Document:	SAR COMPUTATIONAL COMPLIANCE ASSESEMENT OF AUTOMOTIVE WIRELESS POWER CHARGER
Project:	WCA NFC 2.0
FCC ID:	KR5WCANFC2.0
Date:	July 22th, 2020
Version:	Version 2
Analysis conclusion :	The Continental wireless charger WCA NFC 2.0 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 21.24mW/Kg. This represents 0.5% of the 4W/Kg basic restriction limit for 10 g tissue. And for 1g tissue, the Peak Spatial-Average SAR is 45mW/Kg, this represents 3% of the 1.6W/Kg basic restriction limit according to FCC part 2-§2.1093(d)(2).

	Name	Department	Phone	Date	Sign
Author	Brahim Aloui	I BS PG3 RF	(33) 05 62 23 14 34		
Checked by	Said Bouguern	I BS PG3 RF	(33) 05 61 19 82 66		
Approved by	Rachid Benbouhout	I BS PG3 RF	(33) 05 61 19 84 77		

CONTENTS

1 Introduction

This report presents the numerical modeling analysis performed to demonstrate compliance of the WCA NFC 2.0 15W automotive wireless charger, operating at 127kHz, with Federal Communications Comission (FCC) requirements for human exposure to radio frequency (RF) emissions.
The FCC report [3] has been used as a guideline to write this report as it covers wireless charger SAR for low frequency application.

This computational analysis supplements the measurement conducted to evaluate the compliance of the exposure 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.

This computational analysis has been performed as user and bystander can be exposed at a distance lower than 20cm. This wireless power charger WCA NFC 2.0 is considered as portable device and Continental is willing to ensure compliance at contact with the charging pad with the specific absorption rate (SAR) limits for general public exposure according to FCC part 2-§2.1093(d)(2).

Human body contact to this charging pad represents a distance of 5mm from the transmitting coil.

The following SAR assessment includes a worst case approach using:
- Worst case current flowing into the coil (i.e 4Arms : +5% of operational maximum current)
- Worst case transmitter model (i.e transmitter coil with its ferrite and without receiver)
- Worst case phantom (ie. flat phantom with worst case dielectric parameters for exposed tissue)
- Worst case vehicle installation

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 system 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 authentification routine, 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 client 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 client's (Rx) coil.
The frequency to support power transfer is 127kHz.
Maximum output power, delivered by a unique transmitting coil at a time, is 15W with a maximum current available in the Tx coil of 3.8Arms.
Power transfer system overview is shown in figure1 below.

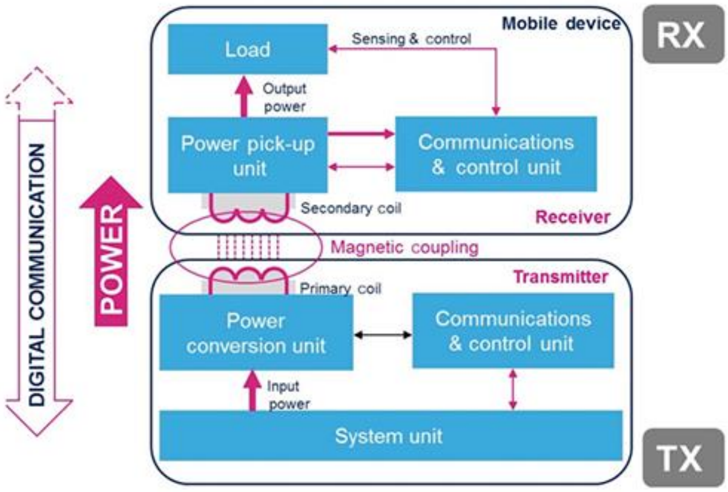


Figure 1: Power transfer overview
Source : Digikey.be

2.3 System installation

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

It could be installed in different car lines with different distance installations relative to bystander.
The minimum distance while charging is in contact with the charging pad (where a smartphone can be placed). This represents an internal distance inside the product itself of 5mm between Tx coil and the users' fingers (extremity).
This installation is illustrated by figure 2.

