

Vector CSM E-Mobility Measurement System

The Measurement System for Developing Electric Mobility



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New developments in E-mobility require improved test and analysis procedures for the optimization of systems and their components: In order to make vehicles “smarter“, data from embedded control units must be synchronized with measured physical variables. This should be done on both the test benches and in road tests, while ensuring safety when measuring inside high-voltage components. This requires a scalable measurement system that can be flexibly adapted to the measurement tasks and provides important analysis results in real time.

The core of the Vector CSM E-Mobility Measurement System consists of an E-Mobility Basic Measurement System. This includes measurement modules, interfaces and software solutions for performing most measurement tasks. The measurement modules can be used to acquire a wide variety of signal types and sampling rates in a HV-safe manner - as required by the application.

Depending on the application, this system can be extended by additional expansions to flexibly meet the requirements of the measurement task.

The compact and robust design of the measurement modules, interfaces and loggers makes the system ideal for both mobile use in vehicles and on test benches. By using the same measurement system throughout the development process, it is easier to compare measurement results and analyses and continuously evaluate different development steps, without uncertainty of variation resulting from disparate measurement tools.

Highlights

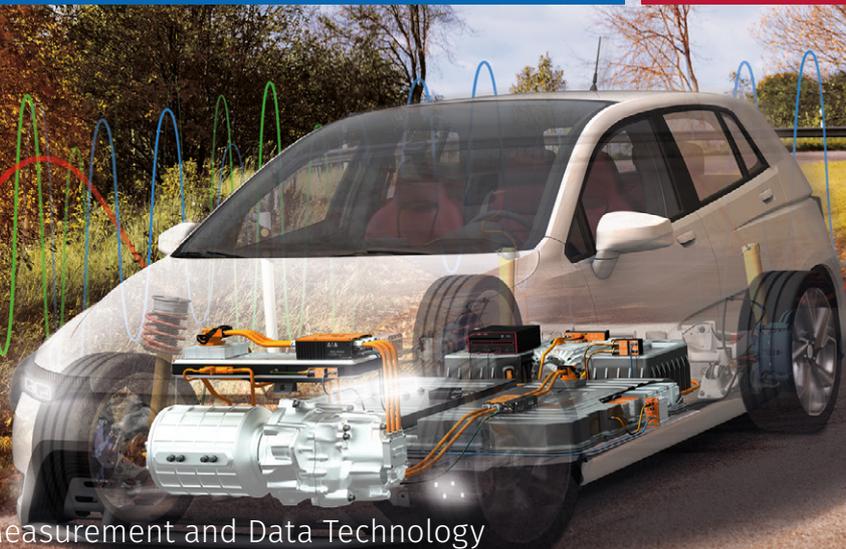
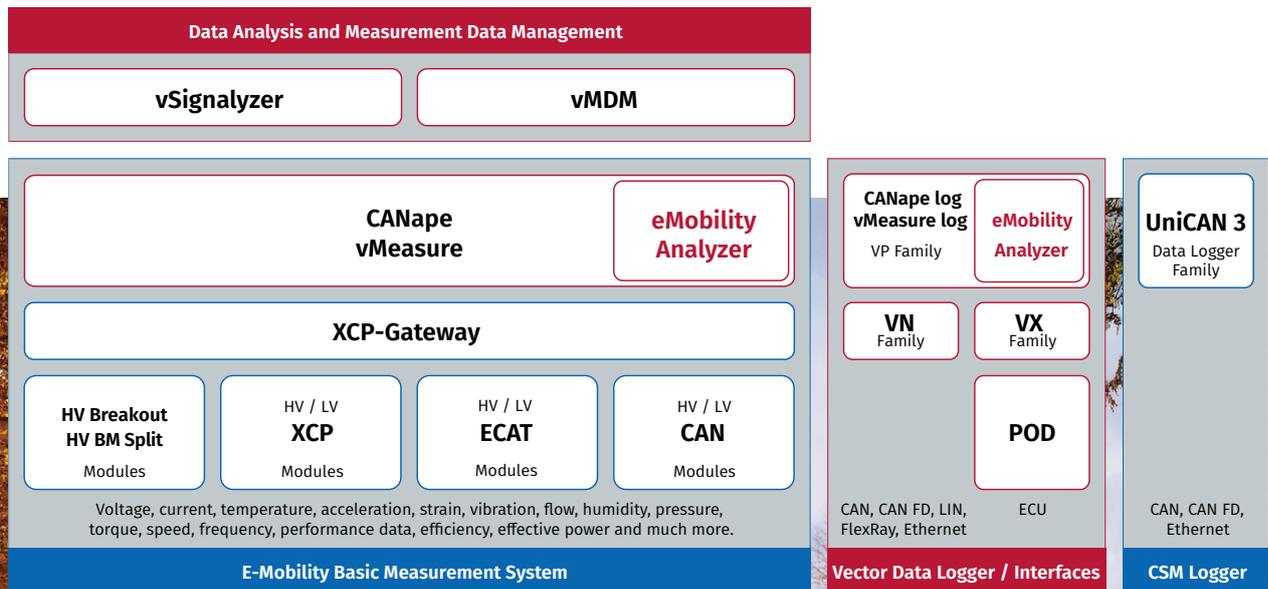
- ▶ Distributed, scalable measurement system for vehicles and test benches with high-performance e-mobility online analysis
- ▶ Extremely compact, robust and interference-free measurement modules for high- and low-voltage environments
- ▶ Synchronous acquisition of measurement data from measurement modules, vehicle buses and ECUs
- ▶ Direct and synchronized measurement of both current and voltage in HV power cables with sampling rates up to 4 MHz per measurement variable
- ▶ Multi-channel real-time performance analysis
- ▶ Raw data recording, powerful signal analysis and evaluation including data mining



The entire Vector CSM E-Mobility Measurement System extends the Basic Measurement System and is a modular toolbox of perfectly harmonized hardware and software for the development of electric and hybrid vehicles.

