

STILLE – Standardization of Inductive Charging Systems Framework for interoperable wireless charging solutions

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Summary

Wireless charging as a convenient automatic alternative for electric vehicle charging is coming closer to market introduction. In parallel to the development of first product implementations, *standardization* activities are running for several years. Besides the benefits of potential *mass market* effects, of course, a major goal of standardization is to define an interoperable interface between *infrastructure* and vehicle side. The German funded project STILLE¹ supports international standardization activities by verifying different technical approaches within a large *consortium*, including several standardization participants.

1 Technical challenges of interoperable inductive charging

Although inductive charging is well known from other applications (e.g. tooth brushes, industrial applications, cell phones, ...) the implementation as vehicle charging technology goes along with some new challenges. Furthermore, the development of a standardized, interoperable interface between infrastructure and vehicle adds some specific requirements compared to dedicated product implementations.

1.1 Power transfer

The power transfer itself happens via a magnetic field that is established by the infrastructure side and captured by the vehicle side. The magnetic and electric design of both sides of the system finally determines the performance with respect to transferrable power and efficiency. Standardization currently takes power levels up to 11kW into consideration and aims at a very minimum of 80% AC/DC-efficiency. In addition, the power transfer needs to be enabled within a certain geometric area, to allow the driver some tolerance in parking (~100mm).

The major challenge of standardization with respect to power transfer is to enable interoperability with different vehicles. Different vehicles require different implementation, e.g. due to various ground clearances or available package spaces. To enable this flexibility in product design (by the way also for the infrastructure side), it is the goal to specify the interface requirements for both sides. Infrastructure and vehicle side thus can be developed independently with certain degrees of freedom for the specific application. Investigations on this specification of the interface are currently ongoing within project STILLE (see 3.2.1).

¹ STILLE is the acronym for the project title „Standardisierung induktiver Ladesysteme über Leistungsklassen“ (in English: „Standardization of inductive charging systems in different power classes“)

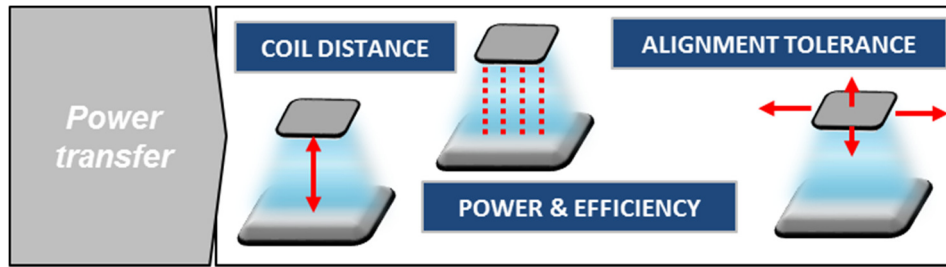


Figure1: Power transfer challenges

1.2 EMC and EMF

Dealing with magnetic fields is connected to keeping limits for the distribution of the field. Two major topics have to be considered thereby: electromagnetic compatibility (EMC) and protection of people from being exposed to hazardous field strengths (EMF). Standardization bodies are currently developing corresponding thresholds and measurement procedures. The responsible group for EMC matters is CISPR whereas the ICNIRP guideline describes the requirements for protection of people. Keeping the limits determined by ICNIRP around the silhouette of the vehicle for sure is a challenging but achievable task. Keeping the limits underneath the vehicle will certainly not always be physically possible. Therefore, so called living object detection (LOD) technologies need to be used to surveil this area.

Detection technologies also come into play in case of metallic objects, which can become potential touch hazards when heated up due to the exposure to magnetic fields. Foreign object detection (FOD) technologies are developed and shall serve to prevent these touch hazards.

In fact, these detection technologies are not relevant for interoperability, since the responsibility will be on the infrastructure side only. However, the challenge for the standardization bodies is to determine corresponding requirements, including test bodies and test procedures, which fit to the existing technical solutions. Project STILLE also supports in determining these.



