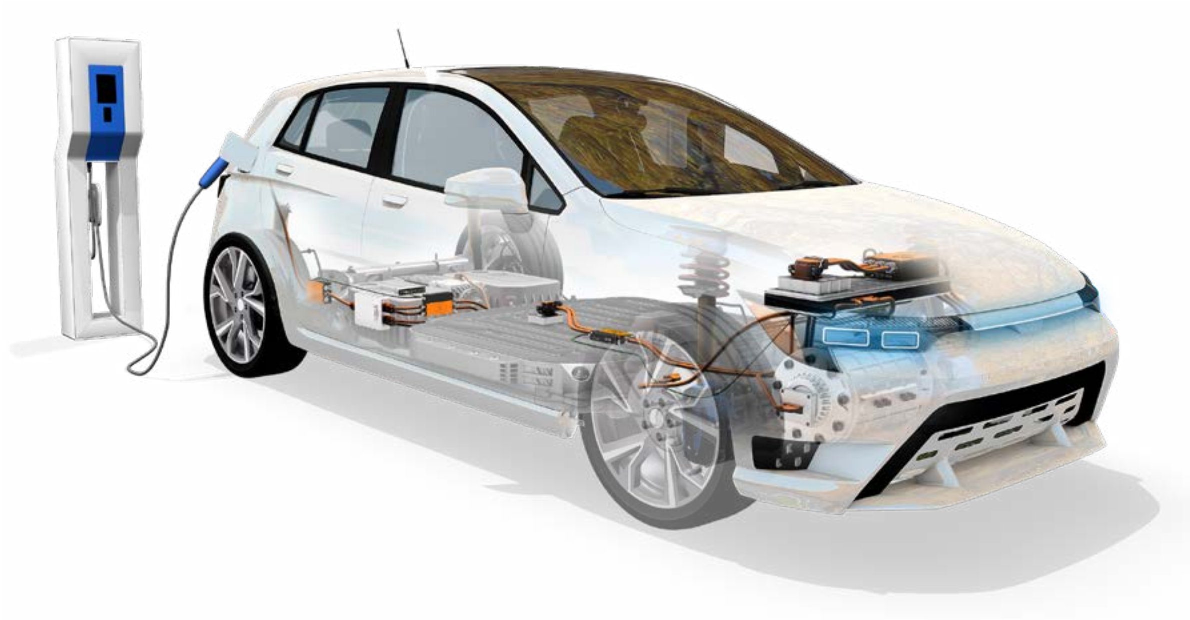
Testing the interoperability of on-board chargers and AC charging stations

HV Current and Voltage Measurement

AC charging stations are standard for everyday charging of EV batteries. In order for electric vehicles to remain attractive to end users, AC charging must work easily worldwide. An on-board charger (OBC), for converting the charging alternating current (AC) into direct current (DC), is therefore an indispensable vehicle component. Vehicle manufacturers validate newly developed OBCs with interoperability tests before series production. However, the charging stations are also a source of errors that must be checked, as they play a key role in the overall quality of the charging process. With the HV Breakout Module (HV BM) 3.1 OBC from CSM, these charging processes can be examined with regard to applicable standards and country-specific characteristics.



Testing worldwide

In order for newly developed vehicles to be sold internationally, corresponding AC charging tests must be carried out worldwide. While a three-phase system usually dominates the low-voltage distribution network in Europe, the split-phase network, a single-phase three-wire system, is established in the USA. Among other things, this results in a wide variety of plug systems, charging station and wallbox types as well as different software that needs to be tested. AC charging must also function at simple sockets and high-voltage sockets via an EVSE (Electric Vehicle Supply Equipment). As the grid quality varies greatly from country to country, the grid robustness of the on-board charger (OBC) must be proven during validation. Likewise, potential repercussions when charging the electric vehicle must be ruled out and compliance with applicable power quality standards must be confirmed, for example in bidirectional operation. Therefore, interoperability tests are complex due to the large number of parameters.