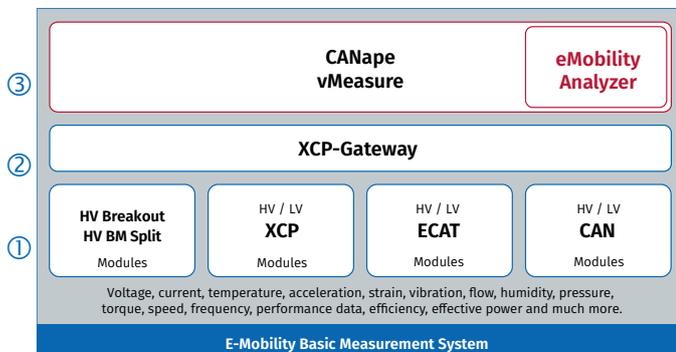
It consists of:

- ▶ High-performance measurement modules, interfaces and software for data acquisition and synchronization of large amounts of data
 - ▶ Analog measurement data (current, voltage, temperature, etc.) from HV and LV environments
 - ▶ Measurement data from vehicles buses
 - ▶ Data from control units
- ▶ The eMobilityAnalyzer function library for powerful, real-time analysis
- ▶ Smart data logger for the acquisition of measurement data and vehicle buses
- ▶ Software for data analysis and data management
- ▶ Data transfer to server and cloud



The Components

The E-Mobility Basic Measurement System



The core of the E-Mobility Measurement System is the E-Mobility Basic Measurement System. Measurements of physical variables such as voltage, current, temperatures, pressures, etc. can be obtained from both low and high voltage environments. The measured values can be analyzed in real-time with the eMobilityAnalyzer function library.

With the components of the E-Mobility Basic Measurement System, measurement setups can be individually configured from a few sensors up to hundreds of measurement points. The common XCP-on-Ethernet, EtherCAT® and CAN protocols allow simple networking. Synchronization with Vector Interfaces is ensured via Precision-Time-Protocol (PTP) per the IEEE 1588 standard.

In addition, the measurement system was optimized for processing very large amounts of data. The precisely harmonized software and hardware allows for easy and time saving configuration.

eMobilityAnalyzer

- ▶ DC and AC power analysis
- ▶ Power analysis electric motor
- ▶ Mechanical axle power
- ▶ Efficiency measurement
- ▶ Charger efficiency analysis
- ▶ Analysis of current and voltage ripple
- ▶ PWM power analysis
- ▶ Harmonic analysis

① CSM Measurement Modules and HV Breakout Modules

- ▶ Measurement of current, voltage, temperature, torque, acceleration, strain, vibration, flow, moisture, pressure, speed, frequency and much more
- ▶ Connected via XCP-on-Ethernet (up to 4 MHz per channel), EtherCAT® (up to 1 MHz per channel) and/or CAN
- ▶ Application-specific configuration, depending on the measured variables, required sampling rate and application area (with standard sensors located inside high-voltage and/or low-voltage environments)

② XCP-Gateway

- ▶ Networking of measurement modules and other hardware via
 - ▶ CSM XCP-Gateways (separate interfaces)
 - ▶ supporting measurement modules (with optional firmware licenses)
- ▶ Synchronization of all acquired measurement data via XCP-on-Ethernet and EtherCAT® better than 1 µs
- ▶ Acquisition of CAN bus measurement data
- ▶ PTP time synchronization (IEEE 1588)

③ CANape / vMeasure

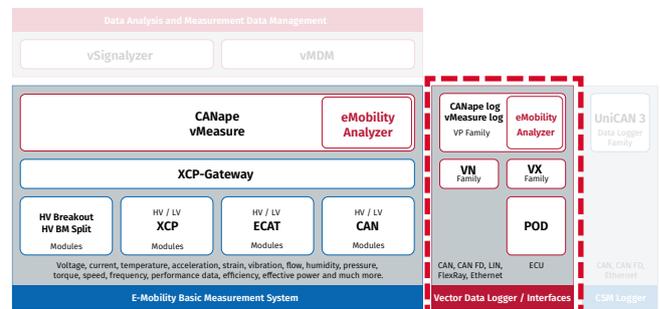
- ▶ Software for data acquisition and visualization
- ▶ eMobilityAnalyzer function library (included) with extensive analysis functions
- ▶ Additional analysis functions are continuously developed and supplemented in the functional scope on a customer-specific basis
- ▶ Integrated CSMconfig software for direct configuration of the CSM measurement modules

Vector Data Logger / Interfaces

The Basic Measurement System can be easily extended with additional Vector tools. Additional Vector interfaces allow the recording of further important measurement data. The entire measurement configuration can be transferred to Smart Loggers of the Vector VP family with the touch of a button.

The **Vector VN and VX family of network interfaces** are used to acquire measurement data from vehicle buses and from ECUs. Thanks to PTP time synchronization, this measurement data is synchronized with the analog measurement values acquired via CSM measurement modules.

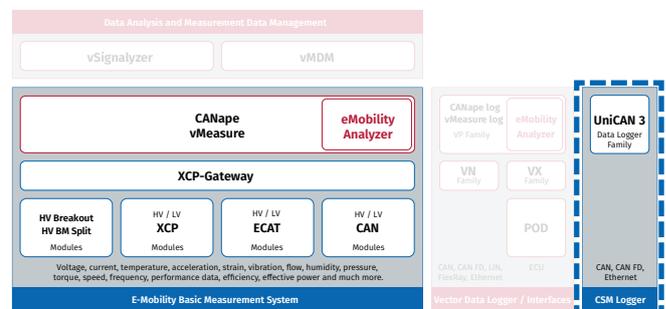
The Smart Loggers of the **VP family** are ideal for use in vehicles and for high-performance, demanding measurement tasks. They can be used, for example, to record up to 40 measured variables at 1 MHz each and perform the eMobilityAnalyzer functions in real-time.



The **CANape log and vMeasure log** software solutions offer the full range of functions, including the eMobilityAnalyzer function library. The acquired data can be simultaneously recorded and analyzed in real-time. In addition, the values calculated in real-time can be used as triggers.

