Document: RF EXPOSURE COMPLIANCE ASSESMENT OF AUTOMOTIVE WIRELESS POWER CHARGER

Project: MRA2-WMI

FCC ID: KR5DWMI2020A and KR5DWMI2020B

IC ID: 7812D-DWMI2020A and 7812D-DWMI2020B

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Version V1.2: June 15th 2020

Version V1.3: September 25th 2020

Analysis conclusion:

The Continental wireless chargers D-WMI2020A and D-WMI2020B complies with FCC requirement for RF exposure based on SAR approach at contact. The numerical analysis shows that for 10g tissue the Peak spatial-average SAR is 18.0mW/kg. This represents 0.45% of the 4W/kg basic restriction limit for 10g tissue according to FCC part 2 - §2.1093(d)(2).

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1 Introduction

This report presents the numerical modeling analysis performed to demonstrate compliance of the MRA2-WMI 15W automotive wireless charger operating at 127kHz with Federal Communications Commission (FCC) requirements for human exposure to radio frequency (RF) emissions.

Product FCC/IC ID:

- D-WMI2020A with FCC ID: KR5DWMI2020A
- D-WMI2020B with FCC ID: KR5DWMI2020B

The MRA2-WMI 15W automotive wireless chargers have been homologated with the real vehicle installation distance with bystanders.

MPE RF exposure in the original homologation for D-WMI2020A and D-WMI2020B shown compliance at distance of 7.3cm.

The present report completes the RF exposure assessment for these two models via SAR approach to asses compliance at product contact (note: Human body contact of the external surface of the whole product is 5mm distance from the transmitting coil)

FCC guidance have been provided through a specific KDB inquiry to ensure this SAR study reporting.

This computational analysis supplements the RF exposure report from this wireless charger with respect to the maximum permissible exposure (MPE) limits, according to 680106 D01 RF Exposure Wireless Charging App v03 and specific KDB inquiry.

The following SAR assessment includes a worst-case approach using:

- Worst case current flowing into the coil (i.e. 4Arms)
- Worst case transmitter model (i.e. transmitter coil with its ferrite and without receiver)
- Worst case phantom (i.e. flat phantom with worst case dielectric parameters for exposed tissue)
- Worst case vehicle installation

Deper details of the study are present in the “*Operational_Description_D-WMI2020A*” document (chapters 3-5).

2 System overview

This section describes how the system works in order to provide a basis for the approach used to efficiently compute the SAR exposure during RF charging of the client (i.e. smartphone)

2.1 Charging procedure

The wireless charger complies with Qi Wireless Power Transfer standard.
The user only needs to deposit his smartphone (Rx) on the interface surface of the transmitter (Tx) and after a short authentication routine, the wireless power transfer is activated.
Power transfer management is insured upon Rx request according to its battery level. This communication is based on load modulation of the carrier wave generated by the Tx.
Charging procedure could be stopped by 3 means:

- Removing the smartphone from the interface surface
- Stop request from the smartphone (battery fully charged or failure detection)
- By the transmitter itself in case of failure or metal parasitic object detection.

2.2 Inductive transfer system description

Power transfer is ensured by tight inductive coupling between transmitter's (Tx) coil and receiver's (Rx) coil.
The operating frequency for power transfer is 127kHz.
Maximum output power is 15W with a maximum current available in the Tx coil of 3.8Arms.
Power transfer system overview is shown in Figure 1 below.

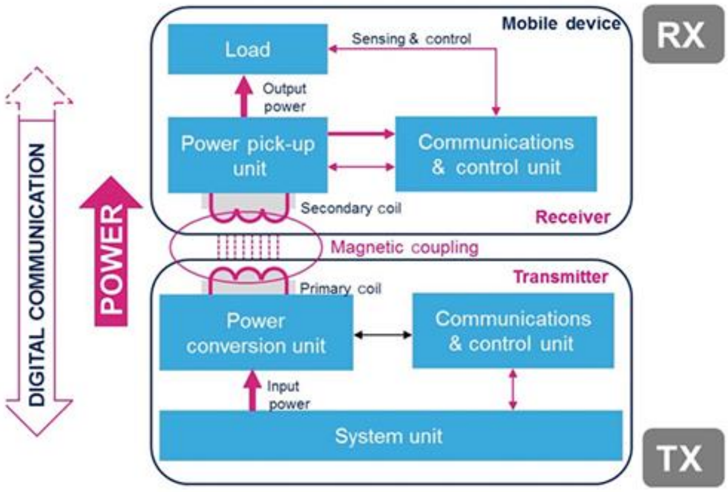


Figure 1: Power transfer overview Source: Digikey.be

2.3 System installation

The product is intended to be installed in a fixed location within a car (or removed) only by professional workers.

It could be installed in different carlines with different distance installations relative to bystander.
The minimum distance while charging is in contact with the interface surface which represents 0mm distance between product surface and the users' fingers (extremity). This installation is illustrated in Figure 2.

Figure 2: In cabin installation provided by OEM car manufacturer

3 SAR evaluation methodology

A numerical model of the DUT was generated and then validated by measurements of the magnetic field in its vicinity. Additionally the electrical parameters such coil impedance was used for comparison.
The field measurements were conducted and a correlation with simulation was done.
The specific Absorption Rate (SAR) values (10g tissue) in a model of a flat phantom were investigated similar to the measurement and assessment procedures as described in IEC/IEEE 62704-1.
SAR evaluation are done with a Sim4Life simulation tool with Magneto Quasi Static Solver.
Exhaustive details about the methodology are available in the "*Operational_Description_D-WMI2020A*" document.

