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| U.S. Radiocommunications SectorFact Sheet |
| **Working Party:** ITU-R WP 1A | **Document No:** USWP1A23\_20\_rev2(final) - PDR Report SM.2451 on WPT-EV |
| **Ref:** ITU-R SM.2451  | **Date:** 08 August 2021 |
| Document Title: Updates to the “Preliminary Draft Revision of Report ITU-R SM.2451-0”, Assessment of impact of wireless power transmission for electric vehicle charging on radiocommunication services. |
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| **Purpose/Objective:** Proposal to finalize corrections, clarifications, and updates to SM.2451-0 including the previously contributed new appendix with a recent study on impact of WPT-EV on amateur radio performed on an OATS. Subsequently the preliminary draft should be elevated for adoption. |
| **Abstract:** The United States Delegation to WP1A contributed updates to ITU-R SM.2451-0 in the last two ITU-R WP1A meetings. The last WP1A meeting determined that work should continue on the *Preliminary Draft Revision of Report ITU-R SM.2451-0* as given in Annex 8 of the Chairman’s report from the ITU-R WP1A June 2021 meeting.This document primarily proposes editorial updates and clarifications to help finalize the current *Preliminary Draft Revision of Report ITU-R SM.2451-0* and prepare it for acceptance as a *Draft Revision of Report ITU-R SM.2451-0*. |

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| **Radiocommunication Study Groups** |  |
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| Received: Date 2021Subject: Question [ITU-R 210-3/1](https://www.itu.int/pub/R-QUE-SG01.210) | **Document XX/-E** |
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| **English only** |
| **United States of America** |
| Proposed Revisions TO the Preliminary Draft Revision of Report ITU-R SM.2451 |

**Background**

Since the initial publication of ITU-R Report SM.2451-0, WP1A has received several contributions from various delegations that have provided editorial and technical updates and improvements to the report. Annex 8 of the Chairman’s report from the May/June 2021 meeting represents the latest modifications of the *Preliminary Draft Revision of Report ITU-R SM.2451-0*.

**Discussion**

The United States has undertaken additional review of the *Preliminary Draft Revision of Report ITU-R SM.2451-0, Annex 8 of the WP1A Chairman’s report from the May/June 2021 meeting*. Upon reviewing, it appears that the updates are ready for elevation to a Draft Revision of Report ITU-R SM.2451-0 once some additional minor corrections are made to resolve bracketed text and editorial corrections finalized.

**Proposal**

In the revision, the United States proposes the following summary of changes to the *Preliminary Draft Revision of Report ITU-R SM.2451*:

* Resolutions for bracketed text and editorial corrections

The Unites States also proposes to elevate the status of the *Preliminary Draft Revision of Report ITU-R SM.2451* based on this contribution for subsequent adoption as an update to ITU-R SM.2451.

**Attachment:** Proposed revisions to the Preliminary Draft Revision of Report ITU-R SM.2451-0

**Attachment**

**Proposed revisions to the PRELIMINARY DRAFT REVISION OF REPORT ITU-R SM.2451-0**

[**USA Note:** Proposed changes in this contribution to Annex 8 of the Chairman’s report are indicated as “USA” and highlighted in blue. All tracked changes shown as “WP1A-2” are the accepted changes from the previous meeting. All USA notes highlighted in blue are for explanation in this contribution and are not meant to be added to the document. No further changes proposed prior to this point.]

**Related ITU Recommendations, Reports**

Recommendation ITU-R SM.329

Recommendation ITU-R P.372

Recommendation [ITU-R SM.1056](https://www.itu.int/rec/R-REC-BS.1056/en)

Recommendation ITU-R SM.1753

Recommendation [ITU-R SM.1896](https://www.itu.int/rec/R-REC-BS.1896/en)

Recommendation [ITU-R SM.2110](https://www.itu.int/rec/R-REC-SM/recommendation.asp?lang=en&parent=R-REC-SM.2110)

Recommendation ITU-R SM.2129

[**USA Note:** The ITU-R Recommendations BS.560 and BS.703 are in no way “related” to wireless power transmission (WPT). These ITU-R Recommendations (along with many others not referenced here) are, however, already appropriately referenced in related studies contained in this report.]Report [ITU-R SM.2153](https://www.itu.int/pub/R-REP-SM.2153)

Report [ITU-R SM.2303](https://www.itu.int/pub/R-REP-BS.2303)

Report ITU-R SM.2452.

