SAR EVALUATION REPORT

FCC 47 CFR § 2.1093
IEEE Std 1528-2013
IEC 62232-2017
IEC 62209-2:2010
IEC TR 62630:2010

For
Wireless Power Source

FCC ID: 2AS57OSSIACOTATX203
Model Name: Cota Tx203

Report Number: 13378408 S1V4
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Prepared for
Ossia Inc.
1100 112th Ave NE, Suite 301,
Bellevue, WA, 98004
U.S.A

Prepared by
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET
FREMONT, CA 9438, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888

NVLAP LAB CODE 200065-0

Revision History

Rev.	Date	Revisions	Revised By
V1	8/27/2020	Initial Issue	-
V2	9/2/2020	Corrected SAR values in section 1 and 11	Dave Weaver
V3	9/30/2020	Updates in accordance with FCC feedback	Dave Weaver
V4	10/20/2020	Section 1 – Corrected FCC ID	Dave Weaver

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1 Attestation of Test Results

Applicant Name	Ossia Inc.		
FCC ID	2AS57OSSIACOTATX203		
Model Name	Cota Tx203		
Applicable Standards	FCC 47 CFR § 1.1307, § 1.1310 and § 2.1093 Published RF exposure KDB procedures IEC 62232-2017, IEEE Std 1528-2013, IEC 62209-2:2010, IEC TR 62630:2010		
Exposure Category	SAR Limits (W/kg)		
	Peak spatial-average (1 g of tissue)	Extremities (hands, wrists, ankles, etc.) (10 g of tissue)	Whole Body
General population / Uncontrolled exposure	1.6	4	0.08
RF Exposure Conditions	Equipment Class - Highest Reported SAR (W/kg)		
	CW		
1 g Peak SAR Average	1.290 W/kg		
Whole Body SAR	0.0580 W/kg		
Date Tested	6/22/2020 to 6/25/2020		
Test Results	Pass		

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

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Approved & Released By:	Prepared By:
Dave Weaver Operations Leader UL Verification Services Inc.	Lance Fleischer Laboratory Engineer UL Verification Services Inc.

2 Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093 and the relevant sections of the following documents:

IEEE Std 1528-2013 IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques.
IEC 62232-2017 Determination of RF field strength, power density and SAR in the vicinity of radiocommunication base stations for the purpose of evaluating human exposure.
IEC 62209-2:2010 Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)
IEC TR 62630:2010 Guidance for evaluating exposure from multiple electromagnetic sources.
KDB 447498 D01 General RF Exposure Guidance v06
KDB 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
KDB 865664 D02 RF Exposure Reporting v01r02

In addition testing was performed in accordance with guidance provided by the FCC via KDB inquiries

3 Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at

47173 Benicia Street	47266 Benicia Street
SAR Lab A	SAR Lab 1
SAR Lab B	SAR Lab 2
SAR Lab C	SAR Lab 3
SAR Lab D	SAR Lab 4
SAR Lab E	
SAR Lab F	
SAR Lab G	
SAR Lab H	

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

4 SAR Measurement System & Test Equipment

4.1 SAR Measurement System

The DASY5 system used for performing compliance tests consists of the items shown in Figure 1:

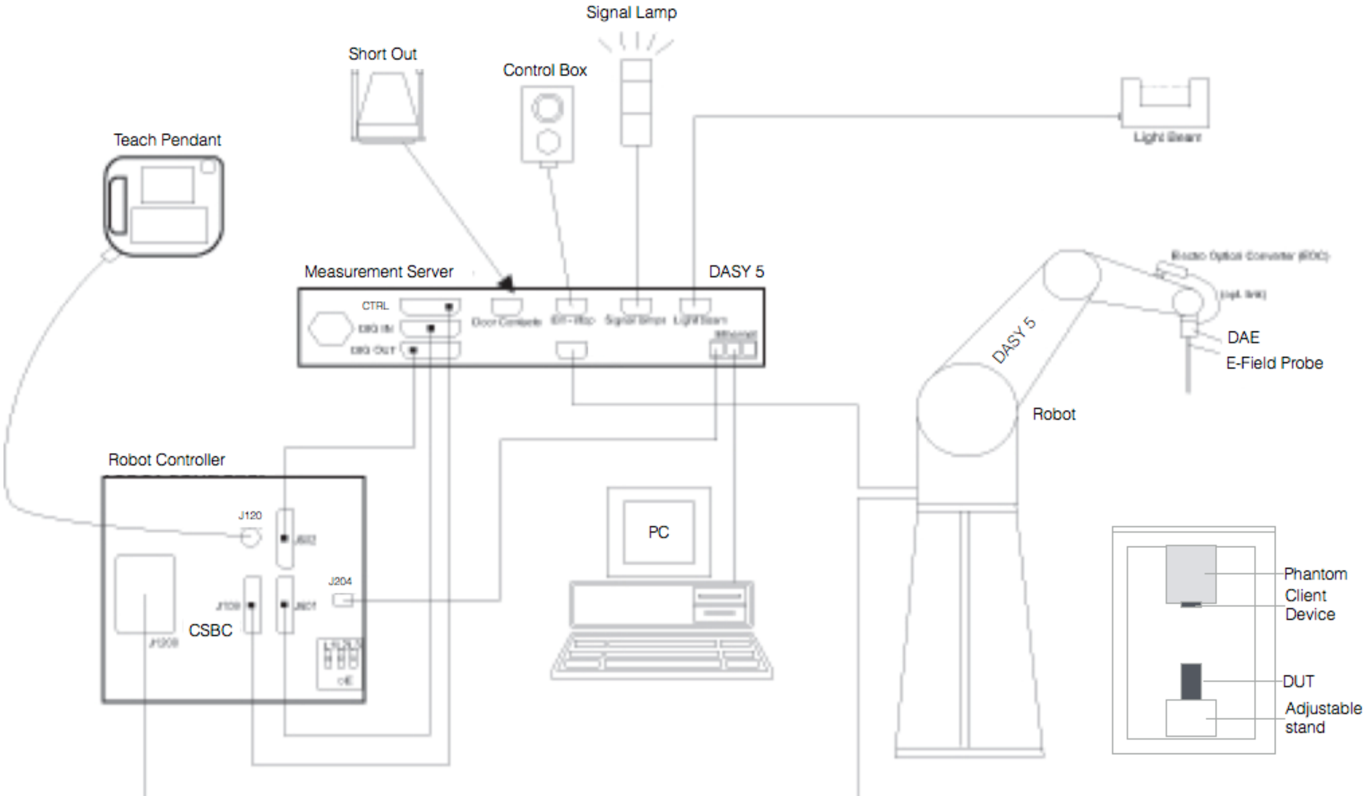


Figure 1: SAR measurement system

- A standard high-precision 6-axis robot with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- A data acquisition electronics (DAE), which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running Windows 10 and the DASY5 software.
- Remote control and teach pendant, as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.
- The phantom is a flat box-shaped phantom with lateral dimensions 0,96 m × 0,233 m. The tissue simulating liquid depth (TSL) is >15 cm. The height of the base of the phantom above the floor is 100 cm. This phantom is referred to as the small box-shaped phantom and is specified in IEC 62232 §B3.2.2.2. The small box-shaped phantom was selected as it is the preferred choice for assessing Whole Body SAR for the general public where exposure to children is anticipated.

4.2 SAR Scan Procedures

4.2.1 1 g SAR

Step 1: Power Reference Measurement

The Power Reference Measurement and Power Drift Measurements are for monitoring the power drift of the device under test in the batch process. The minimum distance of probe sensors to surface determines the closest measurement point to phantom surface. The minimum distance of probe sensors to surface is 2.1 mm. This distance cannot be smaller than the distance of sensor calibration points to probe tip as defined in the probe properties.

Step 2: Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values, before doing a fine measurement around the hot spot. The sophisticated interpolation routines implemented in DASY software can find the maximum locations even in relatively coarse grids. When an Area Scan has measured all reachable points, it computes the field maximal found in the scanned area, within a range of the global maximum. The range (in dB) is specified in the standards for compliance testing. For example, a 2 dB range is required in IEEE Standard 1528 and IEC 62209 standards, whereby 3 dB is a requirement when compliance is assessed in accordance with the ARIB standard (Japan). If only one Zoom Scan follows the Area Scan, then only the absolute maximum will be taken as reference. For cases where multiple maximums are detected, the number of Zoom Scans has to be increased accordingly.