CSM UniCAN 3 Data Logger

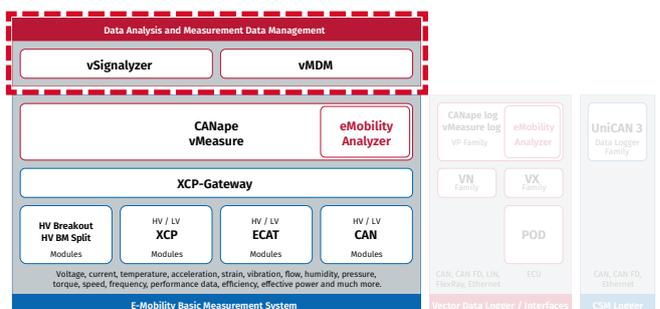
The data loggers of the **UniCAN 3 family** are another alternative for recording measurement data: In addition to the physical measurement data of the measurement modules from the basic measurement system, they can also be used to record data from vehicle buses. The robust and extremely compact design and various connection options (such as WLAN or via LTE modem) make the UniCAN 3 data loggers particularly suitable for testing done with fleets of vehicles.



Data Analysis and Measurement Data Management

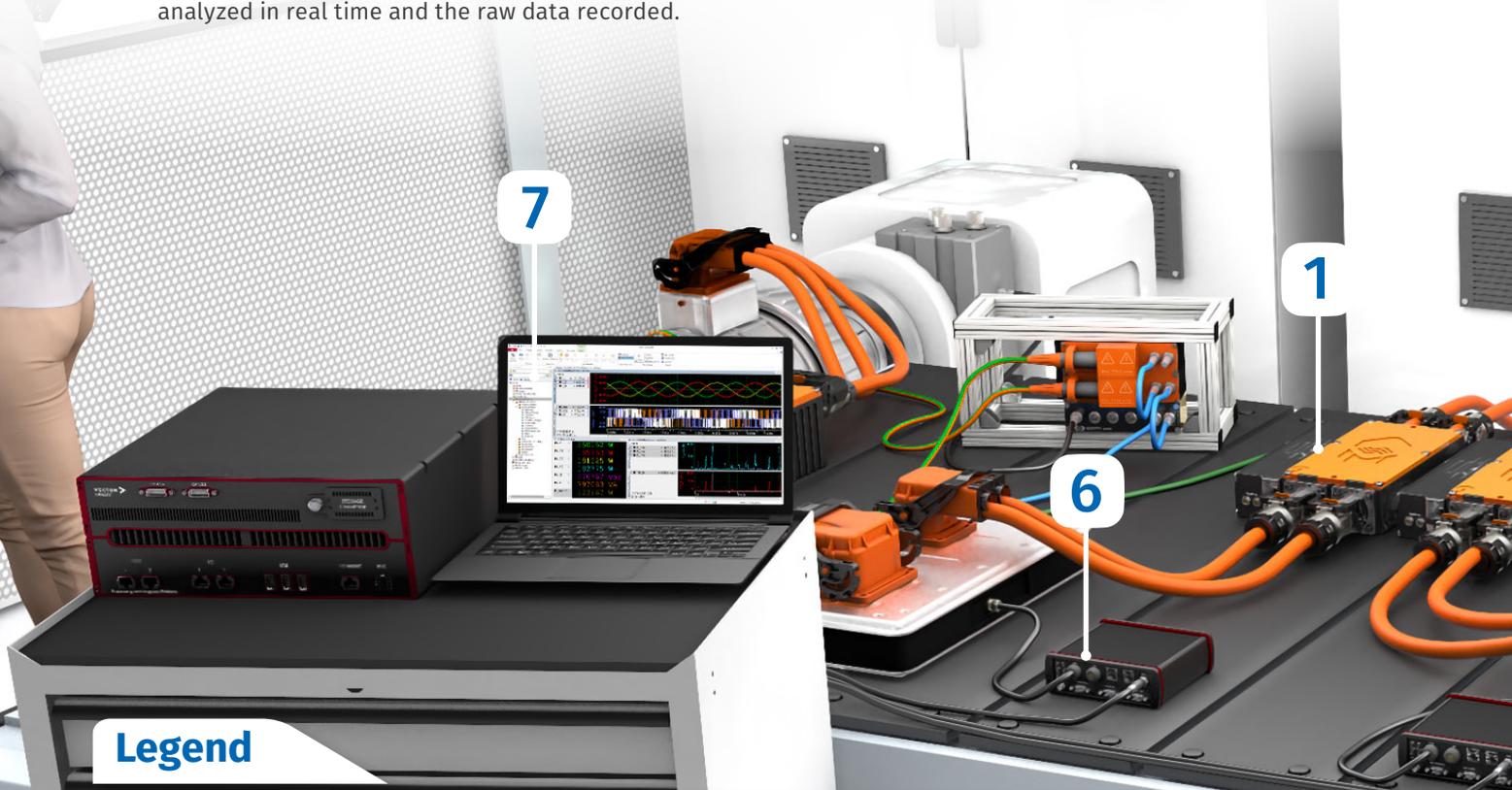
With the Vector software **vSignalizer** (included in CANape), the acquired data can be analyzed in detail, further evaluated using data mining and automatically generate test reports and other documentation.

Data management and data analysis can also be performed in the cloud with Vector's **vMDM** solution. The functions of the eMobilityAnalyzer are available in both software packages.



Power Analysis on the Electric Powertrain I

High-performance electric vehicles run with two, three or even four electric motors in the powertrain. Optimizing the motor control is complex and requires precise performance analysis in order to test the desired driving characteristics. In the early development phase, the interaction of the individual inverters and electric motors is therefore tested on powertrain test benches. All power flows between the components must be analyzed in real time and the raw data recorded.



Legend

1. HV Breakout Module 1.2C

Measures current and voltage between battery simulator and inverter. The "C" variant offer PowerLok connectors for easy change-overs in test bench applications.