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### Brief Explanation of WPT systems being standardized by SDOs

WPT-EV systems are being actively pursued across the globe in support of global initiatives for utilization of electric vehicles. WPT-EV systems are seen by the SDOs as being a critical part of the infrastructure for static and dynamic charging of electric vehicles. There are three primary SDOs with publications for Systems of Wireless Power Transfer for Electric Vehicles (WPT-EV). These are IEC/TC69/WG7, ISO/TC22/SC37/JPT19363 and SAE J2954. Through coordination, these three SDOs are harmonizing the requirements for these systems to help ensure world-wide interoperability.

WPT-EV systems are designed to transfer energy wirelessly, with measured efficiency between 85 % and 93 %, from a coil assembly on the ground (primary device) to a coil assembly placed underneath the electric vehicle (secondary device). The wireless transfer occurs by means of a magnetic field using near-field magnetic properties and resonance. Figure 5 shows a block diagram of such a system.

Figure 5

**Typical block diagram of a WPT-EV system from SDOs**



In general, there are two main subsystems in the WPT-EV system, namely the Supply Device (from IEC & ISO)/Ground Assembly (GA) (in SAE) and the EV device (IEC & ISO)/Vehicle Assembly (VA) (in SAE J2954). The Supply Device’s responsibility is to generate a magnetic field at the desired operating frequency, while the EV Device converts the magnetic field into a DC power that can be used by the EV.

Figure 6



[USA Note: The figure above needs to have increased size to be able to read the numbers in the chart.]

Based on extensive research and review; IEC, ISO, and SAE have determined that the fundamental operating frequency of the WPT-EV system for light duty applications should be within 79-90 kHz. While a frequency band is provided, it is generally expected that a given system will operate nominally at a fixed frequency within this range and not adjust its frequency during power transfer. These systems are expected to operate at efficiencies greater than 80% though measurements have shown typical efficiencies are ~90% AC input to DC output, see Figure 6. All energy transfer only occurs at the fundamental frequency.

During operation, the voltage generated by the Power Converter excites the Compensation Network that operates using resonance with the Primary Device coil. A resultant near sinusoidal current in the Primary Device coil then induces a proportional magnetic field. The energy is coupled between the Primary Device and the Secondary Device through the means of this magnetic field. Both coils can be described using a model of a loosely coupled transformer structure. Because the current generated in the Primary Device coil is sinusoidal and not modulated during power transfer, the field produced is a Continuous Wave (CW).

As of June 2019, the WPT-EV systems for power classes up to 11.1 kW are being standardized by the relevant SDOs. The frequency range of 79-90 kHz is expected to be used for all light-duty vehicles.

SAE J2954 has done studies on several interoperable systems and has published a subset of their data in a Technical paper presented at SAE World Congress in April 2019 titled “Validation of Wireless Power Transfer up to 11 kW Based on SAE J2954 with Bench and Vehicle Testing” (<https://www.sae.org/publications/technical-papers/content/2019-01-0868/>). Additional testing is included in Annex 12.

Standards for WPT-EV systems have been in development since 2010. Standards such as SAE J2954, ISO 19363, IEC 61980, and China’s GB standards have active development for WPT-EV systems and have all collaborated to ensure some degree of harmonization. Most of these standards bodies have committed to releasing a full standard in 2020 or 2021 such as SAE J2954 which was released in October of 2020. These standards are established to ensure interoperability between various manufacturers’ systems, but they also contain important information about human and cardiac implantable electronic device (CIED) EMF safety as well as recommendations for electromagnetic compatibility (EMC) and appropriate conditions for emissions testing to meet global requirements. In 2017, SAE J2954 setup a cooperative research program, which has been actively testing systems since inception and making recommendations based on that testing for harmonized standard adoption.