Area Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°
Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be ≤ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

Step 3: Zoom Scan

Zoom Scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The Zoom Scan measures points within a cube whose base faces are centered on the maxima found in a preceding area scan job within the same procedure. When the measurement is done, the Zoom Scan evaluates the averaged SAR for 1 g and 10 g and displays these values next to the job's label.

Zoom Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$	
Minimum zoom scan volume	x, y, z		≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm
Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see draft standard IEEE P1528-2011 for details. * When zoom scan is required and the *reported* SAR from the *area scan based 1-g SAR estimation* procedures of KDB 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.				

The correction factors from IEC62232 B.3.2.3.3 are applied to the 1 g SAR measurements to account for the separation distance of the DUT from the phantom and varying antenna element load conditions.

$$CF_1(d) = \begin{cases} 1 & d < 200\text{ mm} \\ \dfrac{d}{200} & 200\text{ mm} \leq d < 400\text{ mm} \\ 2 & 400\text{ mm} \leq d \leq 1\,000\text{ mm} \end{cases}$$

$$CF_2(d) = \begin{cases} 2 & d \leq \dfrac{\lambda}{4} \quad \text{AND } N_e > 1 \\ -\dfrac{4d}{7\lambda} + \dfrac{15}{7} & \dfrac{\lambda}{4} < d < 2\lambda \quad \text{AND } N_e > 1 \\ 1 & d \geq 2\lambda \quad \text{OR } N_e = 1 \end{cases}$$

d is the distance of the sample from the phantom.

λ is the wavelength of the signal.

N_e is the number of elements in the antenna array.

The correction factors are applied to equation B.12 from IEC 66232 to provide the 1 g SAR value ($SAR_{psa}(d)$)

$$SAR_{psa}(d) = SAR_{m}(d)xCF_{1}(d)xCF_{2}(d)$$

Step 4: Power drift measurement

The Power Drift Measurement measures the field at the same location as the most recent power reference measurement within the same procedure, and with the same settings. The Power Drift Measurement gives the field difference in dB from the reading conducted within the last Power Reference Measurement. This allows a user to monitor the power drift of the device under test within a batch process. The measurement procedure is the same as Step 1.

Step 6: Z-Scan

The Z Scan measures points along a vertical straight line. The line runs along the Z-axis of a one-dimensional grid. In order to get a reasonable extrapolation, the extrapolated distance should not be larger than the step size in Z-direction. The Z-scan is only required if the highest measurement point is less than 2 penetration depths from the top of the tissue simulation liquid in the phantom. Penetration depth is calculated using the equation from Section 3 of IEEE 1528-2013:

$$\delta = \frac{1}{\omega}\left[\left(\frac{\mu_0 \varepsilon_r' \varepsilon_0}{2}\right)\left(\sqrt{1+\left(\frac{\sigma}{\omega \varepsilon_r' \varepsilon_0}\right)^2}-1\right)\right]^{-1/2}$$

where ω is the angular frequency (radians/s), μ_0 is the free-space permeability ($4\pi \times 10^{-7}$ H/m), ε_0 is the free space permittivity (8.85×10^{-12} F/m), ε'_r is the relative permittivity, and σ is the conductivity of the medium. Penetration depth is expressed in meters (m).

Using the 2450 MHz body tissue dielectric parameters from KDB 865664 D01 of σ = 1.95 and ε'_r = 52.7 the penetration depth (δ) is 0.020 m. The tissue simulation liquid depth is >0.15 m. The highest measurement point was at least 0.09 m below the surface of the TSL which is greater than 2δ = 0.040 m. Therefore Z-scans were not required.

4.2.2 Whole Body SAR

For the whole body SAR evaluation with the small box-shaped phantom, the measurement grid is setup according to IEC62232. The phantom is filled with a liquid volume of 0.96 m × 0.233 m × ≥0.15 m. Whole body SAR measurements are performed by running a *Volume Scan.* As whole body SAR measurements are time-consuming, a maximized grid spacing according to IEC62232 is recommended, e.g., 20 mm × 20 mm × 5 mm in x,y,z dimension for frequencies below 3 GHz.

The measurement volume specified in IEC62232 for the small box-shaped phantom is 0.96 m × 0.233 m × 0.06 m. Due to mechanical constraints (probe body diameter) and boundary effects, SAR measurements at the location of the sidewalls are physically impossible. The local enhancement occurring due to the boundary effects caused by sharp edges of the phantom can be smoothed to better represent the human exposure. This is supported by DASY52 by extrapolating to the sidewalls (up to 30 mm from the walls, see section Post-processing) and towards the bottom of the phantom in accordance with IEC62209. The actual measurement volume is therefore smaller but the measured values are extrapolated to the base and sides of the phantom. This provides test data for the measurement volume specified in IEC62232.

The actual measurement volume is 0.9 m x 0.18 m x 0.06 m. This is the volume over which the SAR probe scanned. This is formed by a 45 x 9 x 12 grid (x, y, z) with grid spacing of 20 mm, 20 mm and 5 mm respectively. Within the actual measurement volume the interpolated grid spacing is 6.667 mm x 6.667 mm x 1.667 mm.

The extrapolated volume is 0.96 m x 0.233 m x 0.06 m. In the extrapolated regions the interpolated grid spacing is 8.83 mm x 10 mm x 1.667 mm which was determined as follows. The extrapolated SAR data was exported. Each

SAR data point contains the SAR value and its associated x, y and z co-ordinate. The co-ordinates were examined to determine the length of x, y and z. (difference between the min and max values for a given axis). Note that due to capabilities of SAR system version used, the Volume Scan listed on the whole-body SAR plots (i.e., 34x142x40) shows the total number of steps for the interpolated and extrapolated overall volume - not just for the 6.667 mm x 6.667 mm x 1.667 mm interpolated data.

The extrapolated volume is 13.4 liters. (0.96 m x 0.233 m x 0.06 m = 0.0134 m^3 = 13.4 liters). This yields a mass of 13.4kg (TSL density is assumed to be 1000 kg/m^3).

The calculation of whole body SAR involves dividing by *M* where *M* is the mass of the body specified in kg. For general public exposure the value of *M* is specified in IEC62232 as 12.5 kg. As this is smaller than the extrapolated mass of 13.4 kg this leads to a more conservative value for whole body SAR than if the value of *M* was set to the extrapolated mass.

Post-processing for General Public whole body SAR

To determine the whole body SAR the total absorbed power in the phantom is calculated by the DASY52:

1. Computation of the SAR from the raw measurement data (electric field strength) at each *measured* grid point (SAR = E^2 x (σ/(ρ x 1000))) where E is the electric field strength, σ is the TSL conductivity and ρ is the tissue density (set to 1).
2. A layer of grid points is created at the sidewalls (within laterally maximum 30 mm from the closest grid point of the volume scan) and the bottom shell of the phantom. Thus extending the evaluation volume to 0.96 m × 0.233 m × 0.06 m. The grid points are used to provide geometric information to the extrapolation algorithm for placement of the extrapolated data. The SAR fields are extrapolated to the bottom and the sidewalls of the phantom using a quadratic SHEPARD interpolator or a constant SAR towards the sidewall.
3. Generation of a high-resolution mesh within the extrapolated volume.
4. Interpolation of the values from the extrapolated grid to the high-resolution grid with a combination of a least-square fitted function method and a weighted average method.
5. Determination of the SAR, volume and mass of each cell in the high resolution grid.
6. Calculation of the absorbed power in each cell by multiplying the cell's SAR with the cell's mass. (Multiplying by the cell's mass gives power in a given volume.)
7. Summation of the absorbed power in each cell over the entire evaluation volume of 0.96 m × 0.233 m × 0.06 m and thus calculation of the total absorbed power.