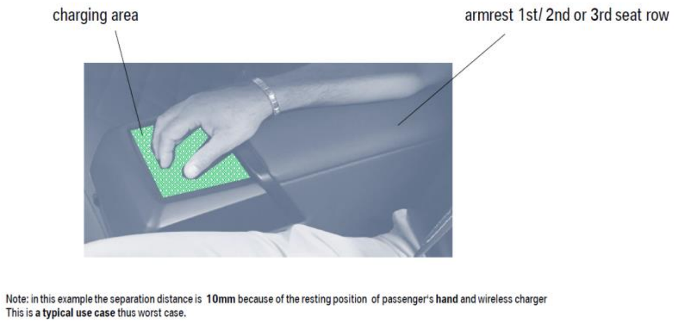


Figure 2. In cabin installation provided by OEM car manufacturer

3 SAR Evaluation Methodology

SAR evaluation is based on numerical approach.

This approach consists of modeling the transmitter and generating the corresponding magnetic field within the Sim4life and FEKO softwares.

The validation of the simulation results was carried out during the EM modelization. In fact, the EM model was built step by step. Each simulation step was validated by measurements (Coils' electrical parameters and magnetic field measurements) and the EM models was adjusted to fit the measurements of the Wireless Charger.

This methodology allows a reliable SAR simulation since it is not needed to build the full transmitter within SAR simulation SW.

3.1 Software and Computer tool

In this section, the two EM simulation softwares are presented.
Sim4life (ZMT) has been used for electromagnetic field and Peak SAR computations whereas FEKO (Altair) has been used for EM modelization, electric parameters and magnetic field correlations.

3.1.1 Sim4Life

This software uses a Magneto Quasi Static Solver and allows to:

- compute spatial-average SAR with moving constant-mass cubes, as recommended in IEEE/IEC62704-1 standard
- compute surface-averaged current densities, according to ICNIRP 1998 guidelines
- compute induced electric fields, which are determined as a vector average of the electric field within a small contiguous tissue cubic volume of 2 x 2 x 2 mm^3, according to ICNIRP 2010 guidelines.
- compute a line-average of the induced electric field, according to IEEE C95.1 2005 (Sec. 4.1.1). It provides spatial averaging of the power density through a surface. It implements the IEEE Standard C95.1a, section C.2.3.

Magneto quasi static approximation can be considered for the presented wireless power charger.
As explained by Sunhohara [1] part II-B : "*the displacement currents are neligible when compared with the conduction current because the magneto-quasi-static approximation is applicable in the frequency band of kHz*."

3.1.2 FEKO

Detailed models have been also achieved with the industrial standard electromagnetic simulation software FEKO using the Method of Moments. This software will be the reference for fields comparison to measurements since the solver is a full wave calculation and the model can be more detailed than magneto quasi static approach.

3.2 Simulation methodology for Peak SAR computation

The Magneto Quasi Static simulation methodology has been used for extremity peak SAR computation. This process is divided in two steps.
1st step: the magnetic vector potentials of the transmitter are computed in all directions and particularly into the space region where the phantom will be located. The specific solver (named Magneto Static Vector Potential) allows the calculation for ferrite materials. Note that the magnetic vector potential can be directly derivated to calculate the magnetic flux density B.

2nd step: these magnetic vector potentials are considered as source for PeakSAR calculation with the phantom. The magnetic field is only relevant for SAR calculation at low frequencies (kHz band), as explained by Sunhohara [1] part II-B : "*The simplification for using the external field without the human body is supported by the fact that i) the human body behaves as a conductor and thus ii) the SAR is primarily caused by the external magnetic field rather than the electric field*".

3.3 WPC Modeling

The WCA NFC 2.0 15W wireless power charger is using the Power Transmitter design from Qi standard : MPA6.