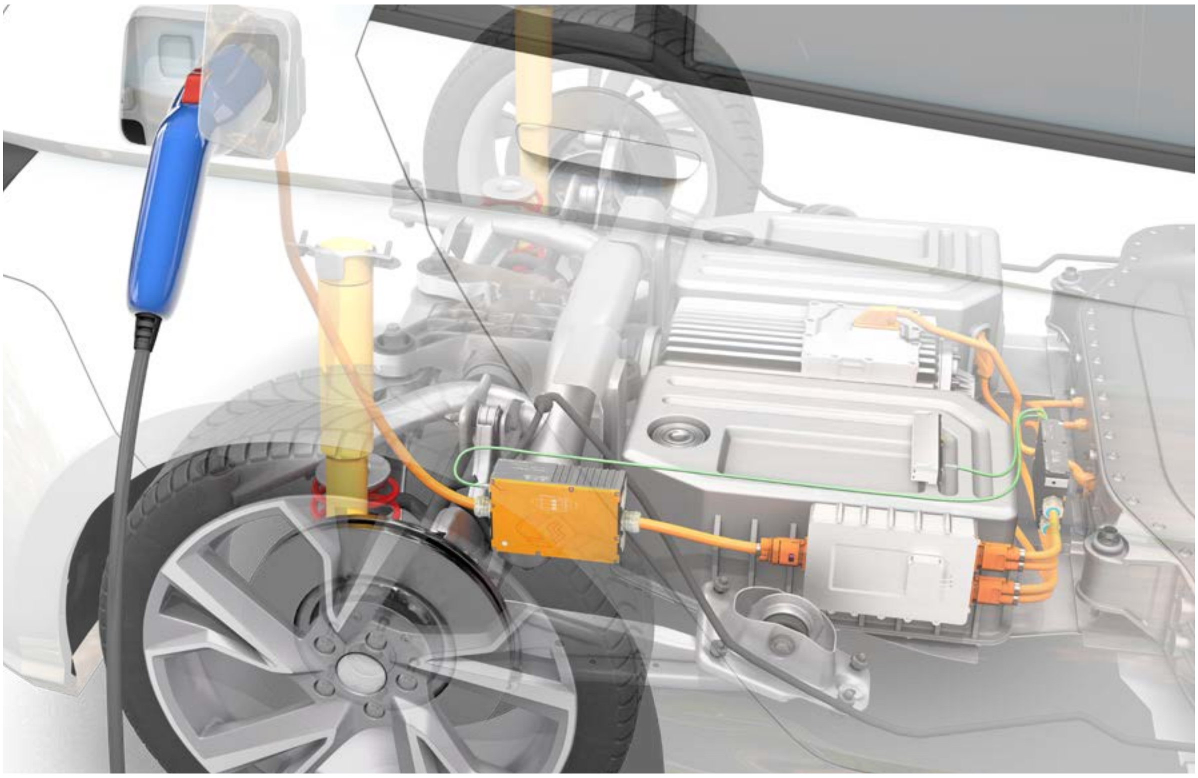


Fig. 1: HV Breakout-Modul 3.1 OBC installed in the vehicle.

Measurement of grid quality

With a measurement setup as shown in Figure 1, the necessary measurements can be carried out during the charging process. With the Vector software CANape or vMeasure and the included eMobilityAnalyzer function library, the necessary analyses and verifications can be carried out to examine the current and voltage curves of the phases with regard to amplitude, curve shape and limit values. For the grid quality, further criteria of the supply voltage must be checked regarding events, symmetry and frequency:

- Are there frequency changes and what is their rate?
- Are the voltages symmetrical?
- Are there abrupt voltage changes, voltage dips or interruptions?
- Do transient or mains frequency overvoltages occur?

At the current transfer point, it must also be checked whether the harmonics exceed limit values. The harmonics and harmonic content are examined using the Harmonics and Harmonic Power functions within the eMobilityAnalyzer. During the charging process, current flows from the grid into the vehicle and the harmonics must be suppressed. OBC also have an integrated power factor correction circuit (PFC) to deliver the power efficiently to the battery and not place an undue burden on the supply grid.