Calculation of the general public whole body SAR:

The whole body SAR value was calculated using:

$$SAR_{\mathrm{wb}}(d) = \frac{P_{\mathrm{A}}(d) \times CF_3(d) \times CF_4(f)}{M}$$

$P_A(d)$ is the average temporal absorbed power (watts) in the phantom measured at a distance *d*, the EUT distance (mm) measured from the liquid surface;

$$CF_3(d) = \begin{cases} 1 + \frac{0{,}8d}{400} & d < 400 \text{ mm} \\ 1{,}8 & d \geq 400 \text{ mm} \end{cases};$$

$CF_3(d)$ is a correction factor to account for a possible increase in whole-body *SAR* due to a tissue layering effect defined by:

$CF_4(f)$ is a correction factor to compensate for a possible bias in the obtained general public whole-body *SAR* when assessed using the large box-shaped phantom for child exposure configurations. For frequencies between the data points a linear interpolation shall be used. For other exposure configurations and phantom type combinations, $CF_4(f) = 1$;

M is the mass specified in IEC62232 representing the body. For general public exposure M = 12.5 kg.

As the small-boxed shape phantom was used for the SAR measurements $CF_4(f) = 1$.

The whole body SAR procedure was applied to both the whole body SAR system check and the whole body SAR measurement.

4.3 Test Equipment

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations and is traceable to recognized national standards.

Dielectric Property Measurements

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Network Analyzer	Rohde & Schwarz	ZNLE6	101274-mn	2/26/2021
Dielectric Probe kit	SPEAG	DAK-3.5	1082	10/8/2020
Shorting block	SPEAG	DAK-3.5 Short	SM DAK200DA	10/8/2020
Thermometer	Fischer Scientific	4242	140562250	6/5/2021

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Signal Generator	Rohde & Schwarz	SMB 100A	180969-yC	2/18/2021
Power Sensor	Rohde & Schwarz	NRP18A	100994-RE	2/18/2021
Power Meter	HP	437B	3125U11364	1/22/2021
Power Sensor	Agilent	8481A	3318A92374	2/12/2021
DC Power Supply	HP	6296A	2841A-05955	N/A

Lab Equipment

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
E-Field Probe (SAR Lab 5)	SPEAG	EX3DV4	706	5/15/2021
E-Field Probe (SAR Lab 5)	SPEAG	EF3DV3	4028	7/12/2020
Data Acquisition Electronics (SAR Lab 5)	SPEAG	DAE4	1547	5/15/2021
System Validation Dipole	SPEAG	D2450V2	706	5/15/2021

Note(s):

*Equipment not used past calibration due date.

4.4 Dielectric Property Measurements & System Check

4.4.1 Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18°C to 25°C and within ± 2°C of the temperature when the tissue parameters are characterized.

The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements. The parameters should be re-measured after each 3 – 4 days of use; or earlier if the dielectric parameters can become out of tolerance; for example, when the parameters are marginal at the beginning of the measurement series.

Tissue dielectric parameters were measured at the low, middle and high frequency of each operating frequency range of the test device.

The dielectric constant (εr) and conductivity (σ) of typical tissue-equivalent media recipes are expected to

be within ± 5% of the required target values; but for SAR measurement systems that have implemented the SAR error compensation algorithms documented in IEEE Std 1528-2013, to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters, the tolerance for εr and σ may be relaxed to ± 10%. This is limited to frequencies ≤ 3 GHz.

Tissue Dielectric Parameters

FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

Target Frequency (MHz)	Head		Body	
	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5000	36.2	4.45	49.3	5.07
5100	36.1	4.55	49.1	5.18
5200	36.0	4.66	49.0	5.30
5300	35.9	4.76	48.9	5.42
5400	35.8	4.86	48.7	5.53
5500	35.6	4.96	48.6	5.65
5600	35.5	5.07	48.5	5.77
5700	35.4	5.17	48.3	5.88
5800	35.3	5.27	48.2	6.00

Dielectric Property Measurements Results:

SAR Lab	Date	Band (MHz)	Tissue Type	Frequency (MHz)	Relative Permittivity (εr)			Conductivity (σ)		
					Measured	Target	Delta (%)	Measured	Target	Delta (%)
4	6/22/2020	2450	Body	2450	52.04	52.70	-1.25	1.95	1.95	0.00
				2400	52.21	52.77	-1.07	1.88	1.90	-1.16
				2480	51.88	52.66	-1.49	1.99	1.99	0.09

4.4.2 System Check

SAR system verification is required to confirm measurement accuracy, according to the tissue dielectric media, probe calibration points and other system operating parameters required for measuring the SAR of a test device. The system verification must be performed for each frequency band and within the valid range of each probe calibration point required for testing the device. The same SAR probe(s) and tissue-equivalent media combinations used with each specific SAR system for system verification must be used for device testing. When multiple probe calibration points are required to cover substantially large transmission bands, independent system verifications are required for each probe calibration point. A system verification must be performed before each series of SAR measurements using the same probe calibration point and tissue-equivalent medium. Additional system verification should be considered according to the conditions of the tissue-equivalent medium and measured tissue dielectric parameters, typically every three to four days when the liquid parameters are re-measured or sooner when marginal liquid parameters are used at the beginning of a series of measurements.

System Performance Check Measurement Conditions:

- The measurements were performed in the flat section of the phantom, shell thickness: 2.0 ±0.2 mm (bottom plate) filled with Body or Head simulating liquid of the following parameters.
- The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm for SAR measurements ≤ 3 GHz and ≥ 10.0 cm for measurements > 3 GHz.
- The DASY system with an E-Field Probe was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10 mm (above 1 GHz) and 15 mm (below 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 15 mm was aligned with the dipole.
  For 5 GHz band - The coarse grid with a grid spacing of 10 mm was aligned with the dipole.
- Special 7x7x7 (below 3 GHz) and/or 8x8x7 (above 3 GHz) fine cube was chosen for the cube.
- Distance between probe sensors and phantom surface was set to 3 mm.
  For 5 GHz band - Distance between probe sensors and phantom surface was set to 2.5 mm
- The dipole input power (forward power) was 100 mW.
- The results are normalized to 1 W input power.

System Check Results

The 1-g and 10-g SAR measured with a reference dipole, using the required tissue-equivalent medium at the test frequency, must be within ±10% of the manufacturer calibrated dipole SAR target. Refer to Appendix A for the SAR System Check Plots.

SAR Lab	Date	Tissue Type	Dipole Type _Serial #	Dipole Cal. Due Data	Measured Results for 1g SAR				Measured Results for 10g SAR				Plot No.
					Zoom Scan to 100 mW	Normalize to 1 W	Target (Ref. Value)	Delta ±10 %	Zoom Scan to 100 mW	Normalize to 1 W	Target (Ref. Value)	Delta ±10 %	
4	6/22/2020	Body	D2450V2 SN:706	5/8/2021	4.930	49.30	49.80	-1.00	2.260	22.60	23.50	-3.83	1,2

5 Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg and the measured 10-g SAR within a frequency band is < 3.75 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

6 Device under test (DUT)

6.1 General

The Cota wireless power transfer (WPT) system delivers wireless power from a Cota WPT Source to one or many Cota WPT Clients. In order to receive power, the Cota WPT Client must be positioned in the allowed power transfer area. The allowed power transfer area is a 1 m radius from the front and edges of the WPT Source and at an angle of up to 60 degrees from a line extending from the edge of the WPT source and perpendicular to its face. This is also described and illustrated in section 9.1. The WPT Source sends RF energy at 2.450 GHz, which is converted to DC current by the client.

The Cota power system is intended to power sensors, actuators, small displays and other devices in a residential, commercial or industrial environment for which changing batteries and/or connecting wires is impractical. Both the WPT Client and WPT Source may be mounted in a fixed location or placed on a flat surface (for example a table top). In the latter case, the WPT Client needs to be mounted in a fixed position relative to the WPT Source.