Therefore, EM modeling of the transmitting coil has been built according dimensional parameters advised within the Qi specification. This model of triple coil is shown in the figure 3 :

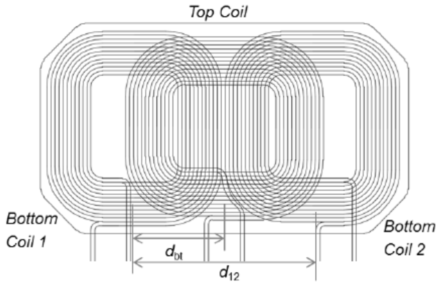


Figure 3. Bottom and Top primary coils of Power Transmitter design MP-A6
source Qi1.2.3 standard

The two coils which are in the bottom side (closer to the ferrite) have a displacement between their centers of d_{12} = 46 $^{\pm4}$ mm, and the displacement between central coil and one bottom coil centers is d_{12} = 23 $^{\pm2}$ mm.

The specific dimensions of these coils (Top and bottom) are shown below in figure 4.

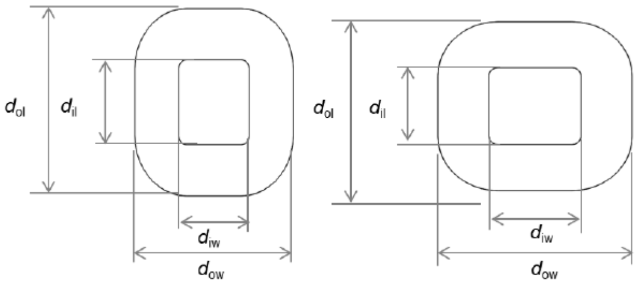


Table 137. Bottom Primary Coil parameters of Power Transmitter design MP-A6

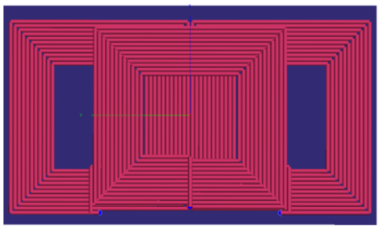
Parameter	Symbol	Value
Outer height	d_{ol}	$49.0^{\pm1.0}$ mm
Inner height	d_{il}	$26.0^{\pm1.0}$ mm
Outer width	d_{ow}	$44.0^{\pm1.0}$ mm
Inner width	d_{iw}	$22.0^{\pm1.0}$ mm
Thickness	d_c	$1.1^{\pm0.2}$ mm
Number of turns per layer	N	11
Number of layers	—	1

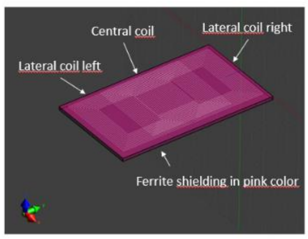
Table 138. Top Primary Coil parameters of Power Transmitter design MP-A6

Parameter	Symbol	Value
Outer height	d_{ol}	$46.0^{\pm1.0}$ mm
Inner height	d_{il}	$21.0^{\pm1.0}$ mm
Outer width	d_{ow}	$49.5^{\pm1.0}$ mm
Inner width	d_{iw}	$25.5^{\pm1.0}$ mm
Thickness	d_c	$1.1^{\pm0.2}$ mm
Number of turns per layer	N	12
Number of layers	—	1

Figure 4. Coil dimension for modeling
source Qi1.2.3 standard

The figures 5a), 5b) and 5c) below present the real antenna and its two different models (FEKO & Sim4life)





(a) Prototype (b) FEKO simulation model (c) Sim4Life simulation model

Figure 5. Considered MPA6 Tx coil

3.4 Phantom model

As mentioned in figure 2, worst case vehicle installation provided by OEM shows that the fingers extrimities 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”.

Moreover this fits with our worst case approach: the exposed surface of a flat phantom is much more critical compared to a realistic hand model.

The dimensions of this flat phantom is 20 cm x 20cm x 10cm (Length x width x height), as shown in figure 6.

