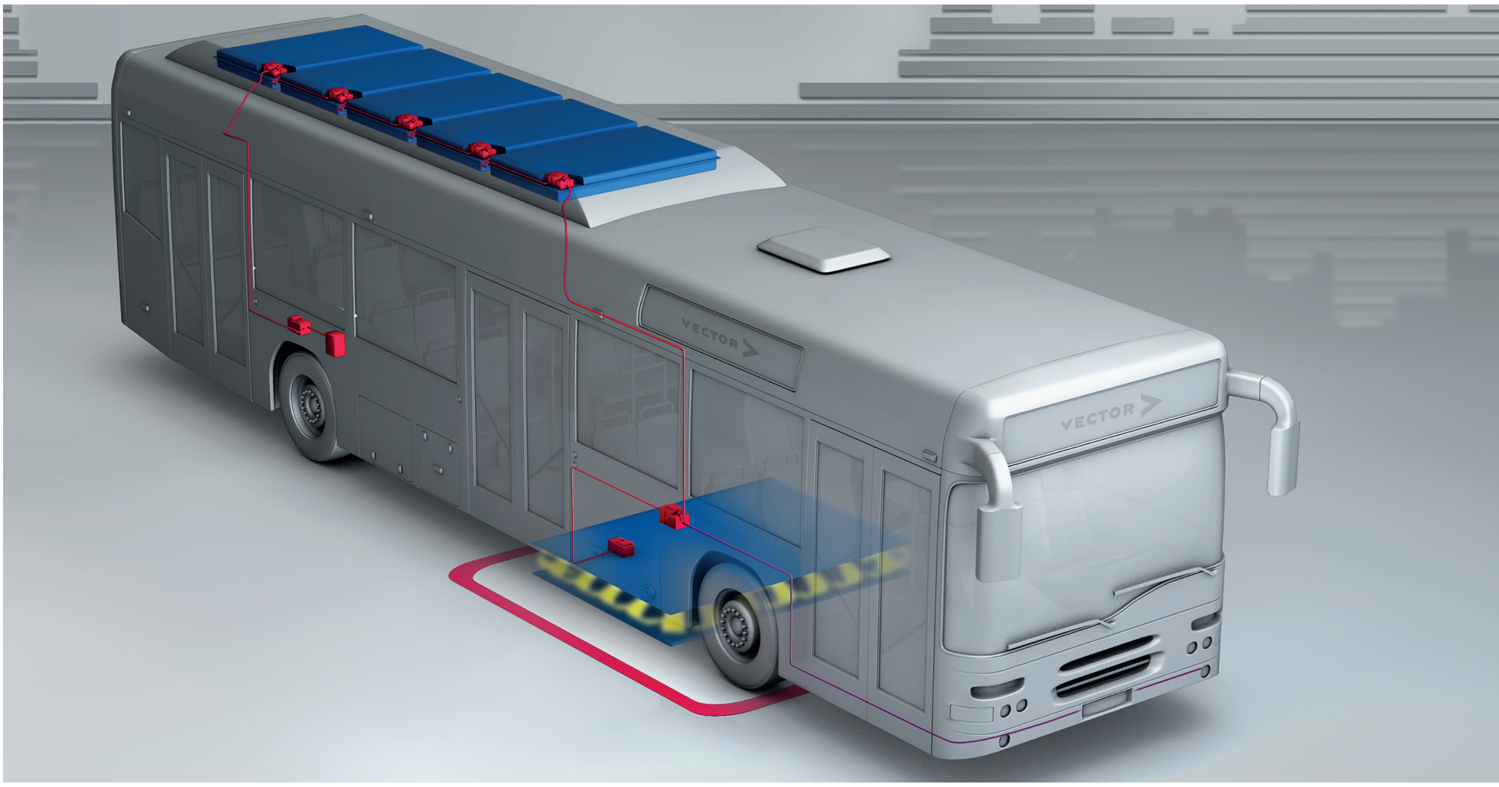

Report on Vector E-Mobility Day

From Inductive Charging to Electric Motors

Ongoing debate about diesel cars has benefited electric mobility by shifting it more into the public spotlight. However, road users are generally unaware of the specific challenges associated with this form of transportation. Specialists are working intensively to fulfill the technical prerequisites for successfully managing the transition. This year, visitors to the 5th Vector E-Mobility Engineering Day can get an impression of some of the issues involved – vehicle technology, the charging infrastructure and standardization.