Figure2: Detection of living and foreign objects

1.3 Positioning and alignment

The core tasks of the positioning system are to guide the driver during the parking procedure and to ensure, that the two sides of the system – infrastructure and vehicle side – are well positioned relative to each other before the power transfer begins. Currently different technologies are under investigation, whereas the challenge for standardizing a technology again is raised due to the necessary ability to serve different types of vehicles. Furthermore, the positioning system has e.g. to have a certain robustness (also against environmental influences) and an adequate accuracy. Investigations with different technical solution are also ongoing within project STILLE (see 3.2.2).

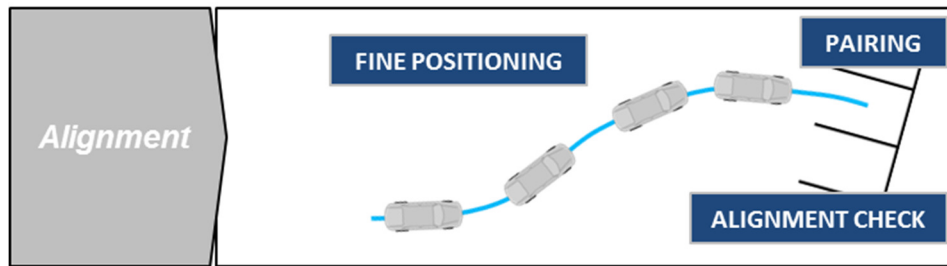


Figure3: Positioning and alignment procedure

1.4 Communication

As physical layer for the communication Wifi has been chosen, final validation tests are still ongoing. With respect to the dedicated messages and sequences, a lot can be taken over from conductive charging. Nevertheless, some inductive specific items have to be taken into consideration, like e.g. communication for positioning or the message exchange to control the power transfer. This significantly differs from conductive charging, since specific parameters like e.g. the frequency are of major influence for inductive charging and may need to be controlled during the charging cycle.

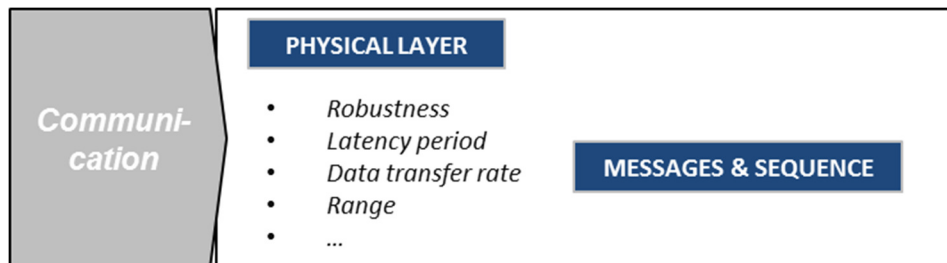


Figure4: Communication challenges

2 International standardization activities

Standardization activities are mainly running in IEC, ISO and SAE. The most important standards, especially focusing on interoperability, are IEC61980 series, ISO15118, ISO19363 and SAE2954. All groups and organizations are working closely together, trying to achieve the goal of one interoperable solution that is applied worldwide. Of course, also different industries are involved in the standardization work (OEMs, suppliers, scientific institutions, ...).

#	next pub	title	focus
IEC 61980-1	IS	Electric vehicle wireless power transfer (WPT) systems Part 1: general requirements	COM
IEC 61980-2	TS	Part 2: Specific requirements for communication between electric road vehicle (EV) and infrastructure with respect to wireless power transfer (WPT) systems	COM
IEC 61980-3	TS	Part 3: Specific requirements for the magnetic field wireless power transfer systems	COM
ISO 19363	IS	Electrically propelled road vehicles – Magnetic field wireless power transfer – safety and interoperability requirements	COM
ISO/IEC 15118	IS	Road vehicles – vehicle to grid communication interface	COM
SAE J2954	RP	Wireless charging of electric and plug-in hybrid vehicles	COM

Figure5: Overview of most important inductive charging standardization groups

The timelines of the organizations are quite comparable. The general goal is to get the first editions of the standards published by 2018. The background, especially for the German industry, is that the second generation of inductive charging systems shall be interoperable based on standards when entering the market by 2020.