3.1 WPC Modeling

MRA2-WMI wireless charger has two models D-WMI2020A and D-WMI2020B:

- D-WMI2020A model has the WPC and NFC functions. No simultaneous emissions are allowed.
- D-WMI2020B model contains the WPC function only. The hardware is similar to D-WMI2020A, but the NFC components are not populated.

Both models are presented in two versions, Low and High. The difference is the antenna PCB version as described below.

EM model of the wireless charger takes into consideration the mechanical assembly of the unit. The Figure 3 shows the manufactured product and the mechanical stack up.

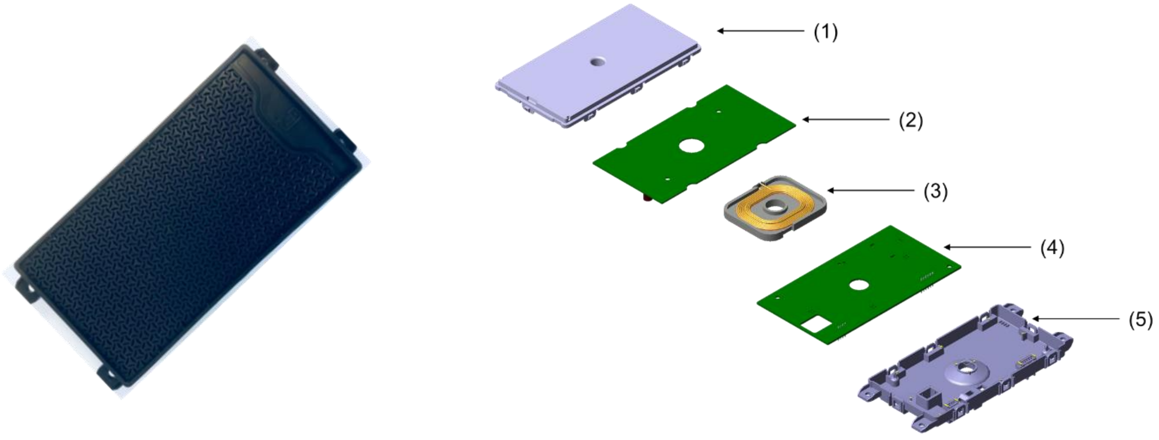


Figure 3: a) Manufactured wireless charger and b) Mechanical stack up

Where:

(1) **Top housing** in plastic material (polypropylene).
  a. Not considered in simulations. No impact on magnetic field.

(2) **Antenna PCB** in FR4 material containing copper traces
  a. Only copper traces were considered for the simulations

(3) **Wireless charging coil** (copper) with ferrite
  a. Complete model considered for the simulations

(4) **Main PCB** in FR4 material containing copper traces in four layers.
  a. Only all copper traces in all layers were considered for simulations.

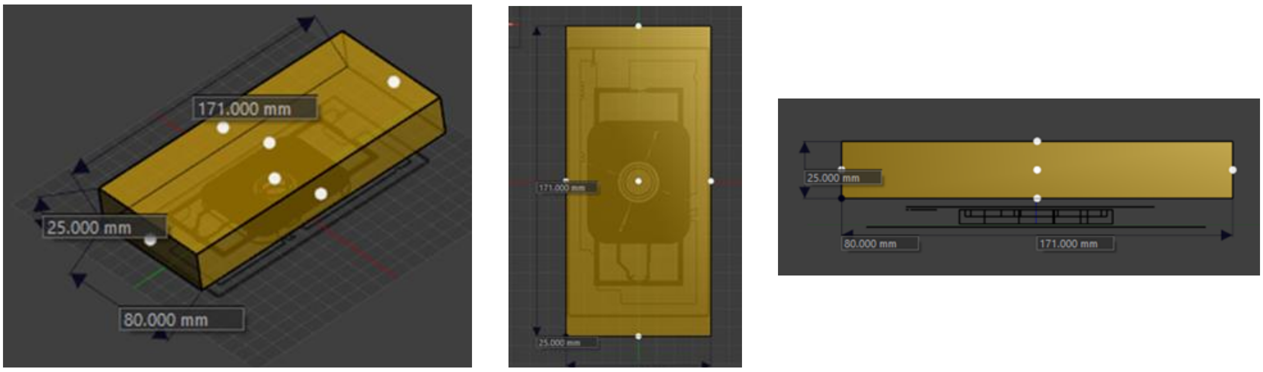
(5) **Bottom housing** in plastic material (polypropylene)
  a. Not considered in simulations. No impact on magnetic field.

Detail explanation about the DUT modeling can be found in "*Operational Description*" document.

3.2 Phantom model

As mentioned in Figure 2, worst case vehicle installation provided by OEM shows that the fingers extremities of the bystander are the more exposed at the considered distance.
As specified in KDB 447498 D01 General RF Exposure Guidance v06 §4.2.3, "When extremity SAR testing is required, a flat phantom must be used if the exposure condition is more conservative than the actual use conditions".

The dimensions of this flat phantom are 171mm x 80mm x 25mm, as shown in Figure 4. Dimensions have been chosen to ensure that the phantom fits with all different vehicle installations.



a) Isometric view b) Top view c) Side view

Figure 4 : Flat phantom dimensions

The typical dielectric parameters applicable at 127kHz for human body tissues are presented into Table 1. Only tissues present into a hand are indicated.