As usual, the numerous presentations on E-Mobility Engineering Day **(Figure 1)**, held on April 12 in Stuttgart, addressed current themes with great dynamism. This year they included future technologies such as integration of electric vehicles into a Smart Grid, inductive – i.e. wireless – charging and related communication solutions. In standardizing communications, a distinction is made between information sharing between the vehicle and the charging infrastructure (ISO/IEC 15118) and between the charging infrastructure and the energy provider (IEC 63110). In the cable-based charging that is available today, the trend is towards a uniform system across Europe, the Combined Charging System (CCS). Many CCS developments are currently near production readiness, and vehicle manufacturers are therefore interested in ways to efficiently testing for CCS conformance and in the availability of high-performance test systems. Advanced developments are also improving efficiency in the vehicle drivetrain – where electrical energy is converted into mechanical energy. One example is a new type of inductively supplied electrically excited synchronous motor (iEESM).

Figure 1: Experts in electric mobility discuss the latest innovations and trends at the 5th Vector E-Mobility Engineering Day 2018.

A Question of Infrastructure

In the not too distant future, electric mobility will become an important component of individual mobility. Making this transition is far more than just a matter of using an electric motor instead of a combustion engine in the vehicle. That is because today's infrastructure lacks the ability to implement electric mobility for the mass market with today's infrastructure. Since the number of electric vehicles doubles every 18 months worldwide, the availability of fast charging stations with broad network coverage is a prerequisite for further success. Electric vehicles not only have zero local emissions; they also make CO_2-neutral driving feasible in many cases. Since the availability of wind and solar energy is subject to the moods of nature, energy demand and energy supply rarely match up. That is why numerous experts are researching the question of how large quantities of renewable energy can best be (temporarily) stored. Here, Vehicle to Grid (V2G) and Bidirectional Power Transfer (BPT) fulfill the technical preconditions for building up an intelligent electrical grid that can effectively balance out grid fluctuations. As soon as millions of electric vehicles are on the road or connected to charging equipment, these vehicles will serve as an energy buffer – as an enormous number of ‚distributed energy storage units. When energy supplies are scarce, the batteries in the vehicles will return a portion of their energy and thereby stabilize the grid. Noteworthy from a control engineering perspective is the fast reaction time of V2G. Within milliseconds, the charging electronics can be configured to feed energy back into the grid, which contrasts with the slow response of a pump storage power plant.

Along with solution models for future electrical grids, experts in various fields are also working on other innovations and defining new standards in standardization committees. Themes such as inductive charging, intelligent charging, charging via pantographs and automated billing are top agenda items for all participants. Above all, they point to the important role of inductive charging in promoting the acceptance of electric vehicles. It would eliminate the inconvenient and time-consuming task of handling charging cables and starting the charging process at the charging station. But what other benefits are realized?

Briefly explained

Pantograph

A pantograph is a movable electrical power receiver. It is used on local transportation buses to build up a temporary charging connection. The pantograph is mounted on the vehicle roof and makes a connection with a charging mast designed for this purpose. An inverted pantograph, on the other hand, is mounted to the charging mast and makes downward connection with contacts on the vehicle roof. This reduces vehicle weight and thereby improves fuel economy.

Inductive Charging: Static and Dynamic Charging are Possible

More important than enhanced convenience is inductive charging's automatic "refilling" capability. It can do this without further user actions as soon as the vehicle is positioned over a counterpart coil in the floor, which is known as the groundpad. Not only does this significantly increase the driving range of electric vehicles; the batteries can also be made smaller and more cost-effective. Ideal locations for inductive charging are found everywhere, such as in parking structures, in public parking lots, in stopping zones at red

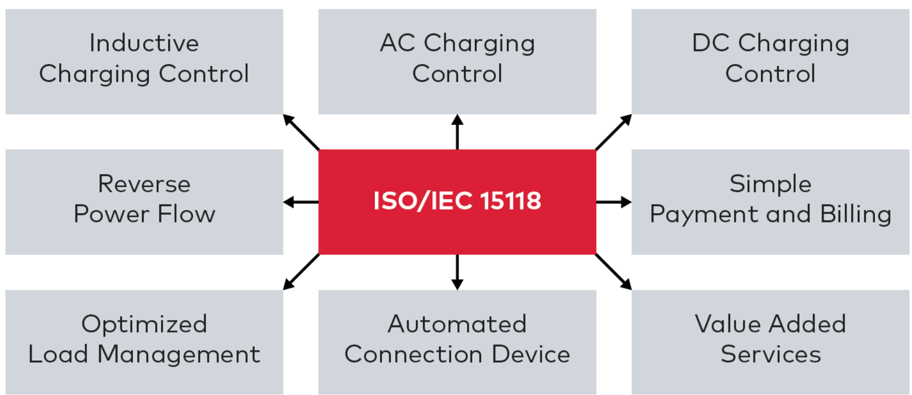

Figure 2: ISO/IEC 15118 is the international standard for charging communications.