2. HV TH4 evo

HV-safe temperature measurement modules are used to measure the temperatures inside the high-voltage environments of the inverters and electric motors.

3. CNT4 evo

A digital counter module acquires speed and torque data for calculation of mechanical output power.

4. HV Breakout Module 3.3C

Current and voltage are measured of the 3-phase system between the inverter and electric motor. With the XCP-Gateway option, the HV BM 3.3C simultaneously acts as an interface for all connected measurement modules and converts the EtherCAT® and CAN data to XCP-on-Ethernet.

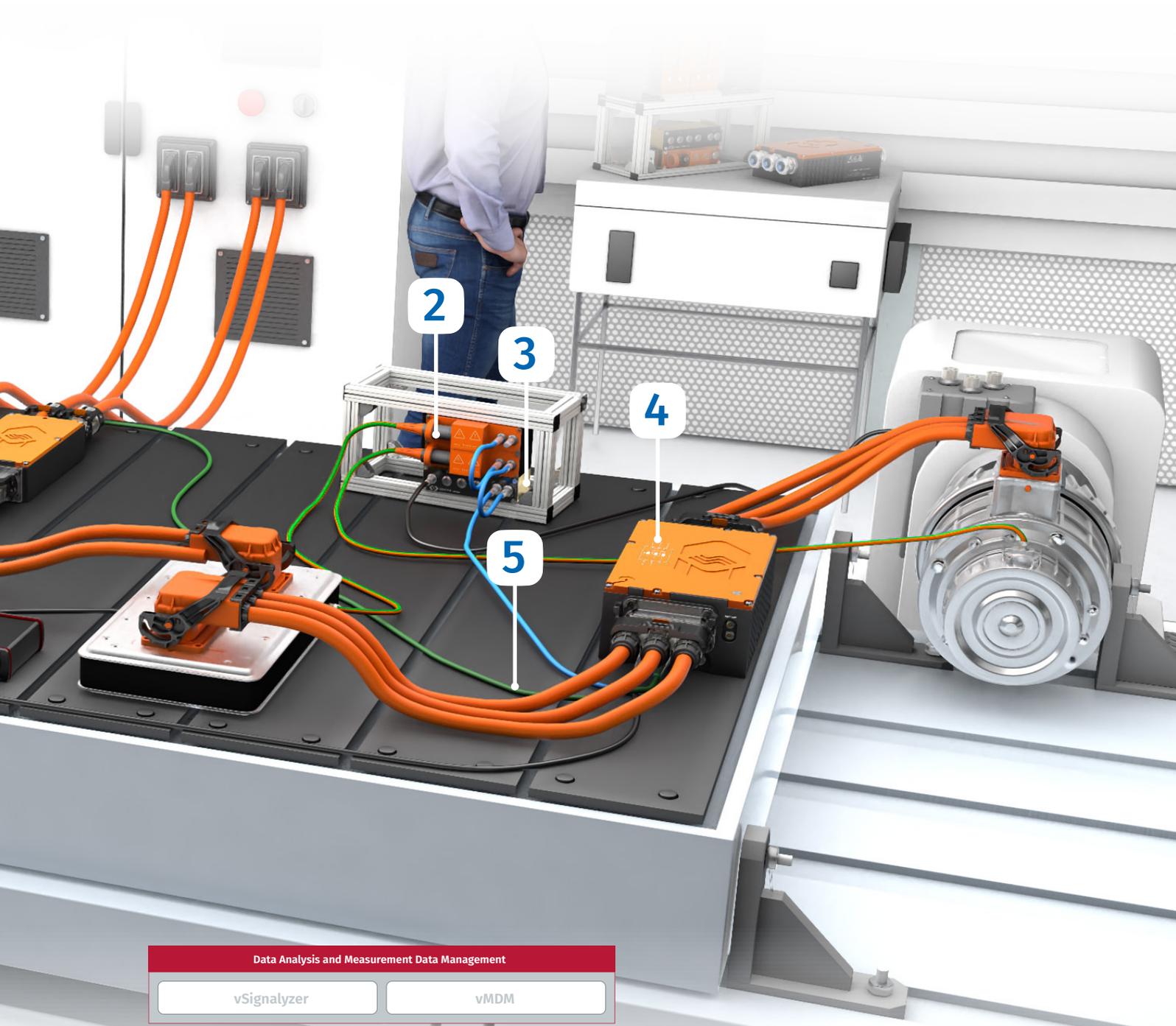
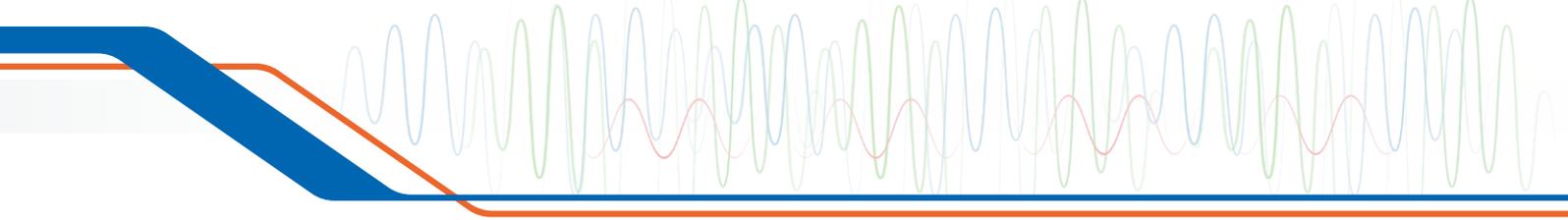
5. All measurement modules are connected via EtherCAT® (HV BM 1.2 C) and CAN (HV TH4 evo and CNT4 evo).

6. Vector Interface VX1000

The Vector interface synchronously acquires data from the inverter control units.

7. vMeasure with eMobilityAnalyzer function library

Based on the electrical input power (P_{el}) and mechanical output power (P_{mech}), various power values can be calculated in real time.