Hand parts	Relative Permittivity ε_r	Conductivity σ (S/m)	Mass Density ρ (Kg/m3)
Bone	438	0.084	1178
Muscle	7512	0.368	1090
Tendons/Ligaments	402	0.389	1142
Skin	1115	0.0006	1109

Table 1 : Dielectric characteristics @ 127kHz of human tissues present into a hand from IT IS database [2]

The dielectric characteristics retained for flat phantom have been defined as worst case tissues parameters at 127kHz. Explanations are developed in "*Operational_Description_D-WMI2020A*" document. The retained values are the following:

- *Dielectric relative permittivity* (ε_r) = **1**
- *Electrical conductivity* (σ) = **0.4** *S/m*
- *Tissue density* (ρ) = ***1000*** *Kg/m*^{3}

4 EM simulations

The EM model was built validating each modelization step by measurements to select the worst-case scenario for SAR calculations.

The detail of the study covers variants, prescence of receiver and metal around the product are decribed in detail in "*Operational Description*" document.

Low and High variants have been compared. <u>Similar behavior is found with a slightly higher magnetic field emissions (~0.1%) in a proximity region to WPC coil for the Low version</u>.

The presence of the receiver on the product has been analyzed. For instance, at 4cm the magnetic field for the wireless charger with receiver is 5 times lower than the one with the wireless charger without receiver. Thus, the WPC <u>Receiver acts as shield for the magnetic field by reducing the emissions levels</u>.

The impact of the environment around the product has been also analyzed by considering only metallic objects 20 cm around the product. The results show that <u>metallic objects don't influence the maximum amount of magnetic field emitted in the main direction</u>. Only small locally influences in a metal proximity of the magnetic field are observed. The maximum magnetic field remains on the top of the product and is not impacted by the presence of the metal surrounding it.

After worst case analysis, taking in consideration the variants, the presence or not of receiver and environments, it is demonstrated that the **worst-case configuration for the SAR calculation is the Low Version** variant of the MRA2-WMI wireless charger.

Low version variant is depicted here in Figure 5.

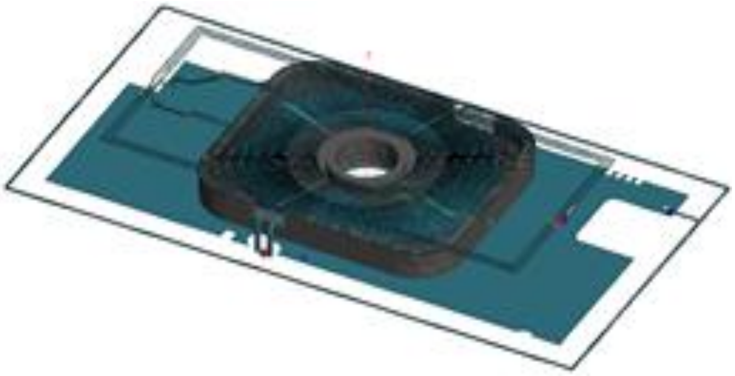


Figure 5: Low version EM model

5 Electrical parameters test setup measurements

The electrical parameters considered are the impedance seen by the WPC coil. Impedance measurements are performed at each step of the modeling for validating the EM model. Detail in "*Operational_Description_D-WMI2020A*" document.

6 EM Field test setup measurements

The purpose of the EM field measurements is to enhance the EM model to reach good correlation with regards of magnetic field level.
Measurement have been performed with E/H field-probe Wavecontrol WP400-3 Isotropic selective E/H field-probe 3cm^2 and EM field meter Wavecontrol SMP2.

7 EM simulations and measurements correlation for worst-case configuration.

EM simulations are in a good agreement and correlate to electrical parameters and field measurements.

7.1 Electrical parameters

Electrical parameters for Low version in simulations and measurements are compared in Table 2.

	Low version	
	Inductance Ls (µH)	**Resistance Rs (mΩ)**
Simulations	13.08	68
Measurements	13.47	76
Difference (%)	2.9	9.97

Table 2: Low version

Correlation error: Model Ls deviation: <3%; Model Rs deviation: <10%. Rs parameter is out of interest as B field only dependent on Ls.

7.2 Magnetic field

The magnetic field for Low version in simulations and measurements are compared here (Figure 6).