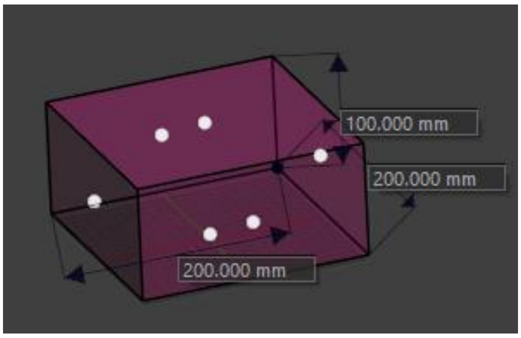


Figure 6 : Flat phantom dimensions and dielectric parameters

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

Hand parts	Relative Permittivity εr	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 within **the functional description document, §3**. The retained values are the following :

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

4 Magnetic Field Measurements

Different EM field measurements were done in order to define the worst case configuration to be considered for SAR simulation and firstly, as requested by FCC, to ensure that Z_0 axis of the central coil is the orientation of the maximum field generated by WCA NFC 2.0. **the functional description document contains additional information, within §3.**

4.1 Test Setup for EM field measurements

Magnetic field Measurements have been performed using a H field probe :

- Brand : Narda
- EM Field probe reference : ELT B-field-probe 3cm^2
- EM Field meter : ELT-400

Minimum distance for accurate measurement is 1.5cm (magnetic probe radius)

4.2 Defintion of Maximum Magnetic field direction.

Since the WCA NFC 2.0 15W Wireless charger is using PTx design with **triple coils,** comparative measurements were also done between central Tx Coil and lateral Tx Coil.

The schematization of the different Tx coils of this wireless power charger and axis where investigations are realized are shown in the following figure 7.

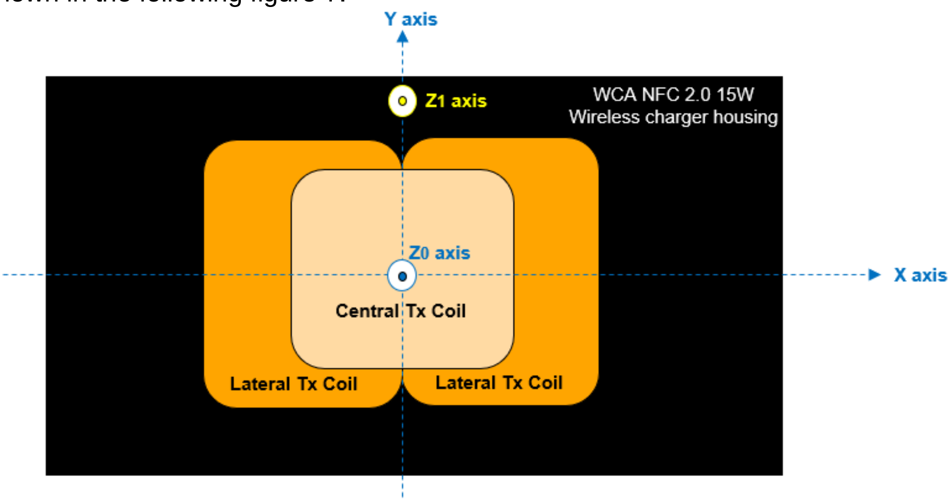


Figure 7 : Schematization of WCA NFC 2.0 Wireless power charger coils and axis for EM field investigations

<u>in the Functional description, §3</u> *it is* shown that:

- ***Figure18*** *and* ***Table 5*** *:* at same distances from the WCA NFC 2.0 Wireless charging pad, <u>highest magnetic field emissions are obtained with central coil (rather than the lateral coil)</u>. This result is already expected since the central Tx coil is closer to the charging pad than lateral coils by almost $1.1^{\pm 0.2}$mm as defined in Qi standard.

- ***Figure20, Figure21*** *and* ***Table6*** *:* Measurements which are done in X, Y, Z_0 and Z_1 transects confirm that <u>the highest field evolution for various distances are obtained along the central axis of the central coil (Z_0).</u>

- ***Figure23*** : B field measurements done <u>without Receiver</u> in the WCA NFC 2.0 charging pad (<u>Z_0 axis) are much higher than B field measurements with Receiver</u>. In fact, the receiver is shielding some of the magnetic field and therefore attenuating the measured emissions.

