Federal Communications Commission
Office of Engineering and Technology
Laboratory Division

October 24, 2023

EQUIPMENT AUTHORIZATION OF WIRELESS POWER TRANSFER DEVICES

1 INTRODUCTION

This document addresses general FCC compliance prescriptions for equipment authorization of wireless power transfer (WPT) devices. As described below, WPT equipment manufacturers may have to use the KDB Inquiry process to provide documentation demonstrating how the device meets the requirements of this guidance, and only proceed with device authorization upon receiving concurrence from the FCC.

2 PART 15 AND PART 18 REQUIREMENTS

Depending on the operating configurations, wireless power transfer devices may need to be approved under Part 15, Part 18 of the FCC's rules (47 C.F.R. Parts 15 and 18, respectively), or both. Devices authorized under Part 15 may not operate in the 90-110 kHz band; under §15.205(a), only spurious emissions are permitted in any of the restricted frequency bands.

Part 18 permits devices operating in the Industrial, Scientific, and Medical (ISM) bands to generate and use RF energy for industrial, scientific, medical, domestic, or similar purposes, excluding applications in the field of telecommunication. In this context, ISM transmitters designed to detect load impedance changes, also referred to as "load modulation," are permitted under Part 18. The load modulation must be an integral part of the power management and control of the WPT device, and must be used only to the extent necessary to enable safe and efficient operations; for instance, rapid shut-down in response to over-voltage conditions, charging status reporting, or identification of receiver/target devices for which the WPT was intended.

For devices authorized under Part 18, load modulation may not be used to communicate any other information, such as device prioritization, or system status data, commands, sounds, images, etc. When communication is part of the design, both Part 15 and Part 18 requirements, as applicable, must be met for equipment authorization purposes. Similarly, devices that use a secondary frequency for load management, control, and data functions must be authorized according to both Part 15 and Part 18 requirements, as appropriate.

In cases where a single WPT device is also capable of transmitting on frequencies other than the primary power transfer frequency, compliance for all applicable Rule parts must be evaluated with all the transmitters that can be active simultaneously including those not used for wireless power transfer. In general, the WPT section of a device may still be authorized under Part 18, provided that it meets the required criteria; however, the inclusion of operations outside Part 18 requires authorization under the Rule Part applicable to such operations (i.e., Part 15 in the case of WPT devices).

3 RF EXPOSURE REQUIREMENTS

3.1 Mobile Device and Portable Device Configurations

Wireless power transfer devices must comply with RF exposure requirements for all design configurations in which they can operate. At a minimum, RF exposure must be evaluated for the worst-case scenario, typically when the transmitter, while delivering energy to a client device, is operating at maximum output power.

RF exposure compliance for equipment authorization must be determined following the guidance of KDB 447498, which includes consideration of the different test requirements for *Mobile Device* and *Portable Device* exposure categories, as defined in §§ 2.1091 and 2.1093 of the Rules.

Sometimes, a device may meet the RF exposure compliance requirements for a specified minimum distance for all but the most unlikely use conditions. For example, some typical desktop applications, such as wireless charging pads connected to household power, operate only when the active coil is covered and coupled with the target, and are characterized by a form factor that would discourage any on-body use because of size and/or weight. Thus, these devices may be considered to meet the § 2.1091-*Mobile* conditions ("generally be used in such a way that a separation distance of at least 20 centimeters is normally maintained between the RF source's radiating structure(s) and [the nearest person]"), and may be tested for compliance according to the applicable procedures for *Mobile* devices that are less onerous than those for *Portable* devices. In other analogous cases, still for a *Mobile* device, RF Exposure compliance may be ensured only for a minimum separation distance that is greater than 20 cm, while use conditions at smaller distances can still be considered unlikely.

For these scenarios, the equipment authorization of the device may be allowed, on a case-by-case basis, only after receiving FCC concurrence. This procedure requires the submittal of a KDB Inquiry selecting "*Equipment Compliance Review*" (ECR) as the first category, and "*Minimum RF Exposure Compliance Distance*" as the second category.