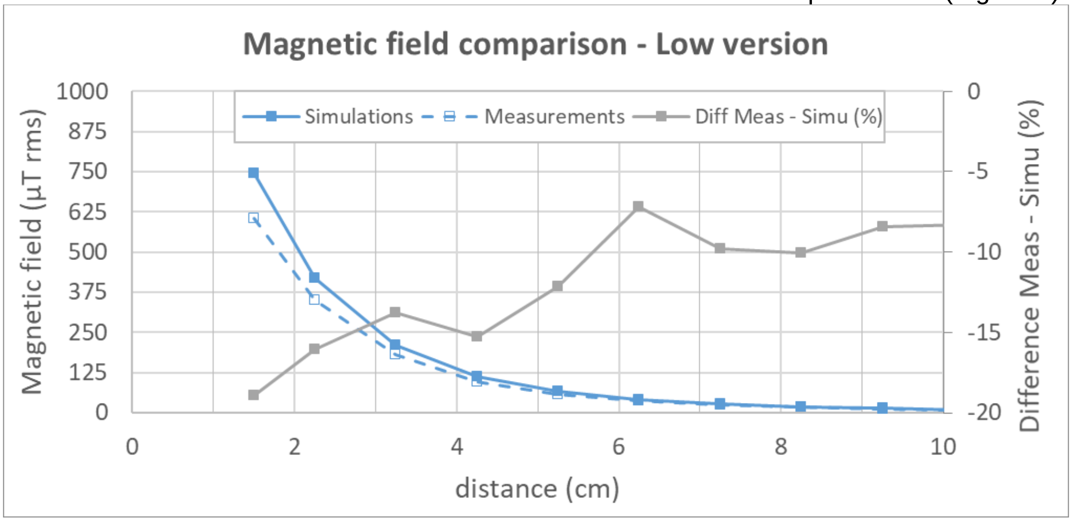


Figure 6: Simulated and measured magnetic field for Low version

Correlation error: Magnetic field: < -20% Simulations overestimates the magnetic field levels, which goes in the direction of the worst-case approach.

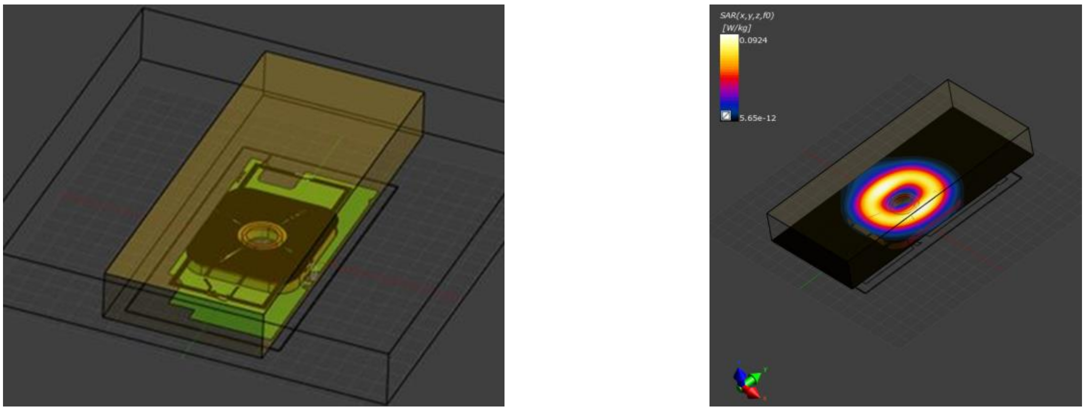
8 SAR analysis results

The SAR calculation considers:

- Worst case sample configuration -> As described in §7 above, the worst-case sample configuration is the Wireless charger alone, **Low version**.
- Worst case flat phantom -> As described in §3.2 above, the worst-case dielectric parameters are used for the flat phantom.
- Worst case current -> The magnetic field corresponds to the maximum current flowing in the WPC coil, which is 4Arms (+5% of real maximum use case = 3.8Arms).

8.1 SAR calculation for Wireless charger Low version

The phantom model is illustrated in Figure 7(a). Local Peak SAR mapping is also represented in Figure 7(b).

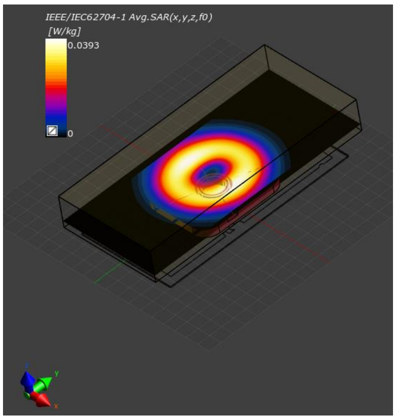


a) Phantom model b) SAR distribution

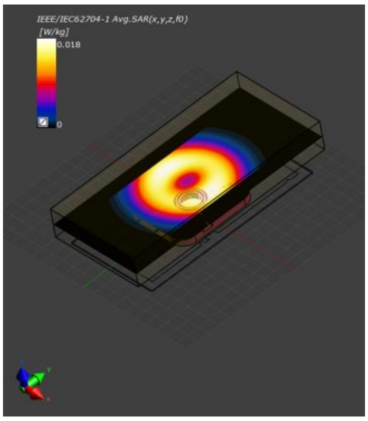
Figure 7: Flat phantom over the wireless charger Low version alone and its SAR distribution

Maximum SAR is in a proximity zone over the WPC coil as shown in Figure 7.

Figure 8 illustrates the SAR averaged over 1g and over 10g tissue according to IEC62704-1 standard.



a) 1g averaged SAR



b) 10g averaged SAR

Figure 8: Averaged SAR over 1g and 10g.

Peak spatial-average SAR computed over 1g tissue is **39.3mW/kg** and for 10g tissue is **18.0mW/kg** considering a current of 4Arms flowing into the coil.

Then, concerning the assessment for the average SAR for Whole-Body, FCC requires a value lower than 0.08 W/kg. Since the peak spatial-average SAR 10g for extremity is lower than 0.08 W/kg for a worst-case scenario, this implies obviously that the global Whole-body average will be respected.

Indeed, since the regions with significant SAR exposure are limited to the regions very near to the device, taking the average over a larger body will only reduce the SAR value. Human bodies mass is significantly larger than the small tissue phantom modeled here. It therefore seems reasonable to argue that Whole-Body requirement will be meet in all normal use cases.

