Testing Charging Processes – Increasing Acceptance of Electric Vehicles

HV Current and Voltage Measurement

Being able to charge e-vehicles worldwide is an important goal in the development and improvement of components involved in charging processes. National differences in power grids as well as individual characteristics of the charging devices are the main challenges. During the prototype development of a new e-car with a modified on-board charger (OBC), international charging processes and their repercussions on the power grids had to be investigated in detail using measurement technology. In particular, the HV Breakout Module (HV BM) 3.1 OBC was used for this purpose.

Expand available charging opportunities

The attractiveness of electromobility is influenced by how many different charging options can be used. The idea is to reduce the time and distance end users have to travel to find a suitable charging point. Vehicle manufacturers are therefore working to improve the compatibility of

their on-board chargers (OBCs) with the various AC charging options for the regions where they intend to sell their vehicles. Particular attention is being paid to charging the vehicle battery at the various wallboxes or AC charging stations around the world on the one hand, and at conventional (power) outlets in individual countries on the other. The current must first be converted by the OBC, which functions like a power converter, from alternating current (AC) into the direct current (DC) suitable for the HV battery. For problem-free charging with a newly developed OBC, it is crucial how it copes with the different charging points and network standards. This component is therefore important for improving charging quality. It is equally relevant that the charging processes function safely and flawlessly everywhere, regardless of local or national conditions. Also, possible repercussions on the power grid must remain within certain limits. The limits for these repercussions (which include harmonic voltages) are defined in standards, the limits of which may differ from country to country. When a new vehicle is launched on the market, these standards must be met.

»In order to make statements about the correct operation of AC charging, it is necessary to measure the current, voltage and power between the charging station and the OBC.«

Johann Mathä, Manager E-Mobility, CSM GmbH

What is an On-Board-Charger (OBC)?

The on-board charger, also known as "OBC" for short, is an important power component in electric vehicles. It enables charging with alternating current (AC). This includes, for example, AC charging stations, the "wallbox" at home or the household socket, instead of only being able to connect the vehicle to special fast charging stations with direct current (DC). Technically, the OBC is a power converter that converts alternating current to direct current. In electric vehicles, the HV battery requires direct current for charging. Installing an on-board charger therefore ensures that every available charging situation can potentially be exploited – an important argument when it comes to existing charging infrastructure and thus also to the acceptance of e-mobility in general.

Different conditions – comparable measurements?

How must the OBC be designed so that e-vehicles can be in use worldwide? To be able to answer this question, the charging situations nationally and internationally must be examined and studied in more detail. There are decisive differences that also play a role in the metrological recording of the charging processes. These are variances in voltages and frequencies, differences in the phase systems of the countries, different power cables and plug variants and, of course, the stability of the distribution networks in general. As an example, let's compare the power supply in private households: In Europe, redundant mesh networks with three-phase alternating current (240 V / 50 Hz) are common, while in the USA, single-phase three-wire power networks (120 / 60 Hz) dominate, which are more susceptible to strong voltage fluctuations.

»Not only many measurement situations in a short time are a challenge, but also that the tests are carried out in high quality with the same measurement technology. Only in this way is comparability of the results possible.«

Johann Mathä, Manager E-Mobility, CSM GmbH

Fig. 1: HV Breakout Module 3.1 OBC for worldwide, one- to three-phase measurement of AC charging.

Measurement technology in global use

Three prototype vehicles were tested during the measurements – one vehicle was used in North America, one in Asia and a third in Europe. The voltages and currents from the charging stations were measured with an HV BM 3.1 OBC. With the star connection already integrated, single-phase as well as two- and three-phase measurements were possible without any problems.

»The very fast measurement with the HV BM 3.1 OBC at a data rate via Ethernet of up to 2 MHz offers a high resolution - so, for example, even very short events, such as voltage peaks during switch-on and switch-off or interruptions in the power supply, can be examined in particular detail.«