The ECR KDB inquiry shall explain why the stated minimum distance for RF exposure compliance was chosen, and justify why non-compliant use conditions (such as a person getting closer than the distance chosen for testing, and for a long enough time) are highly unlikely to occur. If these statements are deemed acceptable, then authorization may be granted, with the provision that the information about these specific conditions is clearly reported both in the grant comments (for certified devices) and in the user's manual/instructions available to consumers, as discussed in further detail in KDB 951290-D01.

3.2 Equipment Authorization Procedures for Devices Operating at Frequencies Below 4 MHz

The RF exposure limits, as set forth in § 1.1310, do not cover the frequency range below 100 kHz for Specific Absorption Rate (SAR) and below 300 kHz for Maximum Permitted Exposure (MPE). In addition, present limitations of RF exposure evaluation systems prevent an accurate evaluation of SAR below 4 MHz. For these reasons, a specific MPE-based RF Exposure compliance procedure for devices operating in the aforementioned low-frequency ranges has been set in place. This procedure is applicable to Equipment Authorization of all RF devices, thus including, but not limited to, Part 18 and WPT devices.

Accordingly, for § 2.1091-*Mobile* devices, the MPE limits between 100 kHz to 300 kHz are to be considered the same as those at 300 kHz in Table 1 of § 1.1310, that is, 614 V/m and 1.63 A/m, for the electric field and magnetic field, respectively. For § 2.1093-*Portable* devices below 4 MHz and down to 100 kHz, the MPE limits in § 1.1310 (with the 300 kHz limit applicable all the way down to 100 kHz) can be used for the purpose of equipment authorization in lieu of SAR evaluations.

Furthermore, consistent with FCC's equipment authorization RF exposure guidance, any device (both portable and mobile) operating at frequencies below 100 kHz is considered compliant for the purpose of equipment authorization when the external (unperturbed) temporal peak field strengths do not exceed the following reference levels:

83 V/m for the electric field strength (*E*)

and

90 A/m for the magnetic field strength (*H*).

These data may be provided through measurements and/or numerical simulations, and for all the positions in space relevant for any possible body exposure.

For all the cases mentioned above, *E* and *H* measurements should be made from all sides of the transmitter, along all the principal axes defined with respect to the orientation of the transmitting element (e.g., coil or antenna). When clearly demonstrated, symmetry considerations may be used to reduce the amount of testing. Furthermore, for "low-frequency" loop/coil emitting structures that lead to dominant H-field near-field emissions (i.e., with *E*/*H* ratio less than 1/10 of the 377-ohm free space wave impedance, typically frequencies less than 1 MHz), only H-field[1] measurements are sufficient for demonstrating MPE limit compliance.

It should be also noted that if numerical modeling is used to support compliance data for certification, the application is subject to PAG, related to the NUMSIM item in the PAG list of KDB Publication 388624-D02.

3.3 Field Strength Measurements

"Large size" probes may prevent the measurement of E- and/or H-fields near the surface of the radiating structure (e.g., a WPT source coil), as in the example shown in Figure 1.

If the center of the probe sensing element is located more than 5 mm from the probe outer surface, the field strengths need to be estimated through modeling for those positions that are not reachable. The estimates may be done either via numerical calculation, or via analytic model: e.g., approximated formulas for circular coils, dipoles, etc., may be acceptable if it is shown that the model is applicable for the design parameters considered. A typical example is the use of a quasi-static approximation formula for a low-frequency magnetic field source.

[1] In this document the terms "E-field" and "H-field" refer to "electric field strength" and "magnetic field strength," respectively.

These estimates shall include points spaced no more than 2 cm from each other. Thus, in the example of Figure 1, at least the estimates at 0 cm[2] and 2 cm are required, while only one point would not be sufficient. In addition, the model needs to be validated through the probe measurements for the two closest points to the device surface, and with 2-cm increments, as indicated in Figure 1. In that example, the same model must also be applied to the 4 cm and 6 cm positions, and then compared with the measured data, for validation purposes. The validation is considered sufficient if a 30% agreement between the model and the (E- and/or H-field) probe measurements is demonstrated. If such a level of agreement cannot be shown, a more accurate model (and/or a smaller probe) shall be used.