3 Project STILLE

Project STILLE is funded by the BMWi² within the funding program “ELEKTRO POWER II: Electric Mobility – Value Chain Positioning”. In total the German Federal Ministry for Economy and Energy (BMWi) supports 13 projects regarding electric mobility with about 25 Mio. Euros. The focus is on the integration of electric mobility to the energy system transformation, the optimization of the value chain regarding electric mobility in the field of production, the advancement of inductive charging systems in the public and cross-sectional topics. ELEKTRO POWER II is part of the set of measures the German Federal Government is running to realize the National Plan for the Development of Electric Mobility.

The STILLE project consortium consists of international car manufacturers and suppliers. Furthermore, there are renowned universities for accompanying scientific research and studies. The composition of the consortium covers different interests and approaches and thus establishes a broad basis for the achieved results. P3 is coordinating the activities of the following partners:

- Audi AG
- BMW Group AG
- Continental AG
- Daimler AG
- P3 Group (Coordinator)
- Qualcomm
- Robert Bosch GmbH
- RWTH Aachen (IKA)
- Toyota Motorsports GmbH/ Toyota Motors Europe
- TU Braunschweig (IMAB)
- TÜV SÜD AG
- WiTricity
- Zeppelin University

Furthermore, the investigations in the project are supported by some associated partners:

- Ford
- Nissan
- Porsche AG
- Paul Vahle GmbH
- Vector Informatik GmbH
- VW AG
- Zollner Elektronik AG

The project started by the middle of 2016 and is planned to be finished by the end of 2018.

3.1 Goals and general approach

The STILLE project aims to support the international standardization by testing and validation of different technological approaches. As introduced in chapter 1, the entire system can be structured into several subsystems (power transfer, positioning, communication, ...). For these subsystems, different technical approaches have been discussed and developed within the last few years for standardization purposes. Within STILLE, these technical approaches are build up and tested to validate the potentials for the development of an interoperable standard and to achieve a higher degree of comparability of existing approaches. The results

² BMWi = German Federal Ministry for Economic Affairs and Energy

of the validation are directly brought into the standardization groups to concretely support the decision making process.

Within eight working packages STILLE follows a holistic approach by investigating the interfaces that are relevant for interoperability. The four technical work packages (power transfer, EMC and EMF, positioning and communication) are framed by market-preparatory activities concerning business models and potential use cases, as well as necessary preconditions to establish a certification platform for inductive charging systems.

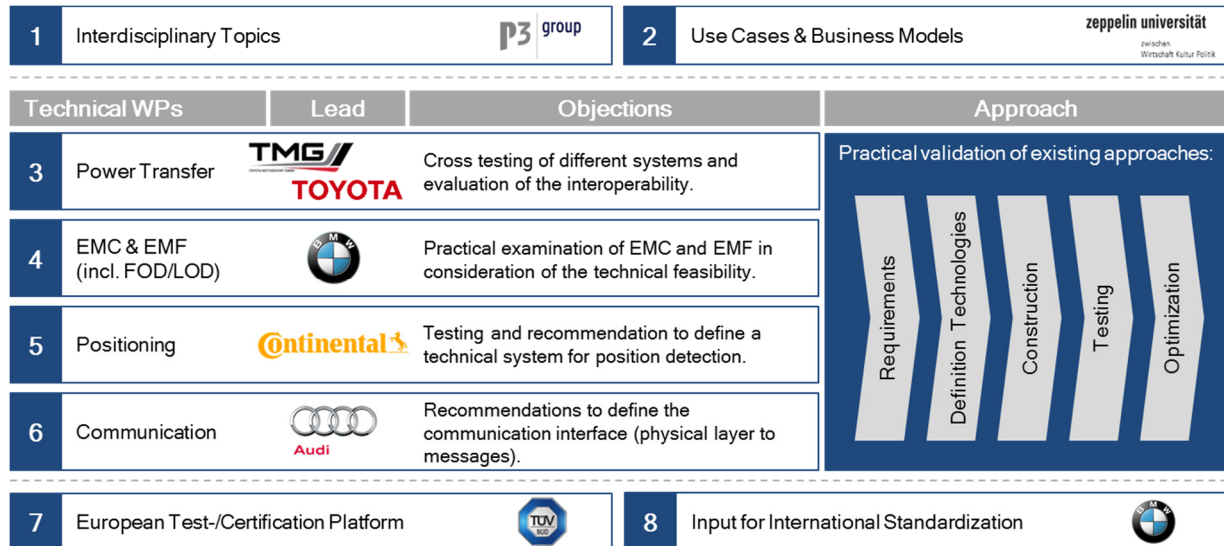


Figure6: Work packages of STILLE

3.2 Status of technical work packages

The following descriptions are limit to the work packages for power transfer and positioning since these have the most inductive-specific challenges.