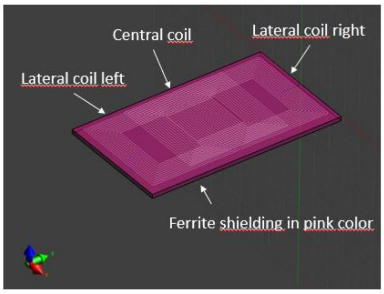
<u>Conclusion</u> : **<u>In order to pursue with the worst case approach,</u>** SAR Evaluation will be based on this demonstration results to have the highest SAR value in worst case direction, without any receiver in the charging pad.

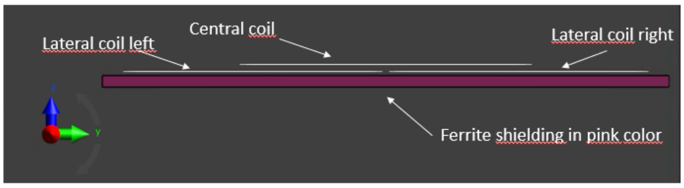
5 EM field simulations and measurements correlation for worst case configuration

For transmitter design, Continental develops some electromagnetic models using FEKO software (FEM/MoM).
EM simulations performed with Sim4life and FEKO are in a good agreement and correlate to electrical and magnetic field measurements.
Prior to this, a study has been conducted to define the level of details to consider to build the EM model of the Tx coils.

5.1 Model definition

The simulation model for the MPA6 transmitting coil with the ferrite has been achieved into Sim4life software. Some pictures are shown into Figure 8.





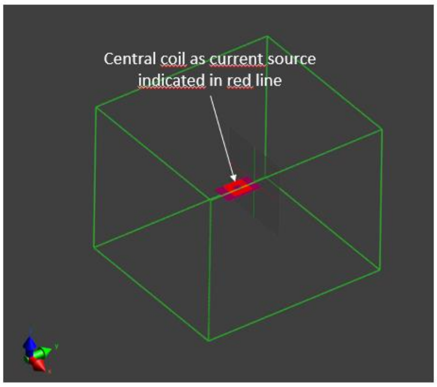
a) b)

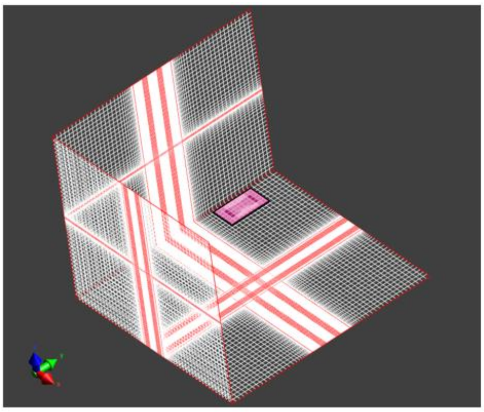
Figure 8 : View of the device model into Sim4life model
a) isometric view ; b) side view to show the stackup

The central coil has been defined as a current source as can be seen into Figure 9 a).

The green box, shown in Figure 9 a), represents the air box within the fields would be calculated.

Sim4life presents the interesting voxel meshing with MagnetoQuasiStatic approximation for SAR evaluations. Indeed, most current relevant standard has been established with voxel definitions. The mesh grid definition is shown in Figure 9 b).





a) b)

Figure 9 : a) View of the calculation air box with source ; b) view of the grid mesh refinement

5.2 Standalone EM simulations field Correlation with measurements

5.2.1 Transmitter coil electrical parameter

In order to build a proper Tx coil model, simulated inductance has been tuned to the measured one. Table 2 presents the simulation vs measurements results at 127kHz.

