SURFACE VEHICLE STANDARD

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(R) Wireless Power Transfer for Light-Duty Plug-in/Electric Vehicles and Alignment Methodology

RATIONALE

Electrified powertrains, specifically battery electric and plug-in electric (BEV/PHEV) vehicles, are projected to become more prevalent in production internationally due to environmental factors (such as GHG, CO_2 emissions, regulations (such as the EU, China, U.S. EPA regulations, and the California ZEV mandates), as well as the increasing price of fossil fuels. The main benefits of electrified powertrains are eliminating or significantly reducing local emissions while increasing the overall well-to-wheels efficiency. In addition, automated are soon to be more commonplace to allow more convenient and safer transportation, especially in traffic settings and long-distance driving.

Standardized wireless power transfer (WPT, also called wireless charging) allows the BEV/PHEV customer an automated, seamless, and more convenient alternative to plug-in (conductive) charging. Essentially the customer simply needs to park in an SAE J2954-compatible parking space in order to charge the vehicle. WPT offers the additional advantage to automated enabling autonomous parking with alignment assistance and automated charging (in all weather conditions, such as rain or snow).

This standard is an evolution of SAE J2954, which is based on actual bench testing and vehicle interoperable data taken around the world. SAE J2954 is meant to harmonize with standard developing organizations in order to make a world-wide WPT standard to 11.1 kVA, useful for commercial applications. The SAE Task Force (TF) harmonized with numerous standard organizations (AAMI, ANSI, CISPR, GB, ISO, IEC, UL, VDA) towards these goals and specifically the documents produced in ISO and IEC. The SAE J2954 TF has worked directly with government agencies to gain feedback (U.S. DOE, U.S. FCC, U.S. FDA) and testing actual systems both in government laboratories and private. The SAE J2954 TF has documented the lessons learned from the first stage of testing with real OEM systems in accompanying SAE technical data reports (see Section 2). It is essential that data-based standards are used as a basis for commercialization of this technology.

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1. SCOPE

The SAE J2954 standard establishes an industry-wide specification that defines acceptable criteria for interoperability, electromagnetic compatibility, EMF, minimum performance, safety, and testing for wireless power transfer (WPT) of light-duty plug-in electric vehicles. The specification defines various charging levels that are based on the levels defined for SAE J1772 conductive AC charge levels 1, 2, and 3, with some variations. A standard for WPT based on these charge levels enables selection of a charging rate based on vehicle requirements, thus allowing for better vehicle packaging and ease of customer use. The specification supports home (private) charging and public wireless charging.

In the near term, vehicles that are able to be charged wirelessly under SAE J2954 should also be able to be charged conductively by SAE J1772 plug-in chargers.

SAE J2954 addresses unidirectional charging, from grid to vehicle; bidirectional energy transfer may be evaluated for a future standard. This standard is intended to be used in stationary applications (charging while vehicle is not in motion); dynamic applications may be considered in the future. In this version, only above-ground (surface mounted) installations are covered; flush mounted installations have been discussed but are not yet ready for inclusion.

SAE J2954 contains requirements for safety, performance, and interoperability. It also contains recommended methods for evaluating electromagnetic emissions, but the requirements and test procedures are controlled by regulatory bodies. Development of the interoperability requirements in this standard employed a performance based evaluation of candidate designs using a standardized Test Station and procedures, resulting in defining reference devices which are used to determine acceptable performance of products.

1.1 Wireless Power Transfer General System Description

WPT systems consist of a Ground Assembly (GA) Subsystem and a Vehicle Assembly (VA) Subsystem as depicted in Figure 1. The GA broadly consists of a mains-connected Power Factor Correction (PFC) converter, followed by a DC-AC inverter, a filter, and Impedance Matching Network (IMN) that is connected to the GA coil. The magnetic energy created by the GA coil is coupled to the VA coil. The VA consists of the VA coil connected to an IMN and filter, a rectifier, and an optional impedance converter that produces suitable voltages and currents to the connected battery.

In order to ensure safety, a certain set of requirements are met by both the GA and the VA, including monitoring for safe operation (voltage, current, and temperature) and the ability to take corrective action in the event that a limit indicating unsafe operation is being approached.

The GA and the VA share a communication system that allows the GA to know the state of the VA and for the GA to receive and respond to messages from the VA. It is critical that power transfer is not initiated until the GA determines that a vehicle with a compatible VA is in place and properly aligned.

The following steps describe the high-level operation of the closed loop charging system with respect to the sub-system blocks in the diagram in Figure 1, after necessary safety and compatibility checks have been performed and passed.

- Within the VA (25), the power desired to charge the battery is determined.
- The request for power is communicated over the wireless communication channel (b) from the VA to the GA (15).
- The GA recognizes the request, draws power from the grid, converts it to high frequency AC, and sends it to the GA coil (11).
- The high frequency AC couples (a) to the VA coil (21), is rectified and processed in the VA, and charges the batteries.
- This process continues until the VA signals a different power level requirement, including no power required, as would be the case when the batteries are adequately charged.