3.2.1 Status of power transfer investigations

Up to the establishment of this paper, 4 different infrastructure sides and 7 different vehicle sides have been built and tested within the project. The construction was based on the latest descriptions in standardization documents, which comprise coils of different geometries, driven by different power electronics. It shall be noted here, that in standardization there is also a Z3-class up to 250mm, which wasn't covered in the STILLE testing.

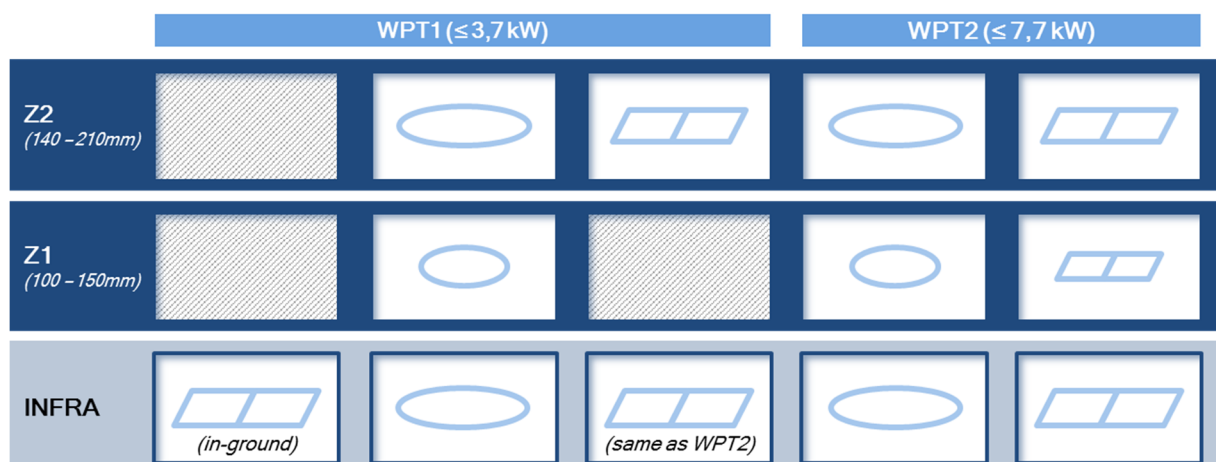


Figure7: System up to 7.7kW built in STILLE

The test results were actually astonishing. Interoperability between different systems was way better than expected, although the systems were not primarily designed to work with each other. Based on this finding the project is currently focusing on trying to specify the interface requirements between infrastructure and vehicle side. This shall finally allow a maximum flexibility in product design, and still ensure interoperability. The interface description is separated into magnetic and electric properties. Based on the test results, the specific requirements are currently under development.

The concept for the magnetic properties is, that a certain magnetic flux has to be established by the infrastructure side. With that information, the vehicle side knows what to expect and can be developed accordingly. Both magnetics and electronics are interdependent at the system level, as the electronics must be designed in a manner to cover for variations of the coil system parameters, which in turn vary with displacement of infrastructure to vehicle coil. Rather than specify the details of the electronics, an impedance based specification of the electrical parameters was chosen to describe the requirements and behavior of the electronics at the terminals of the coils.

Besides the investigations in the interoperable interface, testing of 11kW systems has just started by the middle of 2017. Also these results will serve for further development of the interface specifications.

3.2.2 Status of positioning system investigations

To enable ending up on the right spot for inductive charging, STILLE set the goal to assist the driver from roughly 5-6 meters distance. Therefore 3 different technologies have been taken into consideration (see Figure8).