In 2018 and 2019, SAE J2954 sent liaison letters to ITU-R outlining EMC related requirements, indicated that emissions studies had been underway since 2010, and provided the results of those studies. Furthermore, the general characteristics of standardized WPT-EV systems were provided.

WPT-EV systems based on the aforementioned standards:

• Use near-field magnetic resonance to transfer energy wirelessly between a loosely coupled ground coil assembly and a vehicle coil assembly by means of evanescent magnetic field coupling.

• Utilize filtered sinusoidal currents in the ground assembly coil to generate a local magnetic field for transferring power.

• Have an efficiency from AC mains input to DC output greater than 80% though measured values have shown typical efficiencies at 89 % to 93 %.

• Operate in the range of 79-90 kHz (nominally 85 kHz) but do so at a fixed frequency across the full charging cycle of a vehicle.

• Do not modulate the wireless energy between the ground and vehicle coil assemblies in any way for communication but instead utilize out-of-band wireless communications (such as Wi-Fi), which follow well-established global radio requirements.

• Meet set requirements for human and CIED EMF safety based on ICNIRP 2010 guidelines for human exposure and ISO 14117 guidelines for CIED magnetic field compatibility.

• Meet interoperability requirements for light duty vehicles and power levels starting from 3.7 kW (WPT1 power class) to 11.1 kW (WPT3 power class).

• Meet minimum alignment tolerance requirements as +/- 75 mm in the direction of vehicle travel and +/- 100 mm in the lateral direction.

• Meet requirements for foreign object detection to prevent unsafe metallic object heating.

• Meet general interoperability requirements including defined controls and communications standards.

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**Annex 12

Impact Studies on HF Amateur Radio in United States for WPT-EV**

[**USA Note:** Many modifications proposed in this annex are due to the fact that some of the information has already been moved to other sections in the PDR ITU-R Report SM.2451 or ITU-R Report SM.2303 and therefore are no longer presented in this annex. Other modifications are to ensure clarity of the text. Additionally, the figure renumbering was completed already and so the note highlighted in green below is no longer relevant.]

**A12.0 Abstract**

The impact study reviews the current status of amateur radio regulations and selected allocated HF bands in the United States as of February 2020. A standard pre-production prototype ~11 kW WPT-EV system mounted on a Nissan Leaf is described. Radiated emissions testing was performed with the WPT‑EV system in accordance with standardized international practices at an accredited third-party open area test site and the results compared with typical amateur radio equipment used. Calibrated data was collected by the third-party lab, and licensed amateur radio operators performed the amateur radio tests to collect data both with a calibrated spectrum analyser and off-the-shelf amateur radio equipment. The study attempts to identify interference potential caused by the harmonics of standardized WPT-EV systems in a real-world environment.

**A12.1 Introduction to Amateur Radio in the United States**

In the United States of America, the amateur service is regulated by Title 47 Part 97 of the Federal Code of Regulations. The primary purposes for amateur radio include usage for non-commercial, public, and voluntary emergency communications as well as providing opportunities for the advancement of radio art, skills in communications, and generally enhancing international goodwill. According to the American Radio Relay League (ARRL) and the FCC’s Licensing system, as of February 12, 2020, the number of active FCC amateur radio licenses held by individuals in the United States is 765006 with an average annual growth rate of about 1% over the last 5 years. The number of licensees corresponds to approximately 0.23% of the US population and an estimated density in the range from 0.2 to 2 licenses per km2 in suburban areas. The United States may belong to the top 5 countries with the highest number of issued amateur radio licenses per inhabitant. The states of California and Texas rank as the top 2 states respectively for the number of active amateur radio licenses.