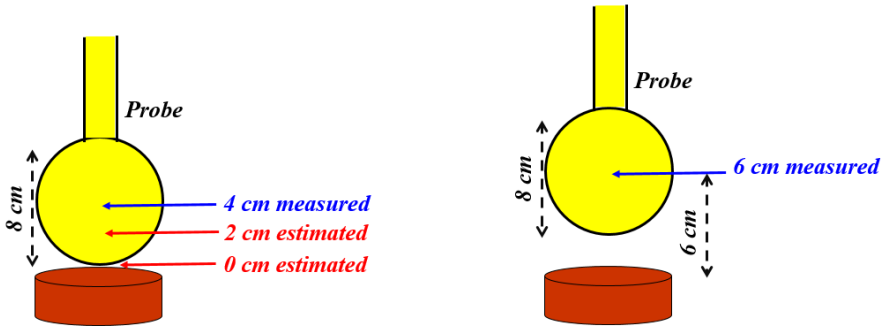

Figure 1. Example of probe (in yellow) measurements in points close to the WPT device (in red/brown). The probe radius is 4 cm, thus the closest point to the device where the field can be measured is at 4 cm from the surface (this example assumes that the probe calibration refers to the center of the sensing element structure, in this case a sphere of 4 cm radius). Data at 0 cm and 2 cm must be estimated through a model, and then the same model must be validated via comparison with the actual measurements at 4 cm and 6 cm, where the probe center can be positioned and collect valid data.

4 OPERATIONS OF WPT DEVICES CO-LOCATED WITH OTHER RF DEVICES

Some WPT transmitters are designed to work in physical contact with, or "very close"[3] to a target device (referred to as "*client*") that also includes a transmitter. For instance, this could be the case of a battery pack that wirelessly charges a cellular phone: the battery pack (equipped with a WPT transmitter) may either be available from the same manufacturer of the cell phone, or as an aftermarket accessory.

For these cases, the WPT conductive structures may alter the pattern of the RF emissions from the *client*, as compared to "stand-alone" *client* operations, i.e., without any additional device or accessory. This modified emission pattern may, in general, impact both RF exposure, and EMC compliance of the target device. In practice, this may be a compliance concern if the WPT structures lead to reflections, thus

[2] The "0 cm" estimate is considered in the extrapolation model. If the probe radius is less than 0.5 cm, measurement at 0.5 cm or less are considered sufficient to represent the "0 cm" data. This is consistent with a similar approach discussed in KDB 447498.

[3] In general, any transmitter may be placed and operated "sufficiently close" to conductors. This terminology here refers to a situation causing enough changes in the RF emission pattern to trigger compliance concerns. The issue related to an RF device transmitting while "near" to a conductive structure is therefore not unique to WPT applications.

redirecting the client's RF emissions. Conversely, the same may occur from the perspective of testing the WPT, albeit less likely for low frequencies, when the wavelength of the WPT transmitter is far greater than the dimension of the device being charged.

Equipment authorization requires testing in all "typical" operating conditions that, in this context, refer to what is expected based on the design features of the device. Accordingly, an RF device that is designed to be charged wirelessly shall be tested to ensure FCC compliance also when positioned for the WPT operations: this would be the case for a WPT transmitter that is tested while charging a *client* device, as well as for a RF device that may, as needed become the *client* device of a WPT system. Since FCC compliance refers to the emissions of a single device (possibly more than one transmitter, but with a single FCC ID), the *client* device transmitter does not need to be activated while the WPT is being tested, and similarly the WPT transmitter does not need to be activated when the client device is being tested (unless the WPT transmitter itself is part of the same FCC ID of the client).