Inductance	
Measurement	11,22 µH
FEKO Simulation	11,28 µH
Sim4Life Simulation	11,23 µH

Table 2 : Tx inductance correlation

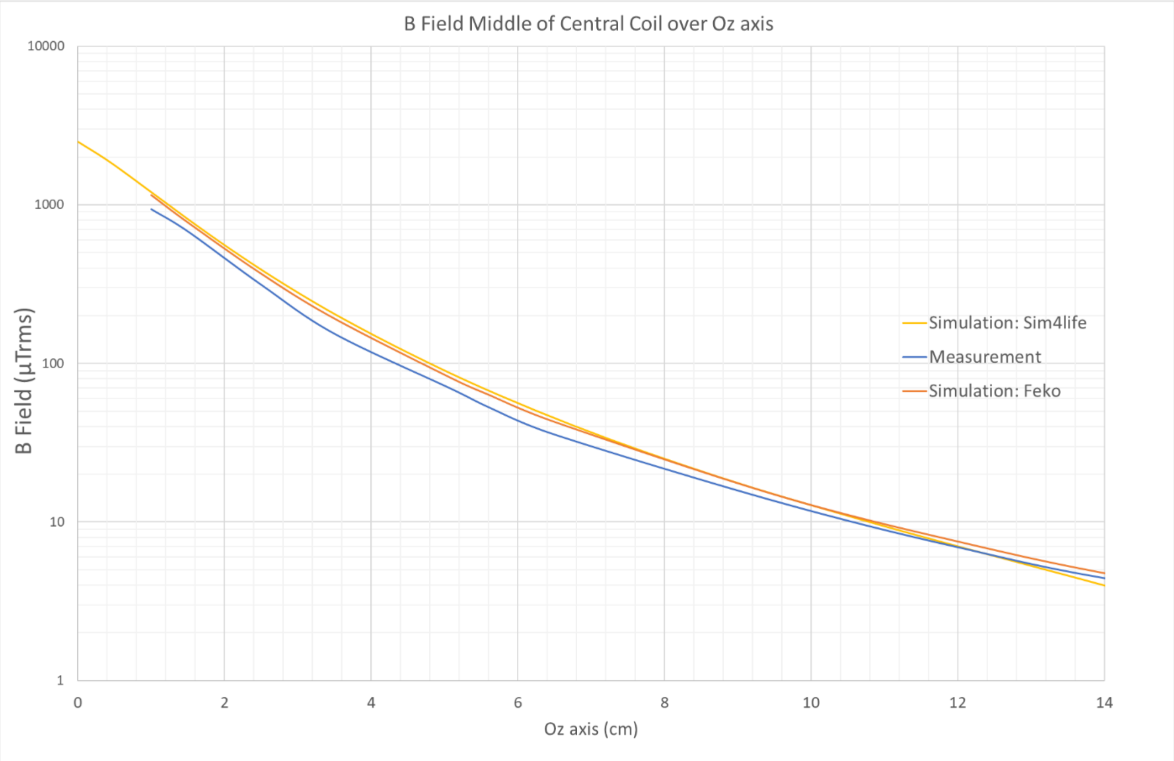
Measurement Equipments:

- Impedance meter: Precision Impedance Analyzer Agilent 4294A
- Test fixture: Agilent 16047E
- Measurement frequency: 127kHz

After modeling calibration, measurement and simulation (whatever the simulation software used) present a good correlation with a deviation lower than 1%.

5.2.2 Measurements and simulations correlation on Magnetic Field

In order to ensure that the modeling of our MPA6 coil transmitter is correct, correlation is performed between measured and simulated field, illustrated in *Graph5* below.
This comparison has been conducted applying 4Arms into the coil (+5% of real maximum use case =3.8Arms). This simulated field is realized using the two different modeling softwares (FEKO and Sim4life).



Graph 5 : Magnetic field correlation between measurement and simulation tools

Correlation is good for the three different tools, with an approximative error < 10%.
The highest magnetic field is provided by the simulations tools which is conforting us in our worst case approach.

