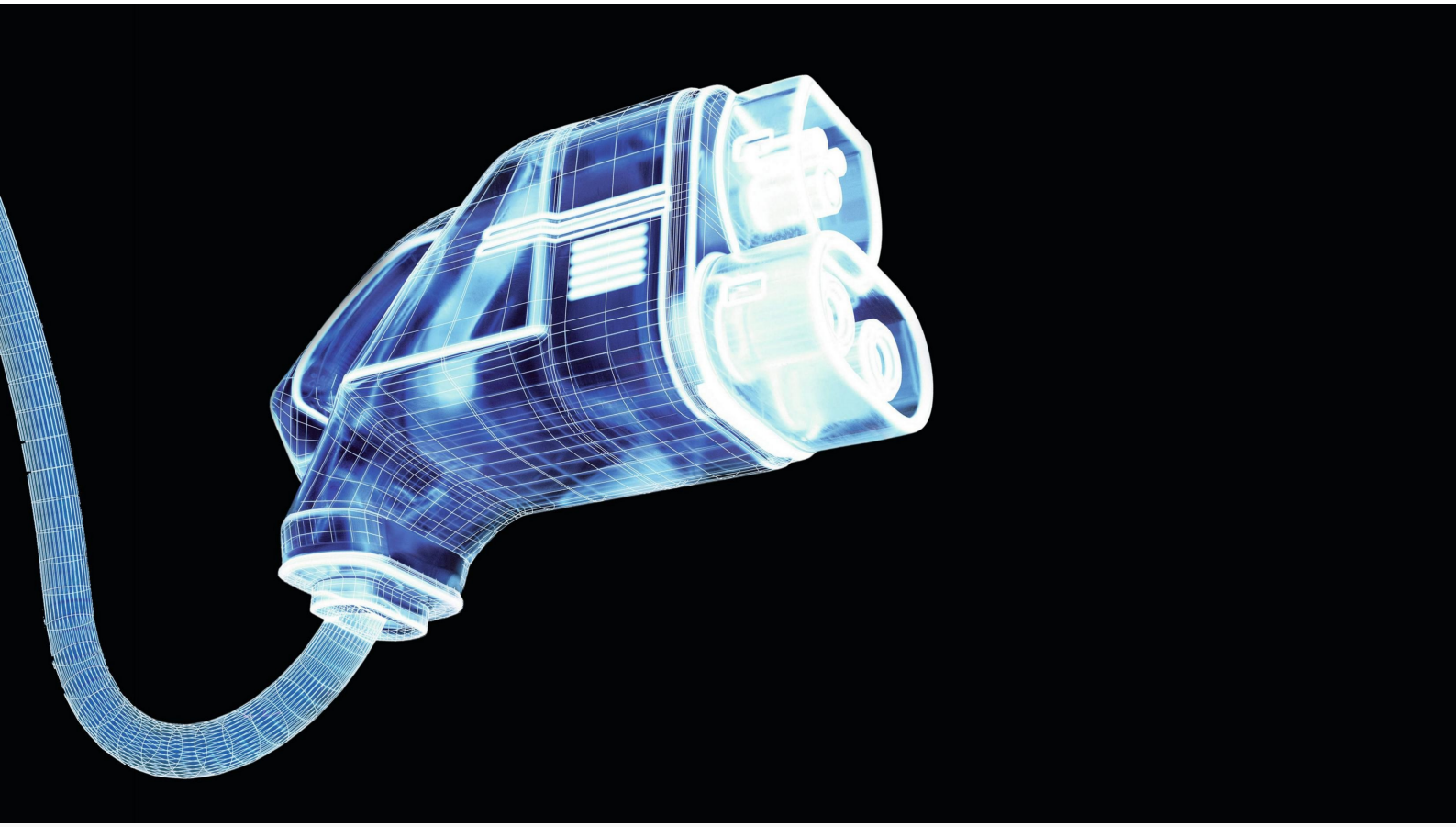

Intelligent charging functions for electric vehicles

21/01/2026 Porsche Engineering offers its customers complete development and validation of high-voltage charging management systems. The solution enables automotive manufacturers to enter the market quickly with intelligent charging functions for electric vehicles. At the same time, the system can be used worldwide because all relevant charging standards have been factored in. The central function of the software is charge planning.

High-voltage charging management (HV charging management) is a key criterion for customer satisfaction when it comes to plug-in hybrid and electric vehicles. It detects the charging power, authenticates the vehicle with the charging station, communicates with the infrastructure, controls the charging flap, and provides the data for the customer's mobile end device, where the charged energy is displayed in an app.

This ensures that the charging process proceeds conveniently for the user and functions reliably in all everyday situations and environmental conditions. Porsche Engineering has been developing advanced charging management concepts since 2011 and has built up extensive development and validation

expertise in the process. “When developing the charging management software, we cover all tasks involved in the V model—from requirements analysis to validation. This enables our customers to enter the market quickly and cost-effectively explains Dominik Langen, Deputy Project Lead for Charging Systems at Porsche Engineering. In this way, Porsche Engineering supports the development of passenger cars with plug-in or electric powertrains within the Volkswagen Group—as a central development partner for high-voltage charging management. “Our team handles every step from defining the requirements to designing the software architecture, modeling the software functions, writing the code, and integrating it into the control unit, all the way to test bench validation,” says Langen.