9 Conclusion

The basic restriction limit is set for 10g peak spatial-average SAR at 4W/kg for extremities.

The proposed worst-case analysis for Continental wireless charger D-WMI2020A and D-WMI2020B shows a **maximum 10g peak spatial-average SAR of 18.0mW/kg** at contact. This value is less than **0.45%** of the **4W/kg** basic restriction limit for 10g tissue. **Thus, the analyzed wireless charger complies with FCC requirement.**

10 References

[1] Tetsu Sunohara, Ilkka Laakso, Akimasa Hirata, Teruo Onishi, *Induced Field and SAR in Human Body Model Due to Wireless Power Transfer System with Induction Coupling*, EMC'2014/Tokyo

[2] *https://itis.swiss/virtual-population/tissue-properties/database/database-summary/*

11 Appendix: Specific information for numerical SAR simulation

This appendix follows the structure outlined in *KDB 865664 D02 RF Exposure Reporting v01r02, October 23, 2015, part 2.5*. Most of the information regarding the code employed to perform the numerical computations has been adapted from the Sim4life User Manuals. The software supplier company (ZMT) is acknowledged for the help provided.

11.1 a) Computational resources

1. *a summary of the computational resource required to perform the SAR computations for the test transmitter and phantom configurations*

   Answer: A machine with the following characteristics has been used for SAR computations of the test transmitter with phantom:

   Hewlett-Packard HP Z440 Workstation
   Intel® Xeon® CPU ES-1620 v4 @ 3.50GHz 4 cores
   RAM Memory 16 Go
   System 64 bits, processor x64

2. *a summary of the computational requirements with respect to modeling and computing parameters for determining the highest exposure expected for normal device operation, such as minimal computational requirements and those used in the computation*

   Answer: Hybrid approach is proposed in this report. This approach allows a reasonable tradeoff between maximum details of the wireless charger and time/resource simulations capabilities.

11.2 b) FDTD or other numerical modeling algorithm implementation and validation

1. *a summary of the basic algorithm implementation applicable to the particular SAR evaluation, including absorbing boundary conditions, source excitation methods, certain standard algorithms for handling thin metallic wires, sheets or dielectric materials etc.*

   Answer: Continental has employed a commercial code (Sim4life Version 5.2.2.1924 from Zurich Med Tech company) that implements a FDTD solver and a Magneto Quasi Static Solver. For present analysis, the Magneto Quasi Static Solver has been used.
   For this, the calculation is run according to Finite Element Method using voxel meshing.
   The meshing process have been derived from the FDTD codes of the software. Therefore, the SAR processing is in accordance with SAR processing from FDTD standards based on voxels definitions.
   The process is divided in two steps.
   - First the magnetic field radiated by the transmitter is computed all around the transmitter and particularly into the space region where the phantom will be located. The magnetic field is calculated by FEKO using the Method of Moment (MoM).
   - Then the magnetic field is considered as source for SAR calculations with a phantom. The solver used in this last step is named "Magneto Quasi Static" in Sim4life.

   SAR evaluation is computing spatial-average SAR with moving constant-mass cubes, as recommended in IEEE/IEC62704-1 standard.

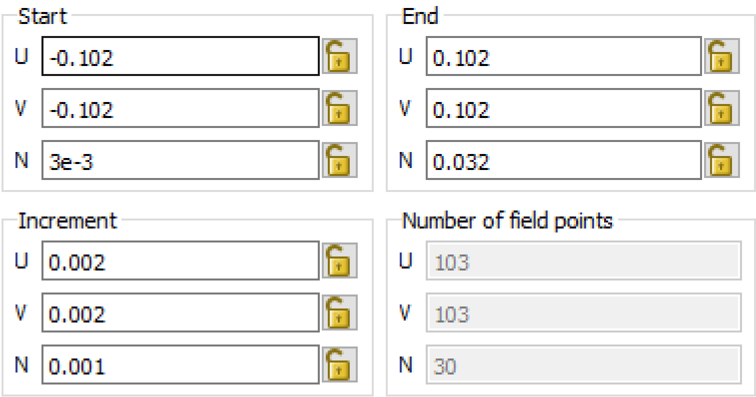
2. *descriptions of the procedures used to validate the basic computing algorithms described in a) and analysis of the computing accuracy based on these algorithms for the particular SAR evaluation*

   Answer: Sim4ife is well recognized simulator tool among medical community to validate RF human exposure.

11.3 c) Computational parameters

1. *a tabulated list of computational parameters such as cell/voxel size, domain size, time step size, tissue and device model separation from the absorbing boundaries and other essential parameters relating to the computational setup requirements for the SAR evaluation*

   Answer:
   FEKO fields data:
   The model has been created with FEKO and calculated with the Method of Moments; a low frequency stabilization option has been used. The near fields into FEKO are requested in an area above the coil, larger than the expected phantom dimensions.
   The requested points are described in the following figure.



   Overall, these points, the magnetic flux density is exported as source data for Sim4life.

   Sim4life phantom modeling:
   The only area to be modeled is the phantom for SAR calculation. MQS methodology does not require distance in between the box borders and the model to be calculated. No propagation, the only presence of the magnetic fields as excitation is requested.
   Some characteristics of computational parameters are provided in Table 3:

	Data
Phantom size	171mm x 80mm x 25mm
Voxel size	0.3mm x 0.3mm x 0.3mm
Number of voxels for phantom	12 784 000 cells

Table 3: computational parameters

   The phantom is described as lossy dielectric material.