6 SAR analysis results

Local SAR distribution over the considered box tissue is shown below in Figure 10.
Distance above the transmitting coil is 5mm.
Max current generated is 4Arms (+5% of real maximum use case = 3.8Arms).
Operating frequency is 127kHz.

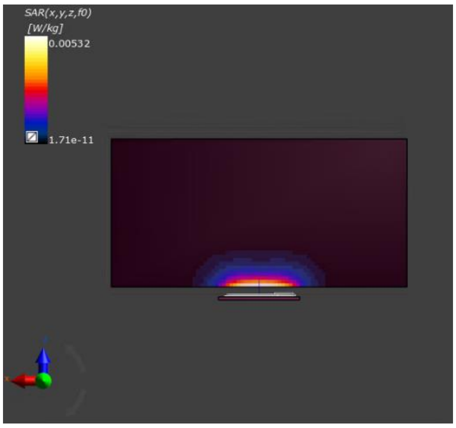


Figure 10 : Local SAR distribution.

Peak Spatial-Average SAR computed over 10g tissue as described in §3.4 is <u>21.24mW/kg</u> considering a current of 4Arms flowing into the coil and for 1g tissue is <u>45mW/kg</u>.

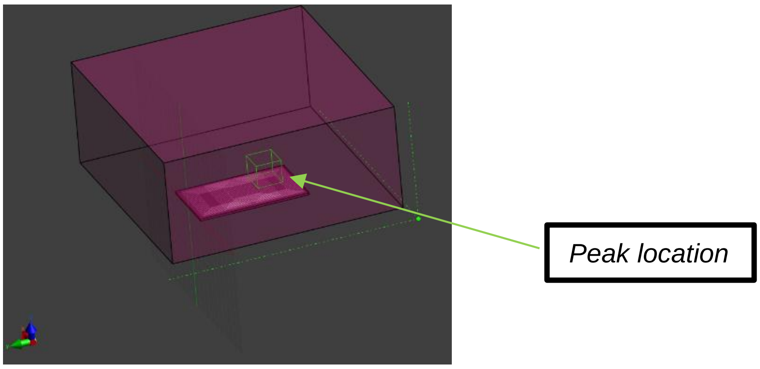


Figure 11 :10g Peak Spatial-Averaged SAR value location.

Then concerning the assessment for the Whole-Body SAR, FCC requires a value lower than 0.08 W/kg. Since the Peak Spatial-Average extremity SAR 10g 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 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 met in all normal use cases.

7 Conclusion

<u>The proposed worst-case approach for Continental wireless charger WCA NFC 2.0 15W shows that it complies with FCC requirement, with maximum SAR values of</u> :

- a 10g/Peak Spatial-Average SAR of <u>21.24mW/kg</u> (<0,5% of the limit = 4W/Kg)
- a 1g/Peak Spatial-Average SAR of <u>45mW/kg</u> (<3% of the limit = 1.6W/Kg)

8 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/*

[3] FCC SAR Analysis Report EnteroMedics Inc. Model 200 Maestro Rechargeable System
FCC ID: 2ABHRMC2402 ref: ENT-FCC-2015-03

9 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.

9.1 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: MQS (Magneto Quasi Static) approach is proposed in this report. This approach allows a reasonable tradeoff between maximum details of the wireless charger and time/resource simulations capabilities.

9.2 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 5.0.0.4412 from Zurich Med Tech company) that implements a FDTD solver and a Magneto Quasi Static Solver. For present analysis, the Magneto Quasi Static Solvers have 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. As a consequence, the SAR processing is in accordance with SAR processing from FDTD standards (IEC62704-1) based on voxels definitions.
The process is divided in two steps.
- First the magnetic vector potentials radiated by the transmitter are computed all around the transmitter and particularly into the space region where the phantom will be located. The specific solver used is named Magneto Static Vector Potential; this solver allows the calculation for ferrite materials. Note that the potential vector can be directly derived to calculate the magnetic flux density B.
- Then these magnetic vector potentials are considered as source for SAR calculations with a phantom. The solver used in this last step is named "Magneto Quasi Static".