6.2 DUT Description

6.2.1 General

The Cota WPT system delivers wireless power by "retrodirective" functionality, using a two-step process. In the first step, the WPT Client sends a low power (<8mW) continuous wave (CW) "beacon" signal. The beacon signal is received by the WPT Source, and its phase information is used to execute the second step. In the second (powering) step, the WPT Source sends a power signal back to the WPT Client, whereby the power signal from each of its 256 antenna ports is phase-offset with the inverse of the received beacon phase detected in the first step. These phase inverted signals generate a antenna pattern with a focused area of RF energy at the location of the WPT client antenna. This two-step sequence is repeated 16 times per second. For the general theory on such systems, see R. C. Hansen, “Reflectarrays and Retrodirective Arrays” in Kai Chang, Phased Array Antenna (Second Edition, 16 November 2009), Chapter 13.

Any obstruction that enters the direct path between the WPT Source and client will necessarily change the beacon signal as it is received by the WPT Source’s antenna elements, either by enabling receipt of a reflected beacon signal, lowering the strength of the received beacon signal or obstructing it entirely. The corresponding power signal will thus also change, creating an inherent safety feature. In normal operation the WPT Source will never focus power on an obstruction for more than 1/16th of a second (62.5 ms) between the time of the last beacon preceding an obstruction's appearance and the next beacon following it; as such an obstruction will always block the direct path for the beacon signal between the WPT Source and client.

6.2.2 Communication radio modules

The WPT Source and client also exchange information by making use of a separate IEEE 802.15.4 radio contained in each device. They operate at a different frequency from the power signal, also in the 2.4 GHz band. Information exchanged includes client authentication information (client devices that are not properly authenticated will not receive power), system information, and other specialized client information, such as information from the device being powered. These radios operate in a manner consistent with section 15.247 of the FCC’s rules.

6.2.3 Regulatory Classification

The Cota WPT Source is properly classified as Industrial, Scientific or Medical equipment as defined in section 18.107(c) of the FCC’s rules, because it is designed to generate and deliver RF energy to power nearby devices in homes, offices, retail facilities and industrial settings (*i.e.* for other than telecommunication applications). The Cota WPT Source generates RF energy on each of its 256 elements and creates a focused area of RF energy at the point of the client Antenna. Per KDB inquiry consultations with FCC staff, this area of focused energy is limited to a specified area within 1 m from the WPT Source where power may be delivered.

6.3 Client Device

The Cota WPT Client receives RF power from the WPT Source, converts the RF energy to DC, and provides DC power to a load device. The WPT Client contains two separate radio elements, an IEEE 802.15.4 communications radio, which is authorized under section 15.247 of the Commission's rules, and a "beacon" radio, which qualifies under section 15.249 of the Commission's rules. The WPT Client communicates with the source to set up power delivery, emits the beacon signal at the specified time, and harvests RF energy when the WPT Source creates the focused power signal at the point of its antenna. The Cota WPT Source can provide power to multiple clients, in which case it provides power to each client in a time-division-multiplexing-like manner, resulting in RF exposure in areas proximate to clients in inverse proportion to the number of active clients being powered by the system. The Cota WPT source powers only one client at the time. When there are multiple clients, each client is only powered during its own time slot (i.e., the duty cycle for each client would be a fraction of the duty cycle considered for a single client scenario). Thus, the potential for RF exposure in a multiple client scenario is always a fraction of the potential RF exposure in a single client scenario. Because of this functionality, a single client scenario is always the worst-case RF exposure scenario, and for this reason, RF exposure testing was conducted with a single client.

7 Testing rationale

RF exposure testing procedures adapted from IEC 62232 are utilized, as per KDB inquiry consultation with FCC staff.

The Cota WPT Source will only send power to a WPT Client that is in the power delivery area (nominally within 1 m from the source). The extent of the power delivery area was verified, and testing results are set out in section 9.2.

The RF exposure conditions for the Cota System with respect to a specific environment and client position do not change, provided environmental conditions and client location do not change. Moreover, system design and behavior as demonstrated by submitted test results, demonstrate signal coherence only in close proximity to the Client where potential exposure by human bystanders is not possible. The conservative approaches of IEC 62630 for estimating SAR for coherent signals for the range of potential signal variations across the antenna array therefore do not apply.

To determine the appropriate conditions for evaluating SAR, mapping of the RF field was undertaken both within and outside the power delivery area and with and without obstructions. Field scans were undertaken at varying distances and orientations of the WPT Source, WPT Client and obstructions. Specific locations for evaluating SAR results are based on these field scans, and the SAR phantom was positioned in such locations to determine potential location of worst-case RF exposure scenarios.

SAR testing was performed using the "small box-shaped phantom," measuring 0.96 m x 0.233 m, as specified in IEC 62232. This phantom was used for the 1 g peak spatial average SAR measurements and the whole-body SAR measurement. This phantom was chosen as it is the preferred option according to IEC 62232. Whole body SAR testing was assessed using a volume approximating to a mass of 12.5kg. This represents the third percentile body weight data for a four-year old girl. This weight is slightly smaller than the WHO data for a fifth percentile four-year-old child and leads to a conservative whole-body SAR for the general public. See Section 4 for the 1 g peak spatial average SAR and whole-body SAR test methods.

IEC 62232 B.3.2.2.2 specifies for products that may be placed arbitrarily in homes, offices and other places, the small box-shaped phantom shall then be the preferred phantom. The testing should be done with a phantom that circumscribes the EUT per Figure B.12 in the standard.

Measured SAR values are scaled to compensate for the difference between the measured output power and the maximum specified output power of the DUT.

The test procedures of IEC 62232 include correction factors to account for the test separation distance and other factors. The calculations for these correction factors and their application to the scaled SAR results are shown in section 11.

8 Maximum output power

The DUT comprises 256 antenna ports, fed from 64 power delivery chips. Each antenna port has a maximum available target power that varies, based on which one of four antenna management units (AMU) is used to send power to that particular antenna port. Each of the DUT’s 64 power delivery chips includes 4 AMUs, which vary slightly in the amount of power each one delivers. For each power delivery chip, AMUs 1-3 each deliver a maximum target power of 11.9 dBm, while AMU 4 delivers a maximum target power of 12.5 dBm. It is impractical to measure the available power to all 256 antenna ports. Therefore, conducted power was measured for 12 antenna ports, which provide a representative sample of the power variance. For SAR scaling, the sum of the measured powers was compared to the sum of the target powers as below:

Table 1: Measured antenna power

Antenna port #	Chip	Antenna Management Unit (AMU)	Power level (dBm)	
			Measured	Target
1	13	1	11.47	11.9
2	14	1	11.90	
3	15	1	11.76	
4	13	2	11.20	
5	14	2	11.79	
6	15	2	11.87	
7	13	3	11.60	
8	14	3	11.83	
9	15	3	11.74	
10	13	4	12.32	12.5
11	14	4	12.50	
12	15	4	12.38	

Sum of the measured power in dBm =22.67

Sum of the target power = 22.85 dBm (9 ports with the target power of 11.9 dBm +3 ports with the target power of 12.50 dBm each)

The total target power is 0.18 dB higher than the total measured power. The SAR results are scaled by +0.18 dB or 1.042.

Scaling was only applied to the SAR results in section 11.

9 Cota area of operation

9.1 General

The Cota system operates in a limited area, which allows powering of devices within a 1 m radius from the front and edges of the WPT Source and at an angle of up to 60 degrees from a line extending from the edge of the WPT source and perpendicular to its face, as shown in Figure 2. These power zone limits are enabled by analysis of the strength of the power received by the WPT Client. The WPT Source will cease sending power when analysis of this signal information indicates that the WPT Client is more than 1 m from the WPT Source.

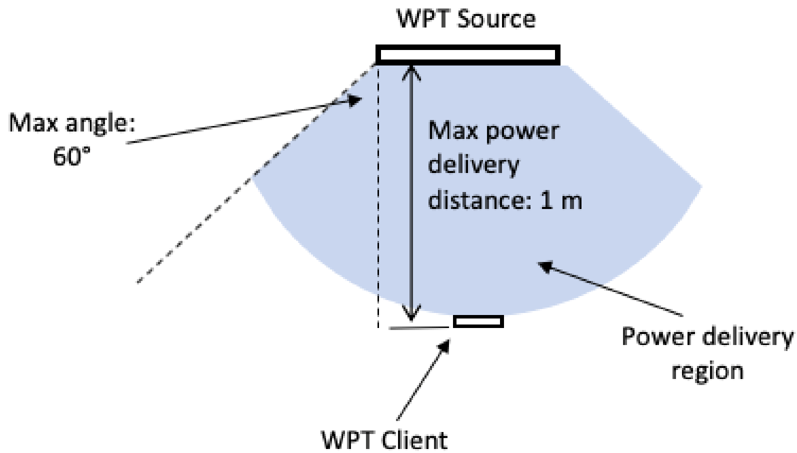


Figure 2: Power delivery area showing relevant angles and distances between Cota WPT Source and WPT Client devices.