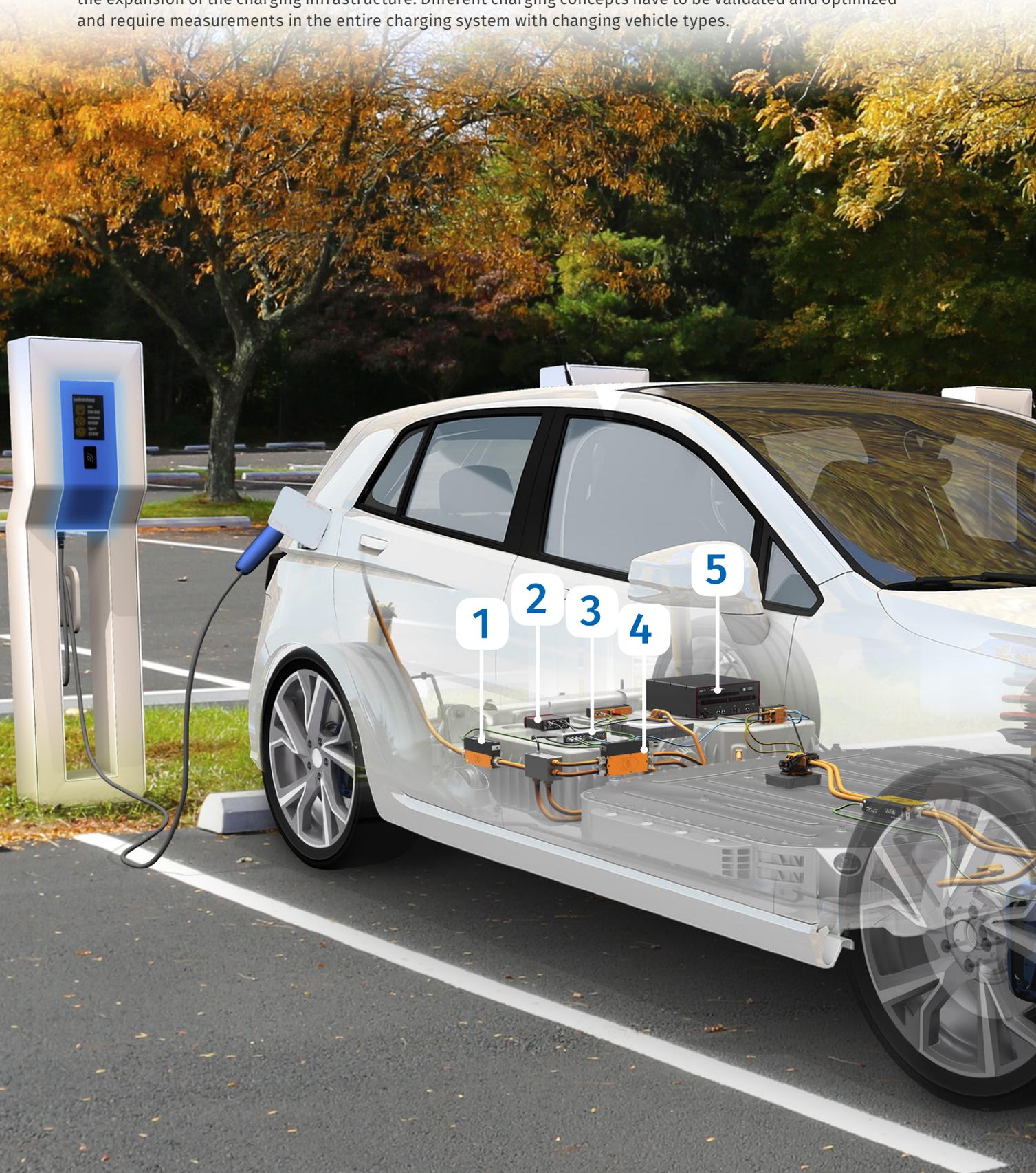
Data Analysis and Measurement Data Management	
vSignalizer	vMDM
CANape vMeasure	
eMobility Analyzer	
HV BM 3.3 C (XCP-Gateway option)	
HV BM 1.2C HV BM 3.3C	HV / LV XCP Modules
HV / LV ECAT Modules	HV TH4 evo CNT4 evo
<small>Voltage, current, temperature, acceleration, strain, vibration, flow, humidity, pressure, torque, speed, frequency, performance data, efficiency, effective power and much more.</small>	
E-Mobility Basic Measurement System	

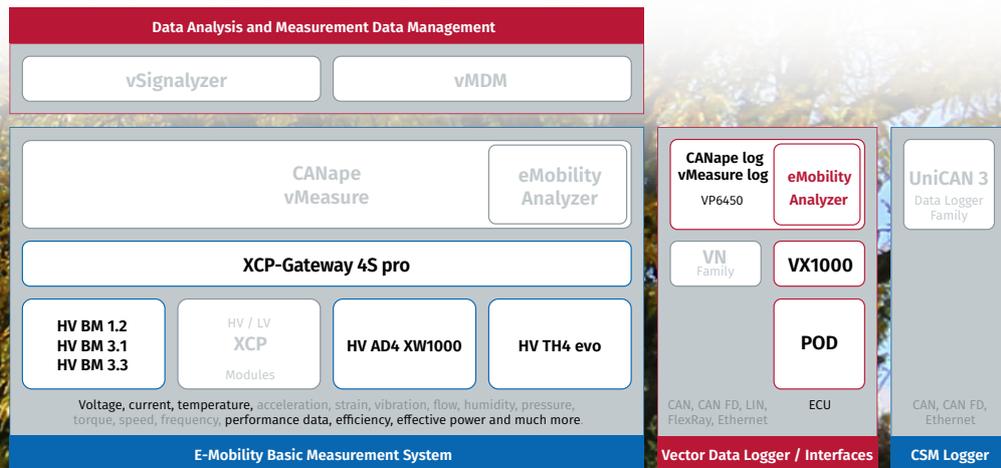
CANape log vMeasure log VP Family	eMobility Analyzer
VN Family	VX1000
CAN, CAN FD, LIN, FlexRay, Ethernet	POD ECU
Vector Data Logger / Interfaces	

UniCAN 3 Data Logger Family
CAN, CAN FD, Ethernet
CSM Logger

Analysis of the Charging Characteristics

Different charging systems are being developed for different needs and regional requirements in order to drive the expansion of the charging infrastructure. Different charging concepts have to be validated and optimized and require measurements in the entire charging system with changing vehicle types.