Jürgen Braunstein, Head of Development, CSM GmbH

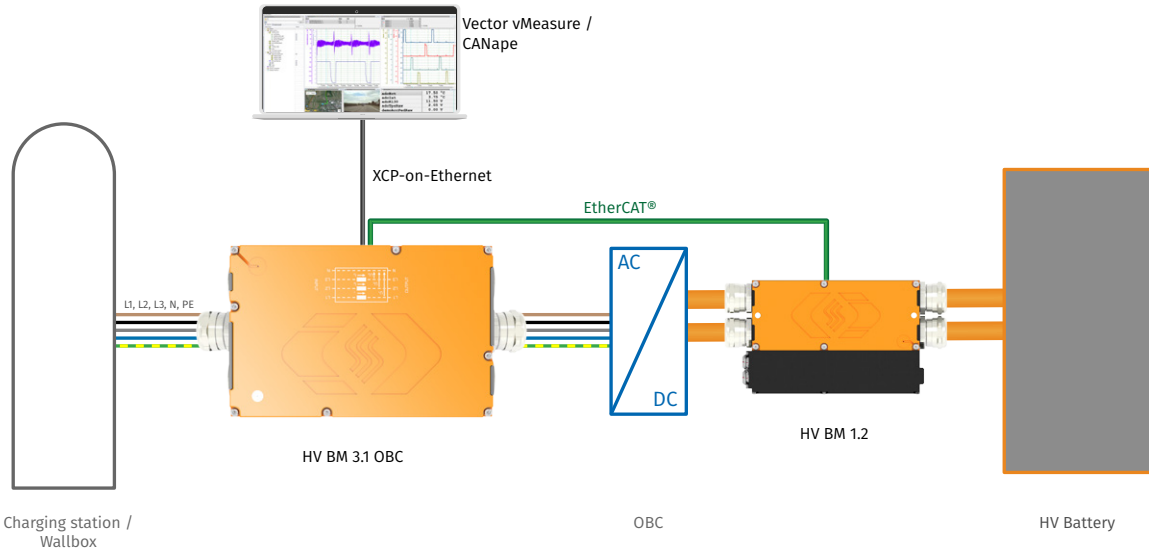

Fig. 2: Schematic measurement setup for current, voltage and power measurement between AC charging station and OBC in the vehicle.

Instrumentation also in the vehicle

Measurement modules were also installed in the electric cars. An HV BM 1.2 was installed between the OBC and the HV battery to measure the current and voltage for the power calculation. With these measurements, it was possible to analyze, among other things, the power dissipation of the respective charging cycle. To view the ECU data in parallel, the vehicle bus was also integrated into the measurement via a Vector interface. Data was forwarded directly to a laptop using the XCP-on-Ethernet protocol with synchronization using the Precision Time Protocol (PTP - IEEE1588).

Practical measurement case application

For uncomplicated handling of the mobile measurement technology outside the vehicles, the HV BM 3.1 OBC was installed by the user in a suitable measurement case, which also included various adapter cables for different AC plugs and AC charging cables. This meant that the test vehicles only had to be equipped with measurement technology once and could then simply be connected to the various charging points. In addition, the compact dimensions of the measuring case meant that it could also be taken along as airline luggage and was immediately ready for use on site. Power was supplied to the measurement case via the low-voltage vehicle battery or via the mains side. The use of an application-specific measurement technology solution with suitable adapter cables eliminated the need for error-prone and time-consuming installation by on-site personnel.

Fig. 3: The user-assembled, application-specific measurement case is simply connected between the charging station and the vehicle using suitable adapter cables.

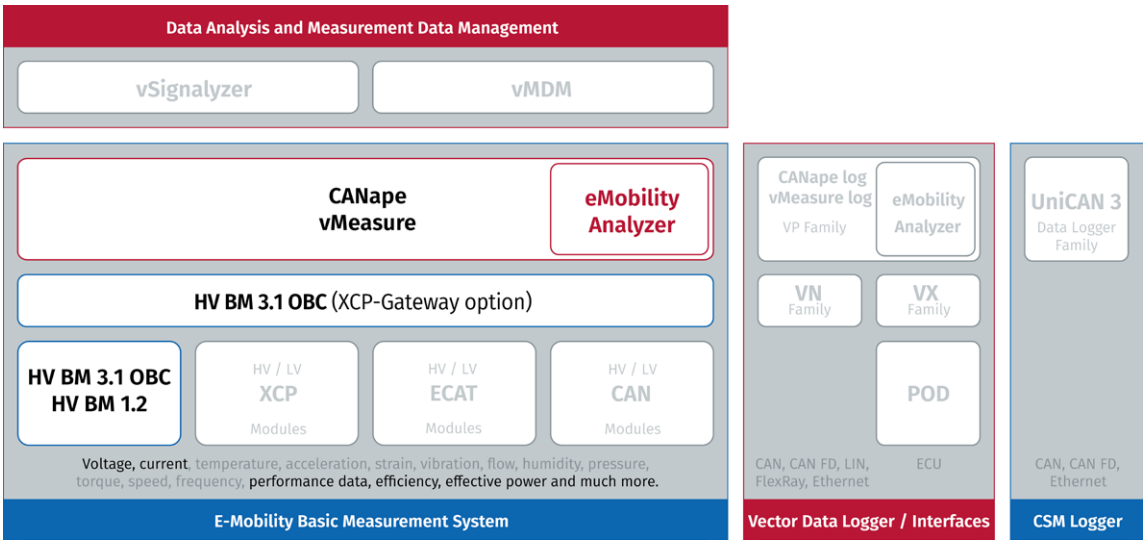

Fig. 4: The analysis of charging processes in the systematics of the Vector CSM E-Mobility Measurement System.

Complete solution from a single source

With the HV BM 3.1 OBC with integrated star connection, various single- to three-phase AC charging processes can be investigated metrologically. The three-phase measurement with only one measurement module offers considerable cost and space advantages compared to other technologies. The robust and compact measurement case solution based on the HV BM 3.1 OBC allows the user to carry out many measurements in a short time, because the associated adapter cables enable the measurement equipment to be connected quickly. In addition, the high measurement data rate ensures that even fast events such as short voltage failures can be recorded.

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 or via e-mail sales@csm.de.

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