For these use scenarios involving client or *accessory* devices (including, but not limited to WPT chargers), the test conditions refer to the impact of passive structures, no cumulative emission effects. For instance, in the worst-case scenario, the RF emission pattern of the *client* device may be altered by conducting structures present on the WPT transmitter and lead to non-compliance, especially for devices that are already close to the allowed limit. Thus in this case, the testing for the impact of the WPT transmitter presence on a WPT *client* becomes the responsibility of the *client* manufacturer, due to the inherent design feature that allows WPT charging.

This *client* compliance testing shall be conducted either with a compatible WPT transmitter/charger provided by the *client* manufacturer and available at the time the *client* device is being introduced on the market, or with any other compatible WPT charger available from other manufacturers (or both, of course). In the (arguably very rare) case that no WPT device is yet available for a particular *client*, a specific test fixture shall be built by the *client* manufacturer and used for compliance test purposes.

This approach is based on the underlying assumption that any compatible WPT charger would provide a meaningful test scenario for establishing if the RF emissions of the *client* transmitter(s) are impacted by the presence of the WPT device structure. While this assumption may not cover all the possible WPT designs, it is expected that the constraint of compatibility for the charging operation is sufficient to ensure that the test results will be approximatively representative of most, if not all, conditions of operation.

In a similar fashion, the same reasoning applies to the compliance testing for the WPT transmitter, that would then be required to demonstrate compliance in a typical operating conditions, i.e. including being placed near a client device. For the most meaningful scenarios (i.e. worst-case impact on the WPT emissions as compared to stand-alone operations), the representative *client* device shall be characterized by a larger, rather than smaller, conductive surfaces. For instance a tablet or laptop is preferred to a small cellular phone.

The testing guidance considered in this section has a more general relevance, not just for WPT, i.e. pertain to all situations where a transmitter by design requires the installation near, or the presence of, other conductive structures that may affect its emissions[2], as compare to the case of unperturbed, nearly free-space, operations. For instance, this could be the case of an RF device to be installed near the surface of the body of a car.

For these cases the guiding principle is that Equipment Authorization requires testing in all "typical" operating conditions for establishing compliance of the device under test (DUT), that include those

involving the presence of passive structure that may alter the emission patterns. However, for Equipment Authorization purposes, the emissions due to other independently authorized transmitters do not need to be considered to account for possible cumulative effects with the emissions from the DUT.

5 EQUIPMENT AUTHORIZATION GUIDANCE FOR PART 18 WPT DEVICES

5.1 General Considerations

This section provides authorization guidance for WPT devices authorized to operate under Part 18 of the rules. Devices certified under Part 15 shall follow the applicable procedures as for all other Part 15 devices.

Per § 18.203(a), Part 18 equipment authorization is permitted via Supplier's Declaration of Conformity (SDoC) or Certification. The policy set forth in this KDB Publication applies to both types of equipment authorization. For devices authorized under the SDoC, the responsible party must keep a copy of the test report(s) demonstrating compliance and provide it to the FCC upon request, per KDB 865664 D02. For devices authorized under grant of certification, the application shall always include an RF Exposure exhibit supporting compliance, per KDB 447498 requirement.[4]

In general, equipment authorization under Part 18 is contingent on obtaining FCC concurrence that the design features comply with applicable FCC requirements for both EMC and RF exposure. The FCC equipment authorization program recognizes that there are cases where additional information may be needed prior to grant or recognition of an authorization. This procedure is in place to ensure that present and novel WPT technologies satisfy all the applicable requirements of the FCC rules in most foreseeable operational conditions.

Regardless of whether the SDoC or certification process is used, no authorization will be considered valid unless FCC concurrence has been obtained (unless the limited exception described in Section 5.2 applies).