lights, and of course at home in the garage or carport, provided that it is equipped with the necessary, uniform and standardized equipment.
In contrast to static charging, an advanced variant that is an interesting future option is dynamic inductive charging while driving. Several companies have jointly built a test track near Paris and proven that it really works. At a speed of 120 km/h, they successfully transferred energy to the test vehicle at a power of 20 kW. Interesting is the fact that the charging system works entirely without communication between the groundpad and the vehicle. The available wireless communication solutions were all too slow for the real-time capability required here. Many questions remain unresolved in this project, and there is much optimization potential.

Seamless Integration into the Smart Grid

With the exception of this test track, reliable communication is a prerequisite for all of the functionalities and technologies mentioned above. Without standardized data exchange between electric vehicles and charging systems, on the one hand, and between the stationary charging equipment and the service provider or smart grid on the other, it would be impossible to implement intelligent charging, bidirectional charging, authentication, billing, fine positioning of the vehicle over the groundpad, the provision of auxiliary services and much more.
One of the most important requirements for electric charging is unlimited interoperability between the solutions of all suppliers. Therefore, the international standards ISO/IEC 15118 and IEC 63110 serve as a foundation for the development of specific products. ISO/IEC 15118 specifies all needs for charging communication between the vehicle and the charging station, which applies to both cable-based and inductive charging **(Figure 2)**. The second version of the standard (ED2) is currently available to the public in draft form (DIS).
IEC 63110 applies to communication from the charging station toward the grid systems. Standardization work on IEC 63110 did not begin until early 2018. A first draft (CD 1) of IEC 63110-1 with basic definitions and application cases is planned for mid-2018; CD 2 is scheduled to follow by the beginning of 2019. IEC 63110-2 contains technical specifications and requirements and should be available in initial draft form in early 2019. Afterwards, IEC 63110-3 will follow with the requirements for conformance tests.

Milestone Rather Than Just an Update: ISO/IEC 15118 ED2

The leap to Version 2 of ISO/IEC 26228 is far more than just a small update. The most important new contents include Wireless Power Transfer (WPT) for inductive charging, feeding energy back into the grid (Bidirectional Power Transfer – BPT) and ACD (Automatic Charging Device). The latter relates to fast charging of electric buses in local public transportation via a pantograph. ISO/IEC 15118 specifies the radio standard IEEE802 as a physical layer for wireless communication. In the consumer electronics field this is familiar under the name WiFi. Furthermore, encryption via TSL (Transport Layer Security) is now specified and mandatory for all types of communication.
The extended functionality of ISO/IEC 15118 ED2 poses all sorts of new tasks for developers. Examples include the implementation of TLS connections for secure billing processes at public charging stations. Especially difficult to design may be the testing of TLS-encrypted communication in debugging. For instance, how can the trace data be decrypted in production vehicles without a debugging interface? Interfacing of a WiFi chip with a SDIO interface which communicates with the controller chip via SPI will also require additional development effort in practice. This is relevant for both inductive charging and in communication with a pantograph. For companies which cannot deploy the necessary development resources, it is therefore advisable to use suitable secure embedded solutions and test tools for smart charging such as those offered by Vector Informatik.

Efficient Testing of CCS Products

The most important European charging system for cable-based charging is the Combined Charging System (CCS). CCS is mandatory for fast charging systems in the EU, and it combines – in a single system – both single-phase and three-phase AC charging up to a maximum of 43 kW and DC charging at a maximum of 200 kW, and in the future up to 350 kW of charging power. Among other aspects, it includes definition of the plug connector and socket as well as definition of the communication between vehicle and charging station. The international organization CharIN e.V. Is driving its distribution, and it now has over 100 members.
An important task for the success of CCS is intensive testing of vehicles and charging stations with one another, which manufacturers are practicing in regularly organized test events. In the growth market of electric mobility, however, it is becoming increasingly more difficult to test every vehicle with every type of charging station. Therefore, the Focus Group Conformance Test of CharIN e.V. works on the definition of a test system which can be set up as a modular and scalable system and enables product qualifications based on standardized test cases. Hardware and software may certainly originate from different producers **(Figure 3)**. Vector Informatik offers a test system based on this architecture. It consists of the software tools CANoe, vTESTstudio and the CANoe Test Report Viewer. The VT System is available as suitable communications hardware; it covers