9.2 Verification of power delivery area

9.2.1 General

Verification of the power delivery area was performed in accordance with guidance provided via KDB inquiry. The Cota WPT Source will deliver power only if the client is within the power delivery area, as shown in Figure 2.

To test the power delivery area, the Cota WPT Source was placed in an anechoic chamber on a turntable capable of rotating 180̊ (from -90̊ to +90̊, where 0̊ represents the Cota Power Source facing the client). The WPT Client was placed on a non-rotating surface relative to the turntable. In order to ascertain the presence of a power signal, a spectrum analyzer with a test antenna was placed approximately 2 m away and slightly offset from the front face of the WPT Source. The spectrum analyzer was used solely to indicate the presence of a power signal. This indication was recorded for each step of the testing process.

Testing was undertaken in an anechoic chamber, because such an environment constitutes the most conservative scenario for verifying power delivery vis-a-vis environments with more reflective and/or scattering characteristics. The range control system delivers power only inside the 1 m range when the power received by the client is higher than the calibrated threshold power. A lower received power will mean a smaller power delivery area. The retro directive functionality of the Cota system is such that maximum power is received when the power signal follows a direct line-of-sight path between the WPT source and client, such as in an anechoic chamber. Reflected and/or scattered power signals result in a lower received power. Thus, because the received power will always be greater, the power delivery area in an anechoic chamber will be larger than in a more reflective environment.

Both the horizontal and vertical axes were evaluated.

9.2.2 Horizontal Plane

Verification of power delivery in the horizontal plane was performed in a two-step process. First, the angular limits of the power field were established by rotating the WPT Source in a full 360°. This was undertaken in two 180° sweeps, due to the turntable's limited range of 180°. To perform these sweeps, the client was positioned at a distance of 70 cm from the front of the power source, and the turntable was rotated clockwise from -90° to 90° at increments of 3°. To achieve a full 360-degree field, the Power Source was rotated by 180° manually such that the 0° of the turntable represents the case where the back of the Cota Power Source is facing the client and the process is repeated. Figure 3 illustrates this process. At each step of the process, data from the spectrum analyzer is recorded to ascertain the presence of the power signal. The first step demonstrated that a power signal was present from 55° to -65° horizontally. No power was delivered when the WPT Source was faced away from the WPT Client and swept from -90° to 90°.

The second step rotated the WPT Source from 70° to -70° at 10° increments with the WPT Client stepped from 70 cm to 105 cm from the WPT Source and the spectrum analyzer output recorded for each step. This setup is shown in Figure . Test results for the horizontal plane are shown in Figure 5 and Table 2 and show the power delivery area extends to 1m.

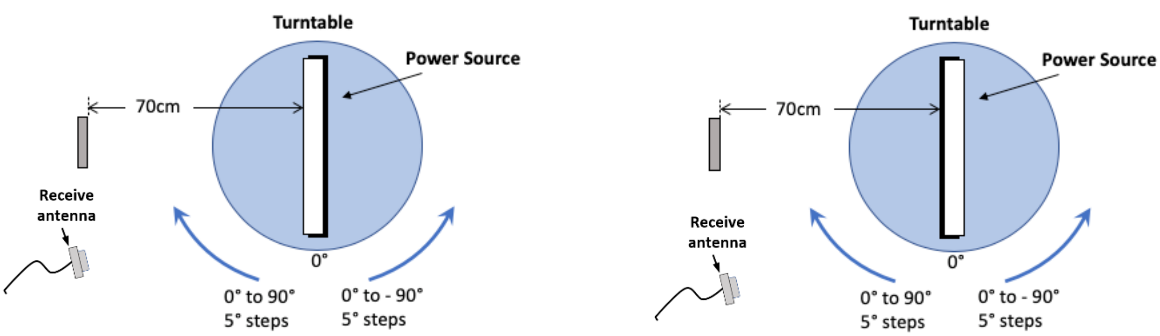


Figure 3 - power distance verification - step 1

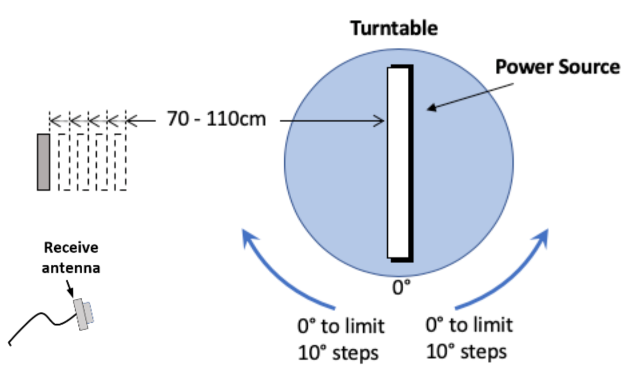


Figure 4: power distance verification - step 2

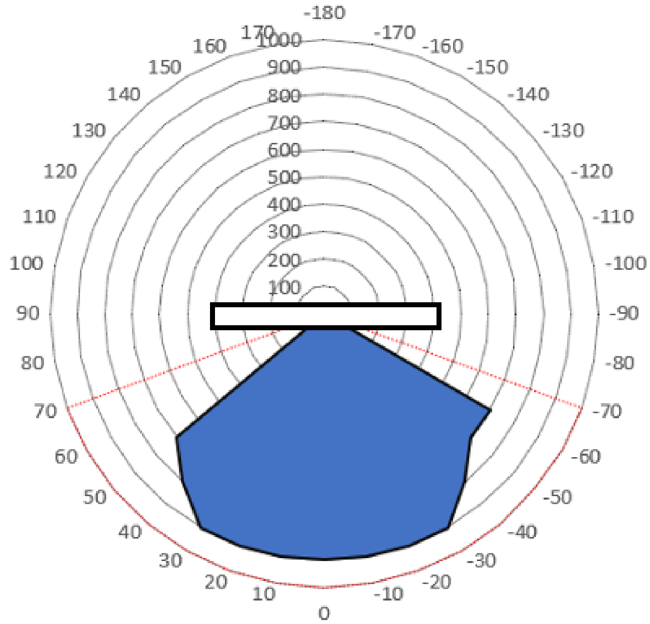


Figure 5: Power delivery area - horizontal

Table 2: Results of horizontal sweep

Angle	Horizontal sweep - Distance from WPT Source				
	700	800	900	1000	1050
-60	ON	OFF	OFF	*	*
-50	ON	OFF	OFF	*	*
-40	ON	ON	OFF	OFF	*
-30	ON	ON	ON	OFF	OFF
-20	ON	ON	ON	OFF	OFF
-10	ON	ON	ON	OFF	OFF
0	ON	ON	ON	OFF	OFF
10	ON	ON	ON	OFF	OFF
20	ON	ON	ON	OFF	OFF
30	ON	ON	ON	OFF	OFF
40	ON	ON	OFF	*	*
50	ON	OFF	OFF	*	*
60	OFF	OFF	*	*	*

* No reading taken

9.2.3 Vertical Plane

The power delivery zone for the vertical orientation was determined in a single step by rotating the WPT Source from 70° to -70° at with the WPT Client stepped from 70 cm to 105 cm from the WPT Source and the spectrum analyzer output recorded for each step. This step showed power delivery from -50° to 50° vertically. The results of this sweep are shown in Table 3, and in Figure 6. These tests show, as with the horizontal scan, that the power delivery area extends no further than 90 cm from the front of the WPT Source.