Manufacturers shall use the KDB Inquiry process to obtain FCC concurrence. This KDB inquiry shall be made by selecting "Equipment Compliance Review" (ECR) as the first category and "Wireless Power Transfer" as the second category. The following information is to be included in the ECR KDB Inquiry:

- WPT operating frequency (or frequencies).
- Conducted power for each radiating structure.
- § 2.1091-*Mobile* or § 2.1093-*Portable* demonstrated scenarios of operation, including RF exposure compliance information
- Maximum distance from the WPT transmitter at which, by design, a load can be charged (including slow-charging operations)

A limited exception to the ECR submittal requirement is provided in Section 5.2. This section applies to Part 18 devices that deliver energy to their design targets through non-conducted electromagnetic coupling (thus radiated and/or inductive EM fields) at a distance no greater than one meter, measured between the closest points between the transmitting and receiving structures, and that meet all six criteria listed therein.

Section 5.3 provides guidance for Part 18 devices that deliver energy to their targets through non-conducted electromagnetic coupling at distances greater than one meter.

[4] KDB 447498 Web page note posted on 1/17/2023.

When applicable, for all the testing required to show compliance of WPT systems, adherence to the ANSI C63.30-2021 (American National Standard for Methods of Measurement of Radio-Frequency Emissions from Wireless Power Transfer Equipment) is encouraged.

5.2 Part 18 Wireless Power Transfer up to One-Meter Distance

This section applies only to WPT transmitters that, by design, can provide power to a load located at a distance no greater than one meter. This distance shall be measured between the closest points between the transmitter and the receiver enclosure surfaces. For instance, two coils positioned as in Figure 2-a may be operated and considered under the provisions of this section, because both receivers are within one-meter distance from the transmitter. However, the case in Figure 2-b cannot be considered in the same way, and it is treated according to the prescription of Section 5.3.

For WPT designs with more than one radiating structure the distance to the load shall be considered as in Figure 3, thus measured between the receiver and the closest transmitting structure.

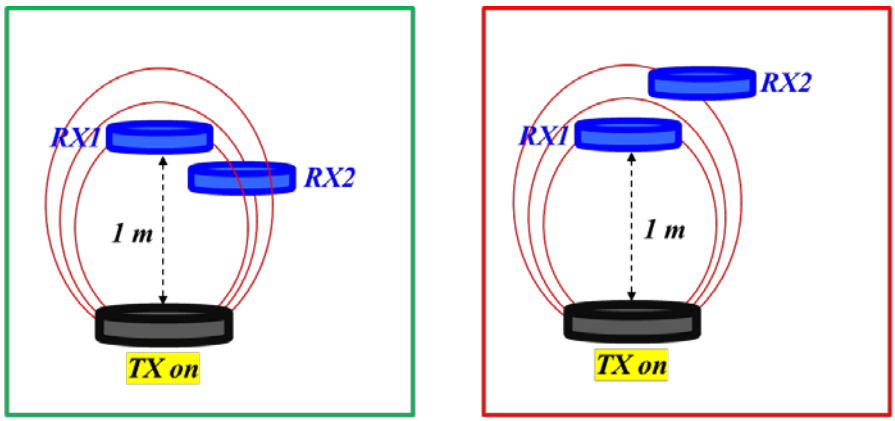

Figure 2-a) For multiple-receiver systems (here shown with two receivers, indicated with RX1 and RX2) the one-meter distance limit must apply for all the receivers that are engaged in the charging process. b) The WPT system is considered "at-a-distance" because it can function when the RX2 is further away than one meter from the transmitter.

There might be situations where the WPT RF emissions are limited enough that even operations in a "crowded" environment, where many similar WPT devices are present, do not pose significant EMC and RF exposure concerns. In this scenario, and for devices operating within a one-meter distance from the receiver, as defined above, a manufacturer will not have to submit an "Equipment Compliance Review" KDB, and receive FCC concurrence before proceeding with equipment authorization. This exception to the requirement of submitting the ECR to obtain FCC concurrence only applies when all the following criteria (1) through (6) are met:

(1) The power transfer frequency is below 1 MHz.

(2) The output power from each transmitting element (e.g., coil) is less than or equal to 15 watts.