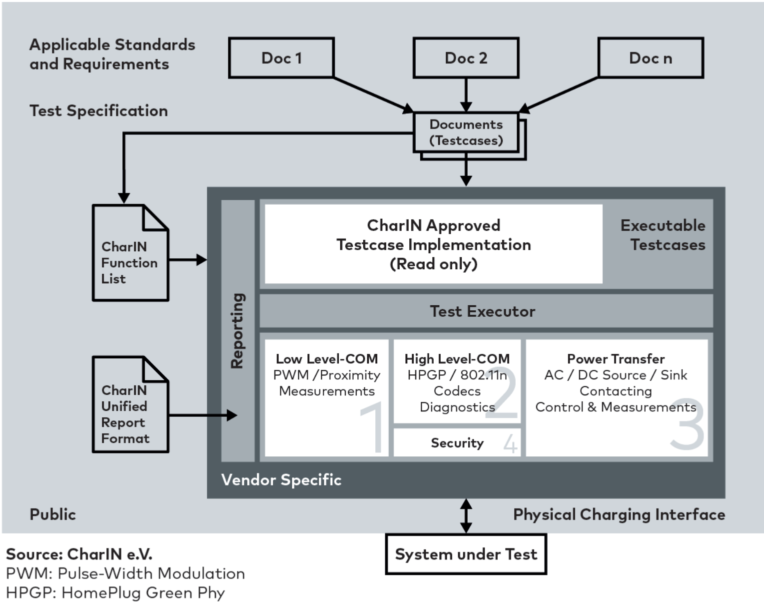

Figure 3: A modular and scalable test definition per CharIN e.V. Enables standardized conformance testing for vehicles and charging stations.

the necessary low-level and high-level communications. In this case, the CANoe development and test tool is used primarily to execute tests, but it can simultaneously conduct remaining bus simulations when testing ECU's. While vTESTstudio proves its capabilities in defining test cases, the CANoe Test Report Viewer supports the presentation of test results in a clear and organized form. Vector also offers the actual test cases for checking conformance to ISO/IEC 15118-4/-5 and DIN SPEC 70122. The comprehensive solution enables wide-ranging test automation and makes it possible to check intentionally designed error cases in addition to good cases.

Better Efficiency

A project at the University of Stuttgart sponsored by the Vector Stiftung ("Vector Foundation") shows how noteworthy optimizations are still possible in the drivetrain. Most manufacturers today use permanently excited synchronous motors (PMSM), and a few use asynchronous motors (ASM) or electrically excited synchronous motors (EESM). The PMSM excels with high torque at lower rpms and high efficiency; but these advantages drop dramatically at higher motor speeds. Other disadvantages include the high costs of the permanent magnets, temperature sensitivity and risks associated with generator mode in error states. Simulations based on the latest WLTP (Worldwide Harmonized Light Vehicles Test Procedure) cycle show that of all motor types under consideration the EESM exhibits the best overall efficiency. The only disadvantage is associated with the friction rings for feeding the exciter coils on the rotor which are susceptible to wear. Prof. (Dr. of Engineering) Nejila Parspour and her team at the Institute for Electrical Energy Conversion at the University of Stuttgart have therefore developed an inductively supplied, electrically excited synchronous motor (iEESM). It offers all of the benefits of EESM, but it is able to operate without mechanical friction rings. Currently, these scientists are retrofitting a BMW i3 and replacing the original PMSM with the special iEESM. It will be exciting to see the results of vehicle testing in real operation.

Conclusion

Presenters and visitors at the Vector E-Mobility Engineering Day agreed that future electric vehicles will combine the most advanced technologies in a variety of areas to form one system. Highly developed systems are firmly embedded in an infrastructure and smart grid adapted to the new requirements, so that a comparison with driving, intelligent and networked robots is thoroughly justified. Optimizations in drive and battery technology – combined with inductive energy transmission – will further improve the convenience and driving range of electric mobility and give the market a boost. The standards defined today represent the foundation for the interoperability that will be needed to achieve this.

More information on the E-Mobility solution from Vector
www.vector.com/e-mobility

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Translation of a German publication in emobilitytec 03/2018 (August 2018).

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Figure 3: CharIN e.V., edited by Vector