The solution domain was discretized according to rectangular grid with an adaptative mesh size for the air surrounding the device and forced to 1 mm length for the source coil.
As a consequence, the ferrite shielding (which is cuboid model) is also required with a grid of 1 mm.
the source is defined as cocentric rectangular current coil wires (no thickness); the source for such solvers is only the definition of a current flowing.
Calculation is done into an air box.

SAR evaluation is computed as 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 famous and well recognized among medical community to validate RF human exposure.

9.3 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 :
Sim4life Magnetic Field data :
Magnetic Fields and vector Potentials are computed in a 20cm domain all around the product into Sim4life, as seen into Figure 10. Such fields are used as source for SAR calculation.

Sim4life phantom modeling :
the worst case phantom were modeled 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.

The modeling has been established according to 1 mm^3 voxel mesh size for coil lines, 5mm for ferrite. Phantom size is 20cm * 20cm *10cm. These characteristics of computational parameters are synthetized in Table 3:

	Data
Phantom size	200 mm x 200mm x 100mm
Voxel size	1mm x 1mm x 1mm
Number of voxels for phantom	4 000 000 cells

Table 3 : Computational parameters

A picture has been shown into Figures 10 and 11.

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.

9.4 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 : A flat phantom has been model. Since RF exposure will be determined for standard usage on a hand, to said a body extremity, flat phantom appears as a worst case situation according to KDB 447498 D01 General RF Exposure Guidance v06.

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 *:* Hypothetical worst-case tissue has been chosen for SAR assessment and dielectric parameter were accepted by FCC. The functional desciprtion document contains additional information.

9.5 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 tissue that are contained into a hand, as indicated into Table 1.
Since SAR is directly proportional to conductivity σ, the maximum value has been considered for conductivity and is set to 0.4 S/m.
For Reminder, our study takes into account the muscle conductivity as defined by ITis i.e 0.368 S/m, which is rounded at 0.4S/m.

As showed in the functional description document, §3, due to coupling conditions with flat phantom, tissue relative permittivity doesn't have an impact on final SAR Value.

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

9.6 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. EM model has a good representation of the real device. More details are in §5.2.

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 §5.2.

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.

9.7 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 were measured on 3 transects and with different coils to confirm the highest emissions direction. Details in §4.2 above : " EM field measurements".

   Worst case scenario was observed in the top direction of product as illustrated in this device test position Figure2 :

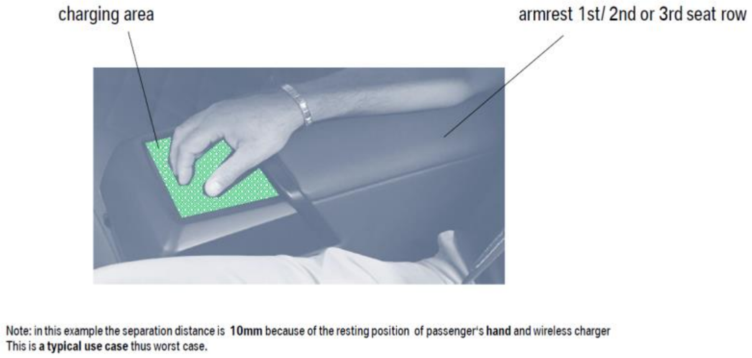


Figure 2. In cabin installation provided by OEM car manufacturer

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.

9.8 h) Steady state termination procedures

Answer : Not applicable to Magneto Quasi Static approximation.

9.9 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

9.10 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. *"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 92704-1 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 and accepted. The functional description document contains additional information in §3 *SIM4life FDTD Solver verification, on 02/13/2020*

9.11 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 *SIM4life MQS Solver verification, on 02/13/2020*
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). "

9.12 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 §6 above.
   Remark: the Peak Spatial-Average SAR average 1g or 10g have been shown; as a remark, due to symmetry of the coil, very near SAR magnitude occurs just above the coil.

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 §4.2 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.