To date, 13 vehicle variants from diverse platforms within the Volkswagen Group have already been equipped with individually tailored charging management solutions. A single software system that can be flexibly adapted to the respective vehicle model and target market always forms the basis for this. Programming into the control unit is carried out easily and reliably via adjustable software parameters. “This makes it easier for automative manufacturers to manage variants, as the same software is uploaded to the charging control for all electric plug-in vehicles. It is only during vehicle production that the employee makes the adaptation by setting specific parameters,” says Langen. Another advantage of the concept is the efficient implementation of software updates: A new program code only needs to be developed, tested, and released once for all models. The software system itself has a modular structure and consists of six program modules, each of which performs defined tasks:

High-voltage charging management (HVLM), intelligent charging function (ILF), high level communication (HLC), control and display protocol (BAP), charging management safety function (CMSF), and value added services (VAS). “Through modularization, we factor in the numerous requirements made of charging management during development and are able to optimally coordinate these with each other,” says Narendra Kumar Boorlagada, Project Lead for Charging Systems at Porsche Engineering. Some of the requirements are determined by the technical hardware components. The status of the battery- for example, its temperature and residual capacity when charging starts—has a significant impact on the energy that can be stored, and therefore the course of the charging process. To put it simply, the energy flow slows down if the battery is too cold or warm or almost fully charged. What’s more, the charging management system offers functions that make charging easier for the end customer and improve the customer experience. For example, the HVLM program module opens the charge port door so that the driver can plug in the charging cable. It also enables the vehicle electronics for charging. Customers no longer need a credit card for authorization at the charging station, as the secure automatic identification is carried out using the HLC program module by means of the “Plug & Charge” function.

In dialog with the infrastructure

During charging, the system detects the maximum available charging capacity, exchanges information with the infrastructure, and supplies the data for the customer's mobile end device via the control and display protocol program module, which can be used to display information such as the battery charge

state and the planned charging time in an app. The possible charging performance of the system includes AC charging with low power, charging at the DC charging station, and even high-power charging (HPC) with several hundred kilowatts of power. If the vehicle is charged at home using a wallbox, automatic data exchange between the HLC and the home energy system ensures that the house connection is not overloaded.

A high degree of flexibility in the charging connection was one of our most important development goals. The HLC program module supports all charging standards worldwide, including GBT, GBT+, Chaoji, Chademo, ISO 15118 or DIN EN 62196, and enables customers to use their electric vehicle in all regions around the world," explains Boorlagada. One development challenge is the imprecise specifications of some charging standards, which leave room for interpretation in the technical implementation. Boorlagada: "In individual cases, the charging system may comply with the standard, but communication between the vehicle and the infrastructure does not function smoothly. We validate these cases with a compatibility mode that guarantees the basic function of the charging process." If a malfunction occurs during charging, the CMSF program module detects this and switches the system to a safe state.

VAS offers functions such as an interface to the in-cable control and protection device (ICCPD), which can be used to charge the vehicle using a standard home electrical socket. The central component of Porsche Engineering's charging management system is the creation of the charging plan. This determines the time curve for the energy input into the battery within the total charging time. The default is for the charging management system to charge the vehicle battery as quickly as possible to a minimum 25 percent state of charge after connection to the charging station, so that a sufficient amount of energy is available for unplanned journeys. "After that, our forecast tool for creation of the charging plan comes into play. It consists of individual time intervals for which an electrical charging capacity is defined.

The overall charging plan is obtained by arranging the individual intervals into a sequence," explains Norbert Melinat, Technical Project Manager for Charging Planning at Porsche Engineering. The charging management system must ensure that the most favorable electricity tariff is used while simultaneously ensuring that the vehicle is fully charged at the desired point in time.

Using surplus energy

The charging plan takes various factors into account, such as current grid utilization, the availability of environmentally friendly energy from the home solar power system, and the vehicle's charging requirements. In a specific example, surplus energy from the solar power system can be transferred to the vehicle when capacities are available, thereby storing it.

The charging management system receives up-to-date information on dynamic electricity tariffs via communication with the infrastructure. By using intelligent algorithms and real-time data, this matrix is used to create a dynamic charging plan that can react flexibly to changes—for example, if the

infrastructure can provide less energy in the short term than predicted. The user is shown the calculated charging process and the expected charging time via a smartphone app. “The forecast-based procedure helps to minimize charging costs while reducing the grid load, which also makes charging management very complex,” says Meliant.

High planning quality during charging

One particular challenge is the calculation of precise charging plans at very low or high outside temperatures, as the chemical reactions in the battery are particularly volatile under these conditions. This is mitigated during charging plan execution by a monitoring function that starts running additional calculations parallel to the actual charging planning and compares the results. “This increases the planning quality over the course of the charging process, and the charging time specifications successively become more precise,” says Melinat. As practical experience in the development of charging management has also shown, focusing on a single optimized charging plan is not expedient, as the charging strategy may have to be adapted during charging.

If the user has specified a fixed departure time using “time charging”, the charging management system must ensure that the vehicle battery reaches the required state of charge in the predefined period of time under all circumstances. In this case, the total charging time is therefore divided into subphases. The main phase comprises the regular charging planning. The end of this phase is limited by the departure time specified by the user, minus a time buffer of typically 30 to 60 minutes. This serves as additional charging time in the event that the charging goal could not be reached within the main phase. In the subsequent third phase, the vehicle is pre-climatized. In this phase, the charging planning makes calculations using a reduced charging capacity, as the charging system must cover the required energy for the air conditioning at the same time. For the validation, dedicated hardware-in-the-loop (HiL) test benches were set up on which the software is tested in an automated process. “From 2021 to 2024, our experienced international team also implemented the next milestone development in charging management: The complete redesign of the software,” says Boorlagada. While the old software structure had evolved over the years and been successively expanded, the new code now includes a compact summary of all functions of the charging management system, including charging planning, so that the already-low memory requirement on the control unit of the on-board charger as well as the computing speed could be further minimized.

Info

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