Vehicle communication during the charging process

To better verify the activities during charging, the processes in the vehicle can also be recorded. For this purpose, the data bus, e.g. a CAN bus of the vehicle, is connected to the measurement computer using an interface and is then analyzed. The additional recording of vehicle communication is particularly important if the following events occur:

- Network anomalies
- Unexpectedly poor power quality
- A charging process that does not start
- An interruption of the charging process
- Incorrect control of the charging power

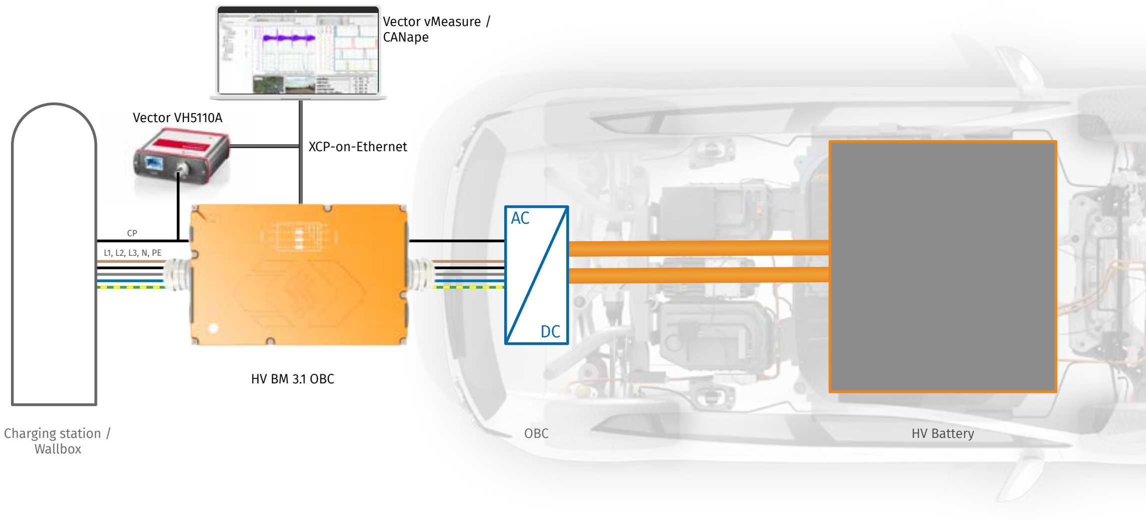


Fig. 2: Man-in-the-middle measurement setup. The HV Breakout Module 3.1 OBC is looped into the line between the AC charging station and the OBC in the vehicle. Communication between the charging station and the OBC is recorded with a Vector interface (VH5110A).

Acquisition of CP low-level communication

The charging cable contains an additional CP (Control Pilot) conductor, which is used to regulate the charging control between the charging station and the electric vehicle. Pulse width modulation (PWM) is used for low-level communication between the electric vehicle and the charging station. The signal voltages switch back and forth between two defined levels. The charging station specifies the maximum charging current for the vehicle via the duty cycle. This signal can be recorded simultaneously with a CSM AD4 measurement module. Alternatively, a Vector VH5110A "CCS Listener" can be installed in the measurement setup. This can be used to record the communication between a charging station (EVSE) and electric vehicle (EV) based on CCS and NACS standards.

Charging cycle power loss

In most cases, test vehicles for testing interoperability are equipped with built-in measurement technology. If, for example, an HV BM 1.2 is installed between the OBC and the HV battery in the vehicle, the energy supplied to the battery can be measured during the charging process. However, other parameters are also important for the interoperability tests: for example, the power loss of the charging cycle shows the efficiency of the OBC at the various charging points or how efficiently the PFC is working. Other measurement modules installed in the vehicle can be easily connected to the measurement technology outside the vehicle via EtherCAT® and are then synchronized to within 1 µs. The Vector eMobilityAnalyzer has a prepared ChargerEfficiency function for this measurement, which calculates the various efficiency parameters in real time:

- OBC input and output power
- OBC efficiency
- Total energy provided by the OBC for the HV battery
- Total efficiency
- Charging cycle power loss