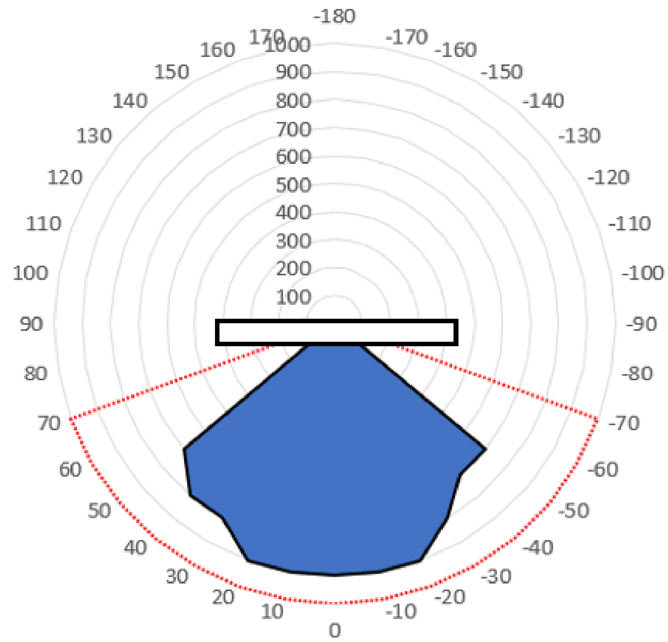


Figure 6: Power delivery area – vertical

Table 3: Results of vertical sweep

Angle	Vertical sweep – Distance from WPT Source				
	700	800	900	1000	1050
-60	OFF	OFF	*	*	*
-50	ON	OFF	OFF	*	*
-40	ON	OFF	OFF	*	*
-30	ON	ON	OFF	OFF	*
-20	ON	ON	ON	OFF	OFF
-10	ON	ON	ON	OFF	OFF
0	ON	ON	ON	OFF	OFF
10	ON	ON	ON	OFF	OFF
20	ON	ON	ON	OFF	OFF
30	ON	ON	OFF	OFF	*
40	ON	ON	OFF	OFF	*
50	ON	OFF	OFF	*	*
60	OFF	OFF	*	*	*

* No reading taken

10 Steps for determining the worst-case scenario

10.1 General

The Cota system is a dynamic system that results in changed RF fields due to changes in the relative positionings of power source, power client and any obstructions between the WPT power source and client. Due to the retrodirective features of the Cota technology, the WPT power signal generally avoids such obstructions. Thus, while there may be high field strength in unobstructed space, such fields are not necessarily indicative of potential exposure levels, absent an actual obstruction mimicking the presence of a human body. This aspect of the system requires ascertainment of the worst-case scenario for the potential positioning of power source, client and any obstruction for the potential exposure to RF energy of such an obstruction.

Through the KDB inquiry process, Ossia established that the EUT operates in a substantially similar fashion to Ossia's previously approved Venus V2 WPT Source (FCC ID:2AS57OSSIACOTATX201). Field strength scans shown below show similar energy distribution and intensity as the scans included in the RF exposure report for the Venus V2 WPT Source. Because of this strong similarity of operation, the same worst-case SAR measurement setup was used as for the Venus V2 device.

10.2 Free space measurements between the WPT Client and WPT Source within the powering zone

The worst-case scenario for the area behind the client was determined to be test scenario 1, where the distance between the Power Source and Client is 1m. The test setup is shown in Figures 7 and 8. Field scan data is shown in Figures 9 to 12.

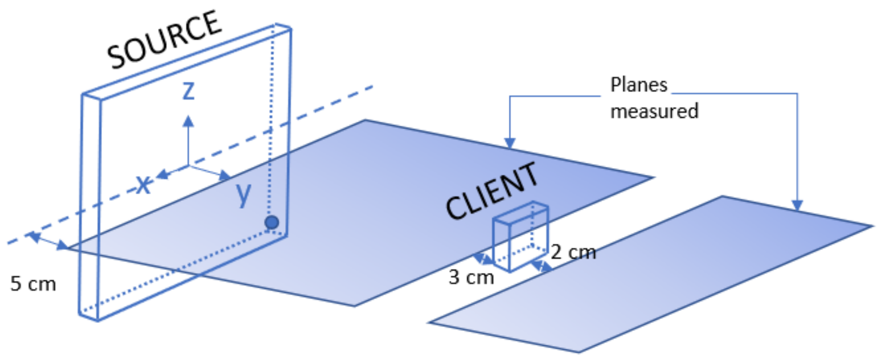


Figure 7: Unobstructed field scan diagram

Table 4: Details, unobstructed field scans

Figures	Description	Maximum field strength	
		Horizontal	Vertical
9, 10	Between source and client	184.2 V/m	189.5 V/m
11, 12	Behind client	71.09 V/m	72.68 V/m

Figure 8 - Unobstructed field scan photo

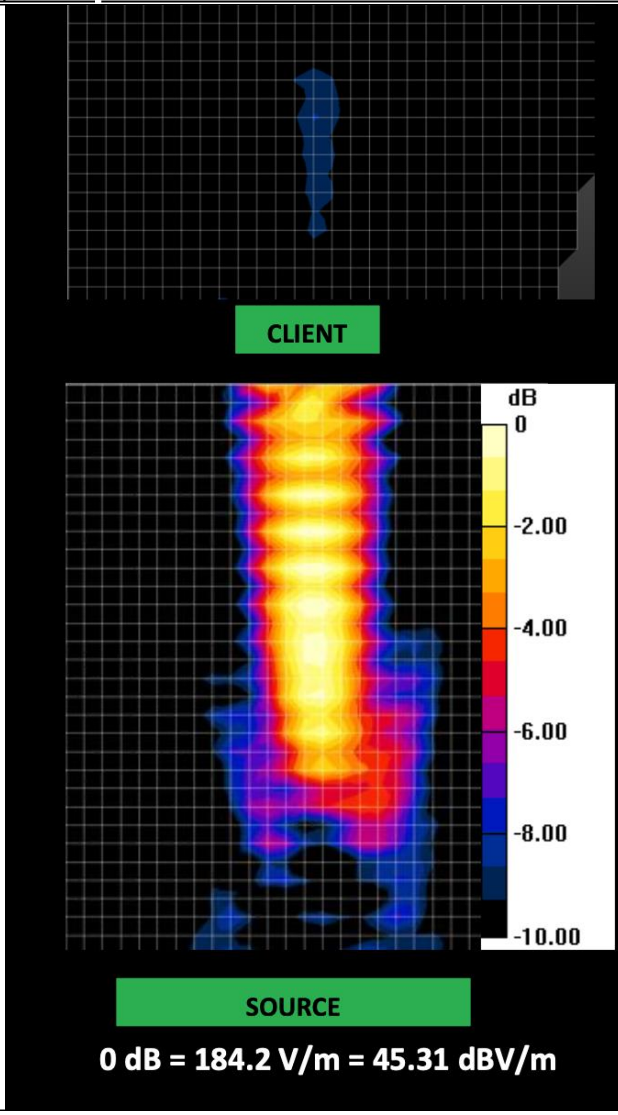


Figure 9 Unobstructed E-field scan at 1 m between Source and Client - Horizontal Plane