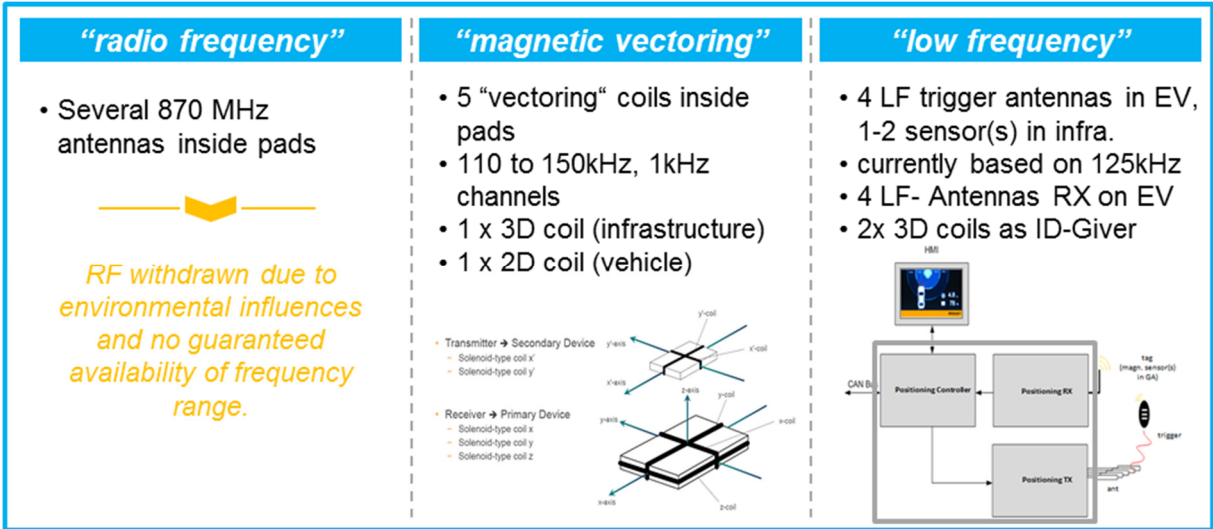


Figure8: Fine positioning technologies investigated

As Figure8 shows, the investigations are currently focused on “magnetic vectoring” and “low frequency”. Test results with respect to general accuracy capabilities look quite promising for both technologies so far. A second testing loop is just starting, focused on validation of some more standardization-specific requirements (e.g. parking of several vehicles in parallel).

For the final determination that the vehicle is positioned correctly before the power transfer starts, other technologies need to be used. The main reason is that this safety relevant position confirmation is supposed to be independent from communication. Therefore, a short range signal is currently being specified and tested, combined utilization with the magnetic field for power transfer is also under consideration.

4 Benefits of STILLE

The first 1.5 years of investigation within STILLE have shown the benefits of the project. The test results achieved have greatly supported the decision making process in standardization. Key factors are especially

the large consortium – results are not only produced by one individual – as well as the concrete orientation of the project to directly serve the standardization groups.

Authors



Michael Scholz studied Business Engineering until 2009 at the University of Applied Sciences in Kempten, Germany. After having finished his diploma thesis he stayed with the consulting company P3 Automotive GmbH, being involved in different projects within the field of electric mobility. Since 2012 he was dealing with standardization of inductive charging system. Right from the beginning coordinating the activities of German automakers, he is project leader of ISO19363 since 2014, which is standardizing the vehicle part of the inductive charging system. Furthermore, he is coordinating the German funded project STILLE, that supports international standardization by building and testing different technical approaches in a consortium of 13 partners.



Johanna Heckmann works as a Consultant for the P3 Group in the field of Electric Mobility with a focus to topics concerning conductive and inductive charging infrastructure. In different projects for major automotive manufacturers and an energy supplier she gained experience along the value chain – from standardization to market roll-out and operation of charging infrastructure. Before she worked for e-mobil BW, the State Agency for Electric Mobility in the German state of Baden-Wuerttemberg and was part of the project coordination office for the “Showcase for Electric Mobility – Living Lab BWe mobil”. Johanna Heckmann is master graduate of the HTWG Konstanz, where she studied Business Management.