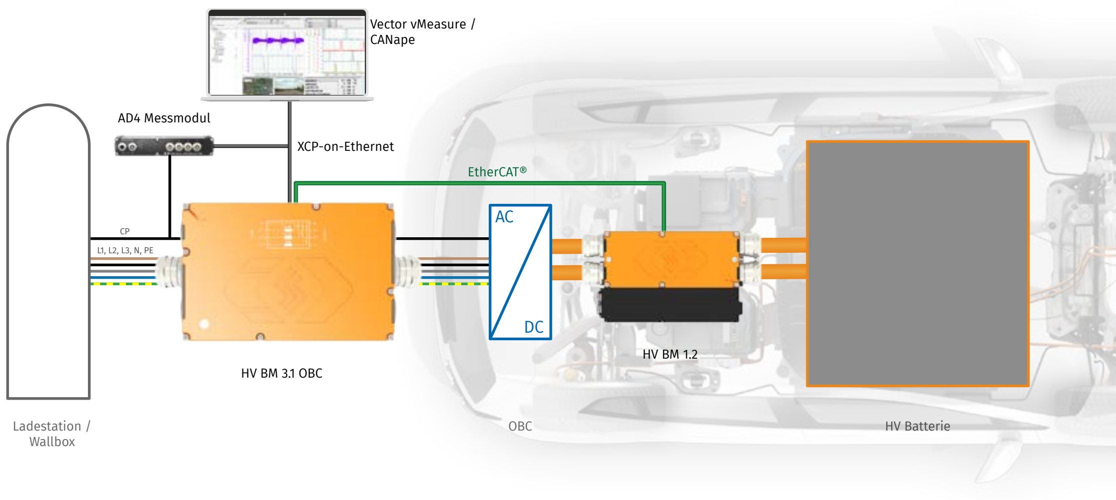


Fig. 3: MMeasurement setup with the CSM HV BM 3.1 OBC: The eMobilityAnalyzer integrated in CANape performs analyses on the measurement computer using the ChargerEfficency function. An AD4 measurement module is integrated into the measurement setup to monitor the low-level communication on the CP conductor.

Testing AC charging stations

Charging station operators and charging station manufacturers also perform various tests: Functional tests, acceptance tests, power quality measurements and interoperability tests with vehicles from different manufacturers. In particular, the grid access of the AC charging station must be verified. At this point, the sum of all feedback effects from AC charging stations operating in parallel and other consumers becomes apparent. Harmonic analysis and the evaluation of interharmonics and supraharmonics are important here. The mutual influence of electric vehicles during parallel, simultaneous charging processes, for example when several OBCs have approximately the same clock frequencies, should also be investigated. An HV BM 3.1 OBC can be used to verify the grid quality and input power of the AC charging pole. The following analyses are performed with the eMobilityAnalyzer in CANape:

- Fourier analysis
- Harmonic analysis
- Frequency analysis

One module - many possible applications

The HV BM 3.1 OBC can be used flexibly for high-voltage safe measurements at various points during AC charging, for example upstream of the charging station to check the grid connection quality or between the charging station and electric vehicle to verify the grid robustness and interoperability of an OBC. With the high sampling rate of up to 2 MHz, fast events such as switch-on and switch-off currents or transient voltage peaks, which lead to charging process interruptions and malfunctions, can be examined in detail.

Featured Products

HV Breakout Module - Type 3.1 OBC

The HV Breakout module (BM) type 3.1 OBC is designed for single- to three-phase measurements of voltage (U), current (I) and power of cables carrying mains voltage for worldwide use.

Designed to measure currents up to ±125 A or 88 A_{rms}, the HV BM 3.1 OBC allows worldwide analysis of AC charging of electric and hybrid vehicles.

HV Breakout Module – Type 1.2

CSM's HV Breakout Module (BM) Type 1.2 was designed for single-phase measurements of current, voltage and power. It is ideal for measurement on large consumers such as electric motors equipped with separate HV+ and HV- cables.

The HV Breakout Module 1.2 is available in two versions for connection via cable glands or PL500 plug-in system (HV BM 1.2C).

Complete solutions from a single source:

CSM provides you with comprehensive complete packages consisting of measurement modules, sensors, connecting cables and software - customized to your individual needs.

Further information on our products are available on our website at www.csm.de
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