Legend

1. HV Breakout Module 3.1

Measures three-phase current and voltage between charging pole and on-board charger (OBC).

2. Vector Interface VX1000

Records the ECU data of the OBC.

3. XCP-Gateway 4S pro

Acquires the data from the CAN- and EtherCAT®-based measurement modules and converts them to XCP-on-Ethernet. In addition, all ECAT measurement modules are synchronized via the Precision Time Protocol (PTP - IEEE 1588).

4. HV Breakout Module 1.2

Simultaneously and safely measures current and voltage between OBC and HV battery.

5. Smart Logger with vMeasure log

The eMobilityAnalyzer calculates parameters of the charging process (e.g. ripple of current and voltage, active power and losses from the charging process) in real time within the Smart Logger.

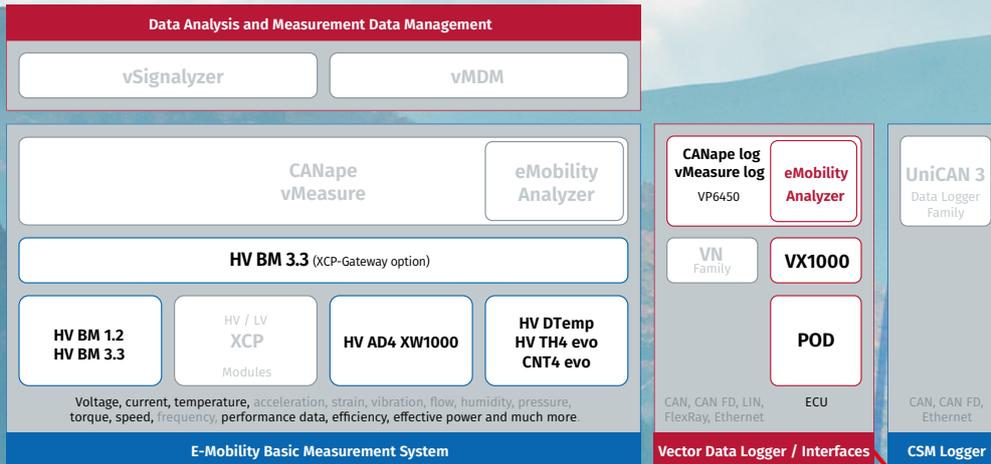
6. Additional HV Breakout Modules

For further analyses, additional HV Breakout Modules are simply inserted into the power cables of the HV electrical system.

6

Power Analysis on the Electric Powertrain II

Since real driving situations can often only be inadequately simulated on the test bench, the interaction of the components in the electric powertrain is also tested in road trials. Here, additional measured variables are included in the analysis. High-performance Vector Smart Loggers are used to record the data while driving and calculate performance values in real time.



Legend

1. Smart Logger VP6450 with vMeasure log

Records all data during the test drive and calculates performance values with the eMobilityAnalyzer in real time.

2. HV AD4 XW1000

Voltage measurement in the DC/DC converter.

3. HV TH4 evo

Measures temperatures inside the high-voltage environment of the inverter and electric motor.

4. HV DTemp Measurement System

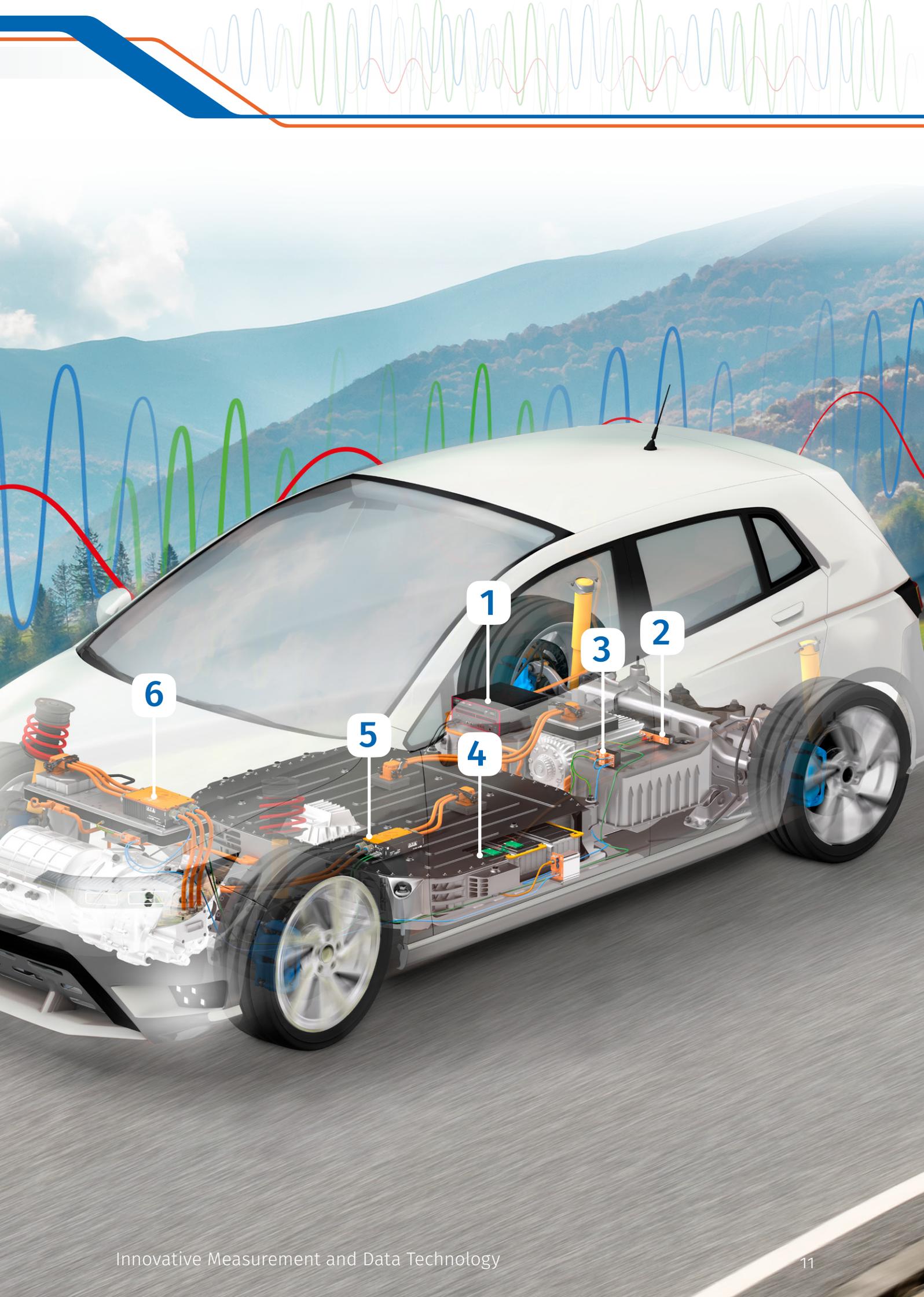
Acquires the temperatures between the battery cells of the HV battery with up to 512 sensors with only one external cable.

