Park & Load: Inductive charging for electric vehicles

The market for electric vehicles is growing fast. Electronics firms are working hard to improve the necessary charging technologies and make them as user-friendly as possible. MicroNova has developed a Hardware-in-the-Loop (HiL) simulator for mechatronics service provider Zollner Elektronik AG that validates an inductive charging system for electric vehicles.

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The charging infrastructure available for today's electric vehicles will not be enough for the expected increase in electric vehicles on the road. In the future, a greater and more easily-accessible charging capacity must be made available. The most user-friendly method is wireless charging via an inductive coupling device, i.e. inductive charging.

With this method, the energy for charging the vehicle battery is transmitted via two coils coupled in resonance mode. One coil is located inside the floor plate, the other one in the vehicle's underbody. This method has achieved efficiencies comparable with cable-based solutions. For the driver of the electric vehicle, this means more convenience for the same level of efficiency.

Testing the inductive charging concept with the HiL simulator

Previously, manufacturers and suppliers have used electromechanical attachment parts to test inductive charging concepts. Moving coil and position sensors allow testers to model different configurations manually. This procedure however has its disadvantages: It is almost impossible to automate and is associated with relatively high costs.

A Hardware-in-the-Loop (HiL) simulator, on the other hand, can increase testing efficiency considerably at a lower cost. MicroNova has developed a NovaCarts HiL-system for Zollner AG, including associated simulation models. This system can be used by testing departments to reliably and dynamically test all constellations between the fixed charger and the moving vehicle. The simulation model used recreates the energy transmission path exactly.

Taking the vehicle position and external obstacles into account

Multiple aspects of the inductive charging process must be taken into account to provide reliable verification. Along with the simulation of the vehicle position, obstacle detection between vehicle and charging panel as well as simulation of power electronics and transmission paths must be considered.

A critical factor for efficient energy transmission is the precise positioning of the vehicle above the charging station. In order to ensure this, sensors are needed both on the ground and under the vehicle, the signals from which, or from the corresponding control units, are monitored by the HiL simulator. In order to check the functionality, it is also possible to induce specific errors.

Another important requirement is that, during operation, the inductive charging system must be able to reliably detect whether a living object or another obstacle is in the charging zone. The control unit regulating the charging process generates an electrical oscillating circuit and several high-frequency signals. At the same time, the electronic control unit (ECU) has sensors to detect changes to these signals caused by external factors. For example, if a cat approaches the vehicle, it will be detected in the same way as a rolling tin can would – in both cases, charging will be halted. Using the HiL simulator, test engineers can influence these sensors directly, and thus ensure that the detection response works reliably.

Simulation of power electronics and transmission paths

During tests on the HiL system, the power electronics and transmission paths are also simulated. The charging station converts A/C from the main electricity grid to the high-frequency charging voltage. This improves the level of efficiency for the energy transmission that follows. Wireless energy transmission to the vehicle system is possible thanks to the coupling of the coils between ground and vehicle panel by means of an alternating magnetic field. The field rectifies the voltage, which is then used to charge the battery.

To control this process, one control unit is located in the charging station and one in the vehicle. Both units have an influence on energy transmission via control and monitoring parameters. The HiL system reads the environmental parameters in order to simulate the control unit environment precisely. This environmental simulation involves not only computing the generated voltages and currents, but also inducing errors to test whether the control units respond appropriately.

Real-time tests with FPGA cards

The NovaCarts HiL system tests the low-voltage functionality of the two control units involved in the charging process. MicroNova has removed high-voltage components from the two ECUs and integrated the remaining low-voltage part, along with the remaining hardware, into a test box. The high-voltage part is described solely by a model. The complete power electronics system is simulated by a Simulink model on the test bench in combination with an FPGA model (FPGA = field programmable gate array). Quick FPGA cards are used to ensure an immediate response to control unit signals. MicroNova has managed to achieve extremely short cycle times and calculate the highly-complex model in real time.

High test quality in a short time

The NovaCarts HiL simulator can be used to freely configure all of the parameters used in charging, e.g. positioning in all three axes, coil inductivity, etc. The system automatically tests, in the various relevant constellations, whether and how changes made to the control algorithm have an effect on the charging efficiency. The simulation of special, in part safety-relevant, requirements of inductive charging in automatable tests yields a multiplicity of results more quickly and at less expense than conventional methods. The EXAM automated testing solution also enables extensive regression testing for each new step in the development process.

Errors can be detected and promptly corrected even in the early stages of development. Individual steps in the development process will thus become smaller and more frequent, which in turn improves quality. As a result, Zollner Elektronik AG will benefit from a highly effective procedure that requires relatively little time. Thanks to the quality and reusability of test data, EXAM also facilitates optimal resource utilization and reliable test evaluations.

„The realistic simulation of inductive, i.e. wireless energy, transmission has been outstanding so far. The resulting closed-loop simulation makes it possible to perform and validate changes to the charge controller much more quickly and easily than before. The combination of direct experience in the hybrid area with great modeling competence and many years of know-how in the simulation of fast power electronics procedures makes MicroNova the right partner when it comes to our development of this forward-looking charge technology."

– Anton Ludwik,
Test Engineer at
Zollner Elektronik AG