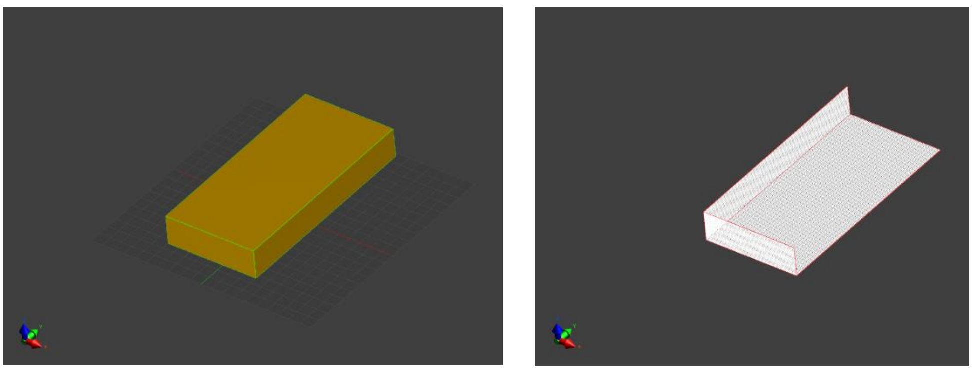


Figure 9 : Voxeled Phantom view (left picture)
Requeted grid view for SAR calculation (right picture)

2. *a description of the procedures used to handle computation efficiency and modeling accuracy for the phantom and the test device*

   Answer: Entire description is done in the previous paragraph.

11.4 d) Phantom model implementation and validation

1. *identify the source of the phantom model, its original resolution and the procedures used to code and assign tissue dielectric parameters for the SAR evaluation*

   Answer: Typical use case for wireless charging is when a hand can touch the surface of the wireless charger. Foreseeable and reasonable use cases could be in addition once a user is laying on the surface and less probably one a head is also laying on it.

   Since the user body surface is much closer to the wireless charger interface surface, more is the magnetic field exposure level. Moreover, the size of the exposed body surface influences the SAR calculation. In fact, bigger is the surface and more the Eddy currents distribution is important on the surface. Thus, the peak SAR is expected to appear in proximity zones to the body surface exposed to RF fields with a reasonable body surface.

   In consequence, an hypothetical part of the body has been used as flat phantom for SAR evaluation. Moreover, since RF exposure will be determined for standard usage on a hand (body extremity - typical use case), flat phantom appears as a worst-case situation according to KDB 447498 D01 General RF Exposure Guidance v06.

2. *verify the phantom model is appropriate for determining the highest exposure expected for normal device operation*

   Answer: Validation of the proposed flat phantom was carried out by considering the phantom size effect.

Peak spatial-average SAR	Large phantom 200 mm x 200 mm x 25 mm	Small phantom 80 mm x 171 mm x 25 mm
for 1g tissue	36.6 mW/kg	39.3 mW/kg
for 10g tissue	16.1 mW/kg	18.0 mW/kg

Table 4: Phantom size impact comparison

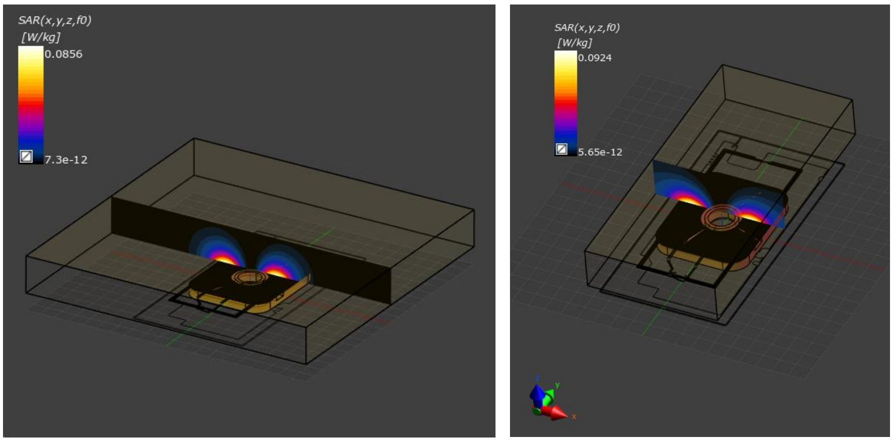


Figure 10 : Local SAR distribution on XZ plane inside large phantom (left picture) vs small phantom (right picture)

The SAR distribution is very close in the common part of the two analyzed phantoms dimensions. Peak spatial-average SAR is also quite equal for the two phantoms analysis.

3. *describe procedures used to verify the phantom model has been correctly constructed for making SAR computations, such as comparing computed and measured SAR results of a dipole or a reference source*

Answer: NA. Hypothetical worst-case tissue has been chosen for SAR assessment, dielectric parameter under discussion within an specific KDB inquiry.

11.5 e) Tissue dielectric parameters

1. *a description of the types of tissues used in the phantom models and the sources of tissue dielectric parameters used in the computations*

Answer: Worst case has been determined according to dielectric values of the different tissues that are contained into a hand, as indicated into **Table 1**.

SAR can be obtained using the following equation described in IEEE C95-3:

$$SAR = \frac{\sigma E^2}{\rho}$$

Where:

SAR	is the specific absorption rate in watts per kilogram (W/kg);
E	is the r.m.s. value of the electric field strength in the tissue in volts per meter (V/m);
σ	is the electric conductivity of the tissue in siemens per meter (S/m);
ρ	is the density of the tissue in kilograms per cubic meter (Kg/m^3).