5. HV Breakout Module 1.2

Current and voltage in the HV power cables between HV battery and inverter are measured with this module.

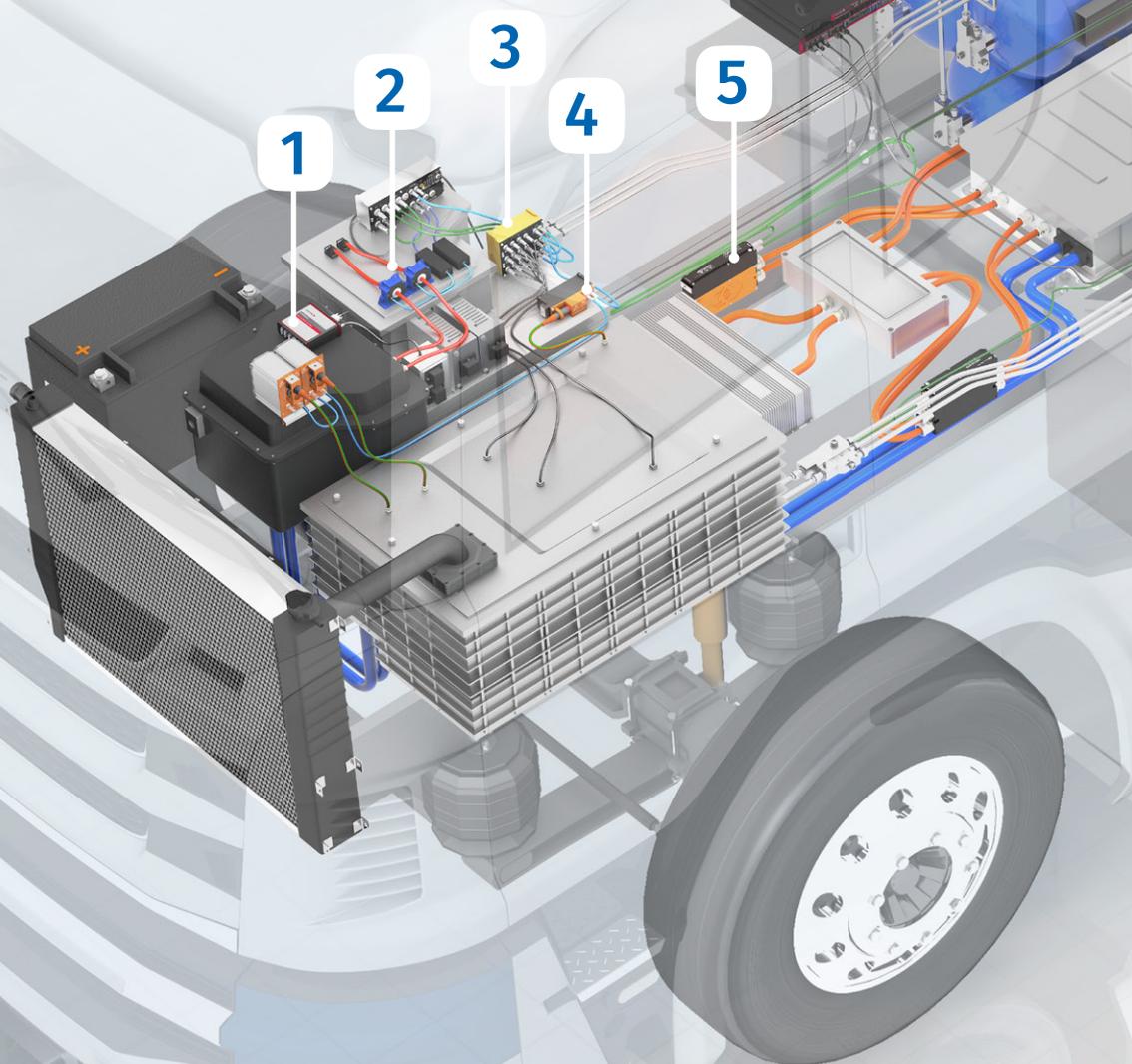
6. HV Breakout Module 3.3

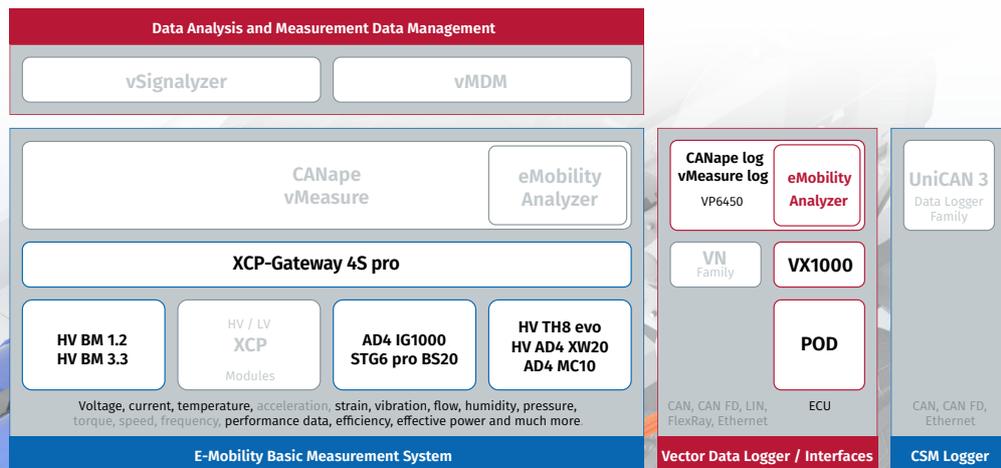
Measures current and voltage between the inverter and electric motor. In addition, the HV BM 3.3 acts as an XCP-Gateway for connected measurement modules.



Measurements in the Fuel Cell-Electric Powertrain

Electromobility is characterized by different powertrain concepts that bring their own development challenges. With its flexible composition and easy scalability, the E-Mobility Measurement System can be used in a variety of ways – including in the development of fuel cell systems. From measurements in the fuel cell stack and media supply to verification of the entire powertrain, all necessary measurements and analyses are performed with just one system.





Legend

6

1. Vector VX1000 Interface

Acquires data from media supply control units and allows direct arbitration and calibration.

2. LEM Sensor Package

Currents can also be measured with different solutions from CSM.

3. AD4 MC10

Acquires sensor data for measuring pressure, flow, and humidity in low-voltage environments of the fuel cell stack media supply.

4. HV AD4 XW20

Measures the humidity sensors in the fuel cell stack.

5. HV Breakout Modules

For analyses in the electric powertrain, the HV Breakout Modules are inserted into the cables of the HV electrical system.

6. STG6 pro BS20

Measures strains by using strain gauges on the hydrogen tanks.

About Us

Vector and CSM – The partnership for developments in electromobility

The Vector CSM E-Mobility Measurement System combines years of experience and innovative hardware and software solutions of two leading manufacturers. For each component of the Measurement System, experts are available to answer your questions and advise you on how to meet your individual challenges.