(3) A client device providing the maximum permitted load is placed in physical contact with the transmitter (i.e., the surfaces of the transmitter and client device enclosures need to be in physical contact)

(4) Only § 2.1091-*Mobile* exposure conditions apply (i.e., this provision does not cover § 2.1093-*Portable* exposure conditions).

(5) The E-field and H-field strengths, at and beyond 20 cm surrounding the device surface, are demonstrated to be less than 50% of the applicable MPE limit, per KDB 447498, Table 1. These measurements shall be taken along the principal axes of the device, with one axis oriented along the direction of the estimated maximum field strength, and for three points per axis or until a 1/*d* (inverse distance from the emitter structure) field strength decay is observed. Symmetry considerations may be used for test reduction purposes. The device shall be operated in documented worst-case compliance scenarios (i.e., the ones that lead to the maximum field components), and while all the radiating structures (e.g., coils or antennas) that by design can simultaneously transmit are energized at their nominal maximum power.

(6) For systems with more than one radiating structure, the conditions specified in (5) must be met when the system is fully loaded (i.e., clients absorbing maximum power available), and with all the radiating structures operating at maximum power at the same time, as per design conditions. If the design allows one or more radiating structures to be powered at a higher level while other radiating structures are not powered, then those cases must be tested as well. For instance, a device may use three RF coils powered at 5 W, or one coil powered at 15 W: in this case, both scenarios shall be tested.

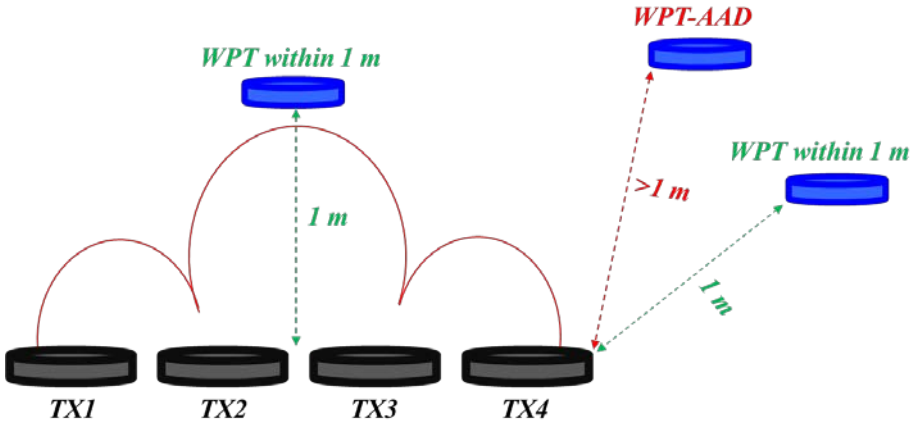

Figure 3. For multiple-coil transmitter systems, the one-meter distance limit is measured from the closest coil edge. A WPT within one meter operates with loads configured as those labeled in green font, if a load can be powered beyond one meter (in red), then it shall be considered "at-a-distance"

5.3 Part 18 Wireless Power Transfer Beyond One-Meter Distance

WPT transmitters operating under Part 18 that by design can provide power to a load beyond one-meter distance (WPT "at a distance" or WPT-AAD, as in the example of Figure 2-b) may be authorized via SDoC or certification. Under either process, manufacturers shall first obtain FCC concurrence via the "Equipment Compliance Review" KDB inquiry process, as described above (i.e., by submitting a KDB Inquiry with ECR as the first category, and "Wireless Power Transfer" as the second category).

The ECR KDB shall include the requested information as listed in Section 5.1 and, in addition, shall demonstrate that the device satisfies the following requirements:

1. Besides complying with the field strength limits in §18.305 (unwanted emission limits at 300 m and 1600 m distances[5]), the RF field strength measured beyond one meter (electric and magnetic components) is lower than that which is measured at one meter. These measurements shall be done while the transmitter is operating at full power to charge the client devices. The client device(s) shall be placed first within one meter from the transmitter antenna (or radiating structure) geometric center. Then, the client device(s) shall be placed beyond one meter, at least in two locations one meter apart (e.g., two and three meters away). The evaluation points shall be chosen along the direction of the main lobe of the field emission pattern (estimates of the lobe direction based on the transmitter geometry are acceptable, e.g., the main axis of a transmitter coil).