Since SAR is directly proportional to the conductivity (σ), the maximum value (0.4 S/m) has been considered as worst case allowing the highest SAR values.

SAR is also proportional to the square electric field into the body. The electric field is inverse proportional to the relative permittivity (ε_r). Consequently, a worst-case scenario appears if the permittivity is set to the physically minimum. For worst case approach, the relative permittivity is set to 1 even if this value is very far from real tissue values.

The Figure 11 bellow illustrates the boundary conditions for the electric field between two medias. Normal electric field component to the surface is affected by the permittivity.

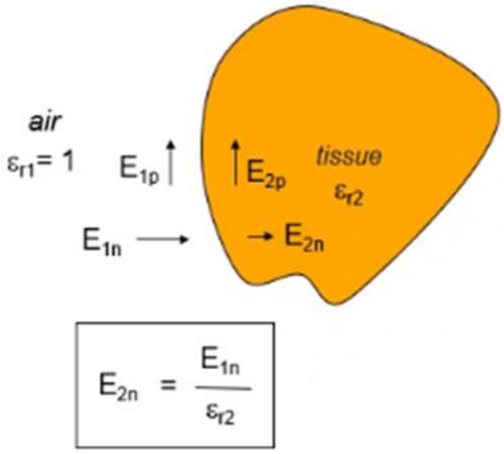


Figure 11: Electric field incidence into a media

2. *verify the tissue types and dielectric parameters used in the SAR computation are appropriate for determining the highest exposure expected for normal device operation*

   Answer: A worst case scenario has been imagined.

3. *a tabulated list of the dielectric parameters used in the device and phantom models*

   Answer: Description is given into **Table 1** of the report.

   The retained parameters for a worst-case scenario are presented hereafter.

Hand parts	**Relative Permittivity** ε_r	**Conductivity** σ **(S/m)**	**Mass Density** ρ **(Kg/m3)**
Worst Case Tissue	1	0.4	1000

Table 5 : Phantom tissue dielectric parameters

11.6 f) Transmitter model implementation and validation

1. *a description of the essential features that must be modeled correctly for the particular test device model to be valid*

   Answer: The impedance / magnetic field emissions seen / transmitted by the WPC coil were analyzed by simulation and measurement at each step of the modelization. EM model has a good representation of the real device. More details in the section Appendix 1 of the "*Operational_Description_D-WMI2020A*" document.

2. *descriptions and illustrations showing the correspondence between the modeled test device and the actual device, with respect to shape, size, dimensions and near-field radiating characteristics*

   Answer: See details in the section Appendix 1 of the "*Operational_Description_D-WMI2020A*" document.

3. *verify that the test device model is equivalent to the actual device for predicting the SAR distributions for satisfying 47 CFR §§2.907 and 2.908 of Commission rules*

   Answer: During wireless charging process, the power is adjusted by the receiver. The maximum current provided by the transmitter is 3.8Arms +/- 0.1Arms. However, due to components variation, we are considering the maximum current as 4Arms (+ 5%).

4. *verify the SAR distribution for high, middle and low channels, similar to those considered in SAR measurements for determining the highest SAR*

   Answer: Only one WPC coil is implemented in the product with only one operating frequency.

11.7 g) Test device positioning

1. *a description of the device test positions (left, right, cheek, tilt, surface, edge etc.) used in the SAR computations*

   Answer: Magnetic field levels where measured on the top of the product (maximum emissions direction). Details in §7.2 above.

   To confirm the maximum direction exposure, two additional measurements were performed:
   - Measurements on top of the product but aligned with the edge (Figure 12).

- Measurements on two orthogonal planes on top of the product (Figure 13).