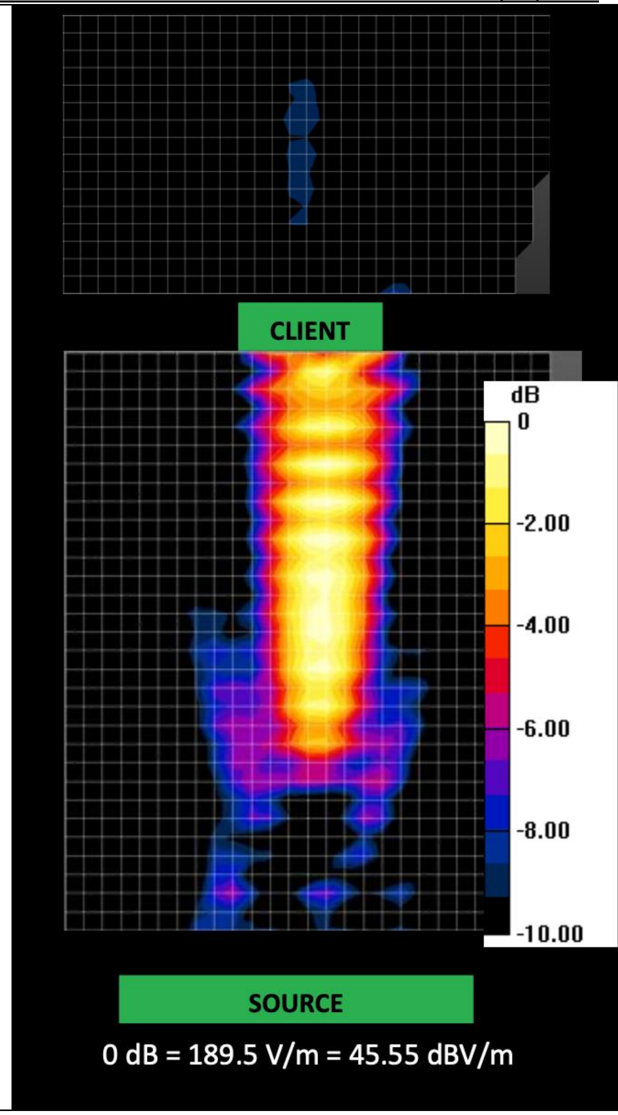


Figure 10 Unobstructed E-field scan at 1 m between Source and Client - Vertical Plane

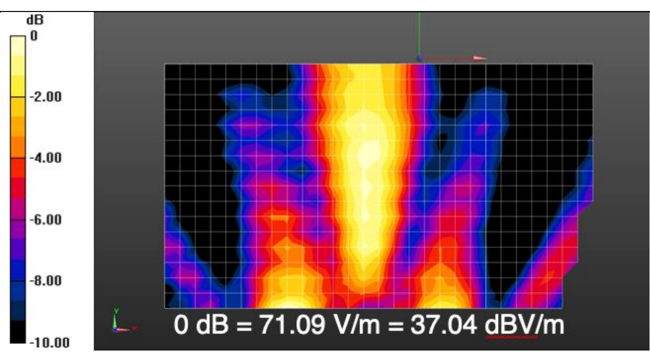


Figure 11: Unobstructed E-field scan at 1 m behind Client – Horiz. Plane (Normalized to peak field strength behind client of 71.09 V/m)

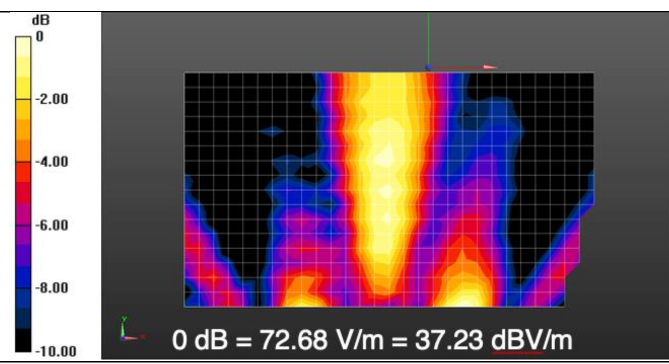


Figure 12: Unobstructed E-field scan at 1m behind Client - Vertical Plane (Normalized to peak field strength behind the client of 72.68 V/m)

10.3 Identifying the worst-case scenario with phantom

10.3.1 General

To determine the worst-case scenario in obstructed cases, we measured the potential for RF exposure with a fluid-filled phantom at varying offset distances from the boresight line between WPT Source and client. In prior testing for the Venus V2 device, the worst-case scenario was determined to be with the Client 50cm away from the WPT Power Source and the center of the phantom offset 22.5cm from the centerline between the Power Source and Client.

10.3.2 Obstructed Case with WPT Source/Client distance of 50cm

Field scans were done of the power field obstructed by a single, vertically oriented phantom, as depicted in Figures 13 and 14. Results are shown in Table 5.

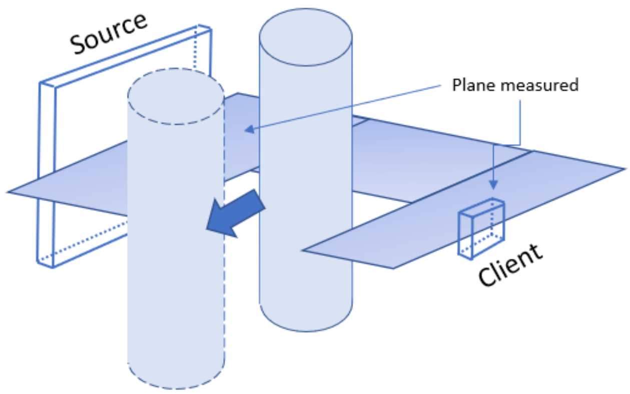
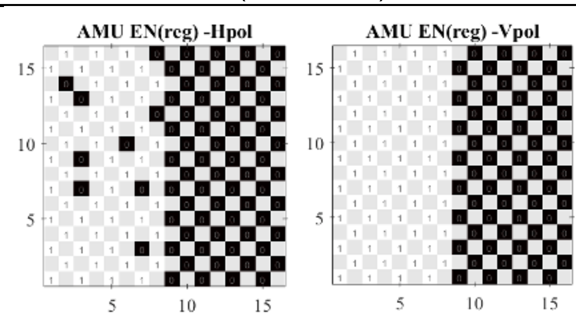


Figure 13: Obstructed case scan diagram

Figure 14: Obstructed case scan photo

Table 5: Details, obstructed scan

Phantom Offset, Vertical (cm)	Max V/m	Number of antenna elements (Horiz./ Vert.) ON (out of 256 Total)	Antenna map (dark squares = off)
0	0	0	n/a (all antenna off)
7.5	0	0	n/a (all antenna off)
15	0	0	n/a (all antenna off)
22.5	173.2	55/64	

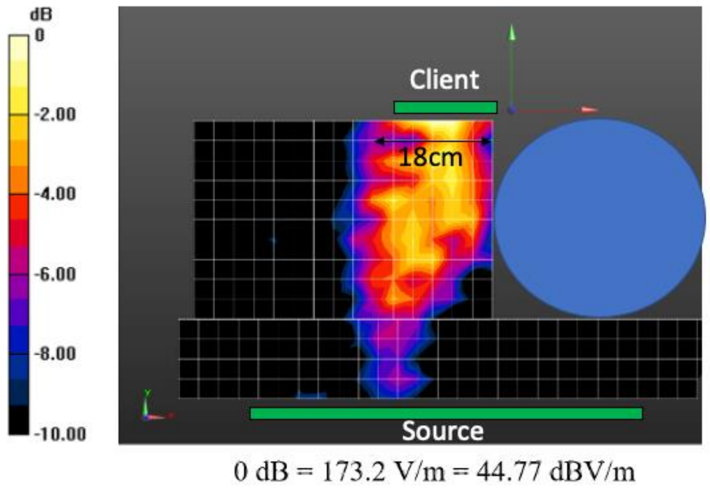


Figure 15: Scan of obstructed field, phantom offset 22.5cm

11 Conducting the 1g-average SAR and whole-body average SAR

As determined per KDB inquiry, we provide SAR values for the phantom placed behind the WPT power client. The "small box-shaped phantom," measuring 0.96 m x 0.233 m and as specified in IEC 62232 was used. The phantom is placed behind the client, relative to the power source, as pictured in Figure 16, with the client 90 cm from the WPT Source. The 90 cm distance is the same distance used to test Ossia's Venus V2 device. The test setup is shown in Figure 16.