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**A12.3.1 Characteristics of the WPT-EV Equipment Under Test (EUT)**

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The design of the particular WPT-EV study used is based on the criteria and details outlined in SAE J2954, ISO 19363, and IEC 61980. The system operates at a fixed frequency of 85 kHz and utilizes magnetic resonance to transfer its energy at that frequency. Refer to the text and images shown in § 3.3.1 which provide information related to the relative harmonic content expected in the ground assembly coil current. While the magnetic field emanating directly from ground assembly coil is not the only possible source of emissions, it is generally the source of most discussion regarding potential impact of WPT-EV on radio broadcasts and amateur radio reception.

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**A12.3.2 Characteristics of the OATS**

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In each of the bands, a marker indicates where a projected WPT-EV harmonic could potentially occur (though the WPT-EV system was not operating during the measurements). It is noted that the measurement conditions using a CISPR peak or peak-hold detector for standard EMC limit evaluation are not the same as the measurement conditions used to measure man-made noise floor levels that are indicated in Recommendation ITU-R P.372 which are derived using measurement techniques outlined in ITU-R Recommendation ITU-R SM.1753. The intent of the ambient measurements made with a typical amateur radio monopole are to assess the relative differences seen at the radio receiver with the WPT-EV system OFF (peak ambient emissions) and ON (peak ambient + WPT-EV system emissions) and to ensure capture of all time varying and rotationally dependent peaks emanating from the WPT-EV system in comparison with ambient emissions otherwise present. It should be noted, however, that peak-hold measurements maintain the maximum peak of time-varying signals or noise that can, in turn, mask noise floor conditions. This is particularly true in a location were any impulse or time-varying noise is present. The OATS location in Cedar Park, Texas abuts a residential neighbourhood to the west and business complexes to the north and south. The location of the OATS could generally be described as a light-business area with offices and small businesses in operation during testing. The site complies with the ANSI C63.7 construction methods for EMC measurements, requiring among other criteria, that the site be located a minimum distance away from obstruction-free areas that could perturb the measurements.

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As can be seen, the ambient conditions between these two distant locations (separated by ~1300 miles or ~2100 km), the peak-hold ambient measurements in the 80 m and 40 m bands showed similar characteristics, whereas in the 30 m and 20 m bands, the levels in Nibley, Utah were on average ~10 dB lower than those in Cedar Park, Texas. A satellite image of Nibley, Utah is shown below for comparison.

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The previous comparisons made were done using peak measurements (using methods described in Recommendation ITU-R SM.329, Annex 2) as seen by the amateur radio receiver; however, some additional measurements were taken by TDK RF Solutions of the ambient environment using similar metrology to that used to measure MMN in Recommendation ITU-R P.372. This is shown below for reference and shows an underlying noise level around 20 dB lower than in the figures taken with peak-hold measurements.

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The conclusion that the ambient environment noise is typical of a residential environment is further supported by independent data and tests shared with the European CEPT SE 24 group [23]. In a separate study performed entirely independently by Swiss amateur radio experts from USKA and Brusa [24], using a different WPT-EV system operating in a residential Switzerland neighborhood, ambient environment measurements were also taken and compared with those taken in Cedar Park Texas, U.S.A. These measurements taken in Ersigen, Switzerland next to an amateur radio station in a residential neighborhood were also taken by BAKOM using the standardized CISPR EMC settings as is typical globally for such measurements (and as described in Annex 2 of Recommendation ITU-R SM.329). In the USKA/Brusa study [25], the independent assessors reference the data from the contributed U.S. study and provide the following peak-hold comparison plot for review. It should be noted, however, that the ambient comparison measurements in peak-hold are entirely unrelated to the man-made noise measurements shown in ITU-R Recommendation P.372 and the measurement procedures indicated in ITU-R Recommendation SM.1753.

[**USA Note:** No further changes proposed. With these updates, the Preliminary Draft Revision of ITU-R Report SM.2451-0 can be elevated to Draft status.]