   If a field pattern estimate is unavailable, measurements shall be repeated on radials that are no more than 30° apart from the direction of the main axis of the radiating structure on the planes containing the three principal axes (i.e., x-y, x-z, and y-z). Both electric and magnetic field components must be measured if the one-meter location is not in the far-field region (computed based on the frequency and antenna size of the WPT transmitter).

2. Detailed installation instructions have been provided with the user's manual (or similar documentation) explaining that the requirements of this Section 5.3 shall still apply when the device is being installed or relocated, and that a device that does not meet those requirements will no longer be authorized to operate and may be subject to FCC enforcement processes.

3. In order to facilitate the FCC acceptance of the specific WPT design as outlined in the ECR-KDB Inquiry, it is recommended that the manufacturer supports provisions for product installation, and/or for post-installation product compliance verification, performed by trained professionals.[6] Manufacturers that deem these provisions as not necessary, must provide compelling reasons for that choice in the ECR-KDB Inquiry.

   This product installation, and/or for post-installation product compliance verification requirement pertains to scenarios of concern that may result from a combination of factors as follows:

   – a sufficiently large conducted power at the source (especially for ISM frequencies)

[5] This may be shown via direct measurement, numerical simulation validated with spot-check measurements from the device, or via extrapolation using 1/*d* far-field decay, where *d* is the distance from the RF source.

[6] In this context, "trained professionals" refer to personnel with the necessary training and qualifications to follow FCC and manufacturer-provided guidance. Verification of these credentials may be requested per § 18.115(c).

- largely unobstructed, unshielded emissions, typically occurring when the representative size of the target device is smaller or comparable to the distance from the transmitter or, for directive antennas, smaller than the beam diameter at the receiving distance.

- significant levels of unwanted emissions, in particular due to insufficient filtering when operating on an ISM fundamental frequency

- WPT transmitters operating with a high-gain directional antenna, and/or showing compliance by referring § 18.305 EMC limits computed based on transmitters' maximum EIRP

As an example, one of these scenarios may occur for installations in the presence of sufficiently large RF-reflective structures, and when the original design, while authorization-compliant, shows emissions near the allowable limits (i.e., for Part 18 authorizations, § 18.305 EMC limits and RF exposure limits referenced in 18.313).

Equipment subject to the requirements of this Section 5.3 cannot receive equipment authorization (neither certification, nor SDoC) unless the ECR KDB with the requirements stated above is accepted by the FCC.

When device equipment authorization is processed via SDoC, the manufacturer (or the *responsible party*, as defined in § 2.909) is still required to follow the described ECR procedure to obtain FCC concurrence. This is consistent with the duty of the responsible party under § 2.906(a) to "… *complete … other procedures found acceptable to the Commission to ensure that the equipment complies with the appropriate technical standards* ...".

If the manufacturer applies for equipment authorization through the certification procedure, the TCB shall be provided with a copy of the ECR KDB correspondence showing FCC concurrence. While the ECR KDB refers to a communication between the manufacturer and the FCC, the TCB may request and obtain clarification from the FCC on any matter discussed therein.

Change Notice:

04/09/2018: 680106 D01 RF Exposure Wireless Charging Apps v03 replaces 680106 D01 RF Exposure Wireless Charging Apps v02. Updates to Section 5 on equipment authorization considerations.

01/27/2021: 680106 D01 RF Exposure Wireless Charging Apps v03r01 replaces 680106 D01 RF Exposure Wireless Charging Apps v03. Updates to Section 3 on RF exposure requirements and Section 5 on equipment approval considerations.

10/24/2023: D01 RF Exposure Wireless Charging Apps v04 replaces 680106 D01 RF Exposure Wireless Charging Apps v03. Introduced many editorial changes, guidance for test compliance, and provisions for for WPT at a distance".