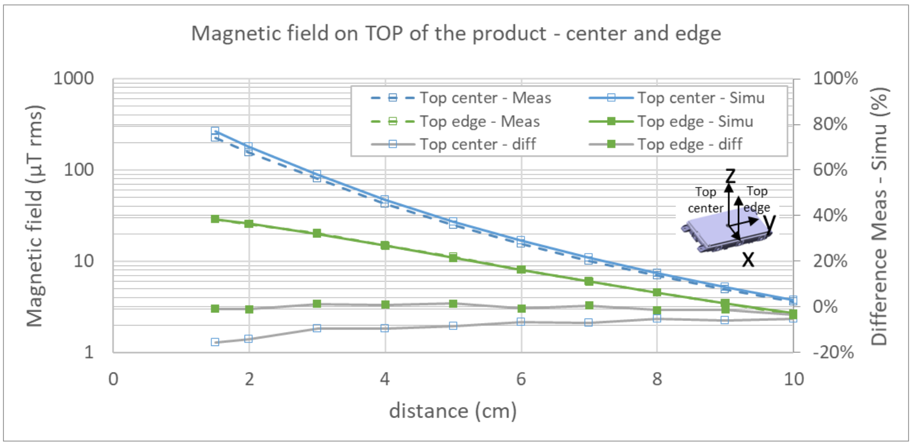


Figure 12: Magnetic field on top center and top edge

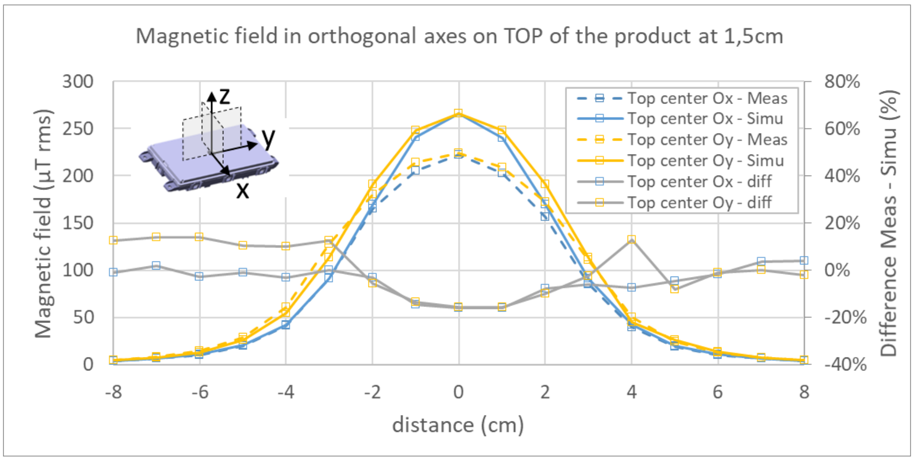


Figure 13: Magnetic field on top of the product in two planes

From these two additional measurements, it's confirmed the maximum direction of RF exposure is in the middle of the WPC coil (middle of the product) and in the perpendicular direction to the product top surface.

SAR computation takes a phantom model in a region of maximum RF exposure in contact condition; this means Phantom position is set parallel to transmitting coil and covering the surface of the product.

2. *illustrations showing the separation distances between the test device and the phantom for the tested configurations, similar to the reporting procedures used in SAR measurements*

   Answer: The separation between the product (wireless charger + rubber mat) and phantom is 0mm. This means the phantom is laying on the surface of the product.

11.8 h) Steady state termination procedures

Not applicable to Magneto Quasi Static calculation.

11.9 i) Computing peak SAR from field components

1. *a description of the procedures used to compute the sinusoidal steady total electric field with the required field components at each tissue location*

   Answer: Not applicable to Magneto Quasi Static approximation.

2. *a description of the expected error margin provided by algorithms used to compute the SAR at each tissue location according to the required field components and tissue dielectric parameters*

   Answer: Worst case approach has been preferred.

11.10 j) 1-g averaged SAR procedures

1. *a description of the procedures used to search for the highest 1-g averaged SAR, if applicable, including the procedures for handling inhomogeneous tissues within the 1-g cube*
2. *the 1-g cube tolerance should be determined according to (draft) IEC 62704-1 requirements*
3. *a description of the expected error margin provided by algorithms used to compute the one-gram SAR*

Answer for the 3 points:
The peak SAR algorithm is compliant to IEC 62704-1 standard.

Software supplier, Zurich Med Tech Company, has provided a validation report named “Sim4Life EM-FDTD Solver Verification According to the IEC/IEEE 62704-1-2017 Standard”.
This document has been transferred to FCC via specific KDB inquiry.

11.11 k) Total computational uncertainty

1- *a description of the expected error and computational uncertainty for the test device and tissue models, test configurations and numerical algorithms etc.*

Answer: Software supplier, Zurich Med Tech Company, has provided a validation report named “Sim4Life and SEMCAD X Low Frequency Magneto Quasi Static Solver”.
This document has been transferred to FCC via specific KDB inquiry.

Section 4 Conclusions of the document is indicating about the magnetic field calculation:
“It was shown that grid resolution has an important impact on accuracy. It is possible to keep the deviation between numerical and analytical solutions lower than 0.5%, by choosing the appropriate discretization (grid step). “

11.12 l) Test results for determining SAR compliance

1. *illustrations showing the SAR distribution of dominant peak locations produced by the test transmitter, with respect to the phantom and test device, similar to those reported in SAR measurements*

   Answer: Details in §8 above.

   Remark: the peak spatial-average SAR 1g or 10g have been shown; as a remark, due to symmetry of the coil, very near SAR density occurs just above the coil. The Figure 14 :is also an illustration for such situation.

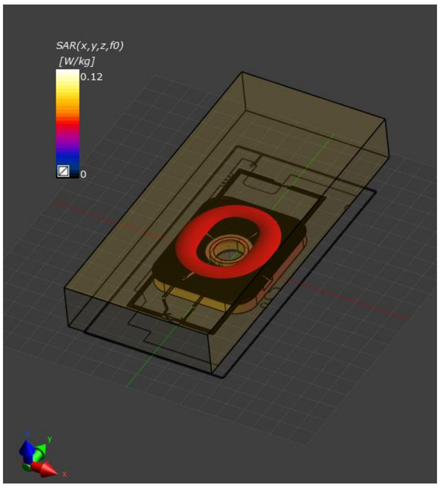


Figure 14 : Iso surface SAR distribution

2. *a description of how the maximum device output rating is determined and used to normalized the SAR values for each test configuration*

   Answer: Worst case approach, assuming an hypothetical body part permanently exposed to a peak SAR.
   In the proposed worst-case approach, the smartphone shield is not considered for allowing maximum RF exposure as explained in §7 above.

3. *if applicable, a description of the procedures used to compute source-based time-averaged SAR*

   Answer: Worst case approach, assuming an hypothetical body part permanently exposed to a peak SAR with a maximum continuous carrier wave. In typical use cases, RF exposure with real smartphone drops accordingly to the battery charge increase.