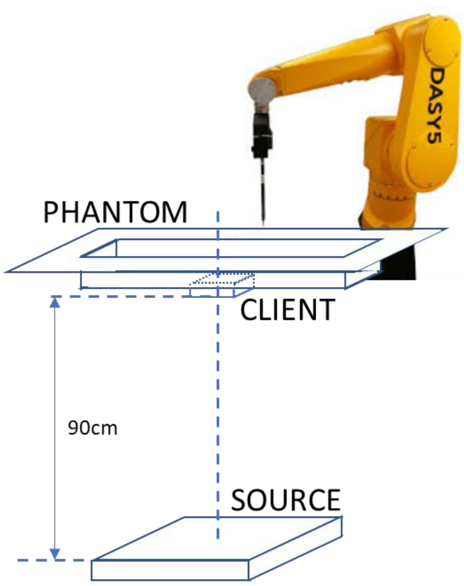


Figure 16 - SAR measurement test setup

IEC 62232 requires a correction factor to be applied to whole-body and 1g average peak SAR measurements. The factor is determined according to the following formulas:

1g average peak SAR:

$$SAR_{PSA}(d) = SAR_m(d) \times CF_1(d) \times CF_2(d)$$

$$CF_1(d) = \begin{cases} 1 & d < 200\text{ mm} \\ \frac{d}{200} & 200\text{ mm} \le d < 400\text{ mm} \\ 2 & 400\text{ mm} \le d \le 1\,000\text{ mm} \end{cases} \qquad CF_2(d) = \begin{cases} 2 & d \le \frac{\lambda}{4} \text{ AND } N_e > 1 \\ -\frac{4d}{7\lambda} + \frac{15}{7} & \frac{\lambda}{4} < d < 2\lambda \text{ AND } N_e > 1 \\ 1 & d \ge 2\lambda \text{ OR } N_e = 1 \end{cases}$$

Where d (the distance from the phantom to WPT Source) = 900 mm and λ = 124 mm.

For these values, $CF_1(d)$ = 2 and $CF_2(d)$ = 1. The total correction factor [$CF_1(d) \times CF_2(d)$] is 2.

Whole body SAR:

$$SAR_{wb}(d) = \frac{P_A(d) \times CF_3(d) \times CF_4(f)}{M}$$

$P_A(d)$ is the average temporal absorbed power (watts) in the phantom measured at a distance *d*, the EUT distance (mm) measured from the liquid surface;

$CF_3(d)$ is a correction factor to account for a possible increase in whole-body *SAR* due to a tissue layering effect defined by:

$$CF_3(d) = \begin{cases} 1 + \frac{0{,}8d}{400} & d < 400\text{ mm} \\ 1{,}8 & d \ge 400\text{ mm} \end{cases};$$

$CF_4(f)$ is a correction factor to compensate for a possible bias in the obtained general public whole-body *SAR* when assessed using the large box-shaped phantom for child exposure configurations. For frequencies between the data points a linear interpolation shall be used. For other exposure configurations and phantom type combinations, $CF4(f) = 1$;

M is the mass specified in IEC62232 representing the body. For general public exposure *M* = 12.5 kg.

As d is 900 mm $CF_3(d)$ = 1.8. $CF_4(f)$ = 1 as the large box shaped phantom was not used. The total correction factor is 1.8.

The corrected SAR values are 1g SAR = 1.290 W/kg and whole body SAR = 0.0580 W/kg. These values are below the FCC's limits. 47 CFR § 1.1310 defines the general population limits for peak SAR averaged over any 1g of tissue as 1.6 W/kg and whole-body average SAR as 0.08 W/kg.

Table 6 Measured and corrected SAR values

	Measured value	**Corrected value**	**Gen. pop. limits**	**Pass/Fail**
1g SAR[1]	0.619 W/kg	1.290 W/kg	1.6 W/kg	Pass
Whole-body SAR[2]	0.0557 W/kg	0.0580 W/kg	0.08 W/kg	Pass

Note 1, The Corrected 1g value includes power scaling (1.042) and ***$CF_1(d)$***

Note 2. The test equipment reports the Whole-Body SAR result with *$CF_3(d)$* included for a value of d >400 mm. The whole body corrected value in table 4 is corrected for power scaling only.

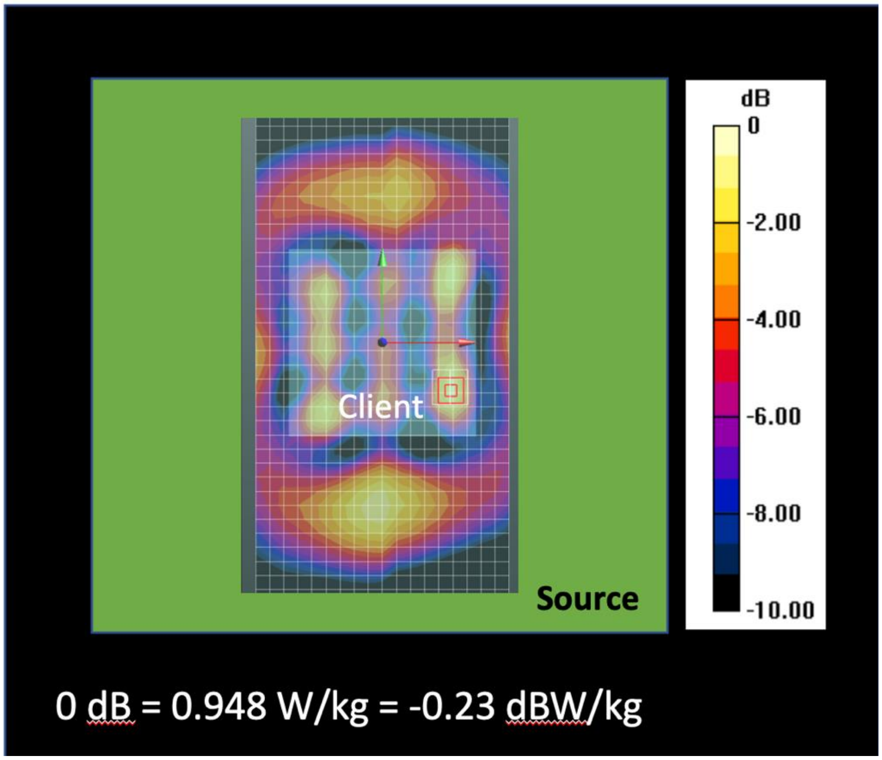


Figure 17: 1g SAR scan with phantom placed behind WPT client

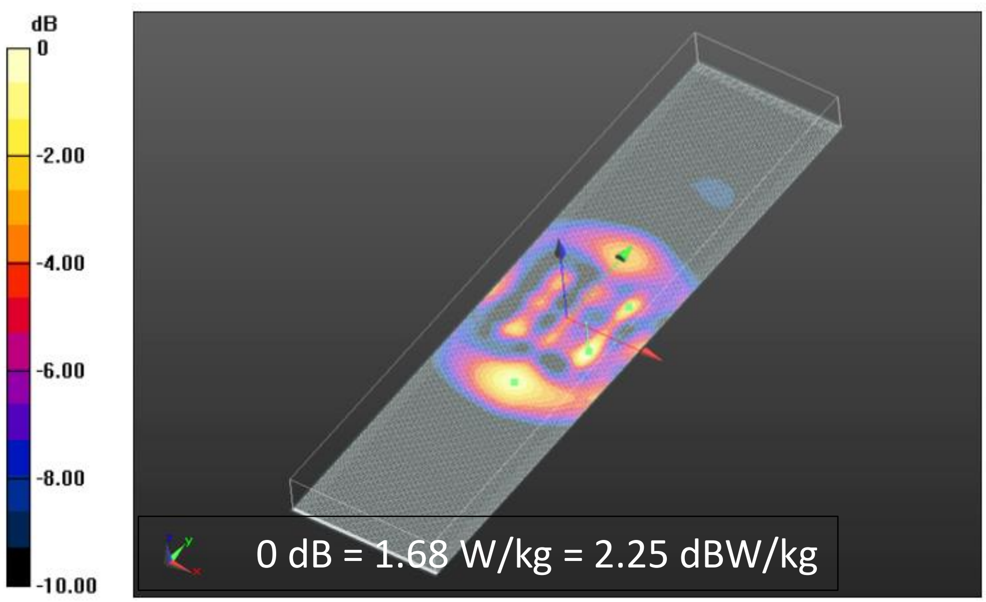


Figure 18: Volume scan with phantom placed behind WPT client

Appendixes

Refer to separated files for the following appendixes.

Appendix A: SAR System Check Plots

Appendix B: SAR Probe Certificates

Appendix C: SAR Dipole Certificates

Appendix D: SAR Tissue Ingredients

Appendix E: Test Case Summary Table

Appendix F: SAR Plot and Volume Scan

Appendix G: E-Field Plots

END OF REPORT