We look forward to working with you to further develop the measurement system and to take the steps towards future mobility.

CSM Computer-Systeme-Messtechnik GmbH

CSM is a leading, highly innovative manufacturer of decentralized networked, robust measurement technology and data loggers for applications in vehicles and test benches. We have been setting technological standards in this field for nearly 40 years. Our products are successfully used worldwide by almost all manufacturers of passenger cars, commercial, agricultural, and material handling vehicles as well as their suppliers and service providers.

Continuous innovation and long-term satisfied customers are our guarantee for success. With our high-voltage safe measurement and Breakout Modules developed for fast and synchronous measurements on electric and hybrid vehicles, we actively accompany our customers' transformation towards eMobility.



*Measurement Technology for E-Mobility
We accompany you on the way to the future*



Vector Informatik GmbH

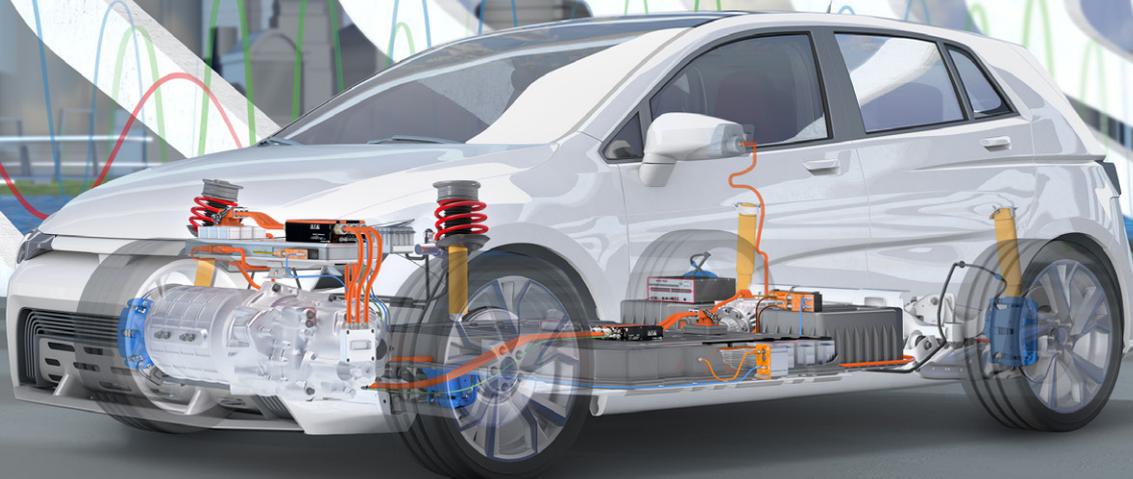
For more than 30 years, Vector has been your capable partner in the development of automotive electronics. More than 3,000 employees at 30 locations worldwide support manufacturers and suppliers of the automotive industry and related industries with a professional platform of tools, software components and services for developing embedded systems.

Driven by our passion for technology we develop solutions which relieve engineers of their demanding tasks. Not only do our employees work on tomorrow's electronic technologies every single day.

All Products, Data, and Information at a Glance

Our website www.csm.de provides you with further information about the CSM measurement modules and data loggers. Make use of our solutions for the development and testing of passenger cars; commercial and special vehicles; construction and agricultural machinery; cranes; wind turbines; airplanes; ships etc.

www.csm.de





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