

SAR EVALUATION REPORT

IEEE Std 1528-2013

For Wireless Power Transfer Device for Wearable Strap

FCC ID: 2AJ2X-WP40 Model Name: WP40

Report Number: R14664772-S1V1 Issue Date: 6/3/2023

Prepared for WHOOP, Inc.
1325 Boylston St, Suite 401
Boston, MA 02215-3900, United States

Prepared by
UL LLC
12 LABORATORY DR
RTP, NC 27709, U.S.A.
TEL: (919) 549-1400



Revision History

Rev.	Date	Revisions	Revised By
V1	6/3/2023	Initial Issue	

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1. Attestation of Test Results

Applicant Name	WHOOP, Inc.
FCC ID	2AJ2X-WP40
Model Name	WP40
Applicable Standards	Published RF exposure KDB procedures IEEE Std 1528-2013
	SAR Limits (W/Kg)
Exposure Category	Extremities (hands, wrists, ankles, etc.) (10g of tissue)
General population / Uncontrolled exposure	4
DE Everanue Conditions	Equipment Class - Highest Reported SAR (W/kg)
RF Exposure Conditions	WPT
Extremity	0.002
Simultaneous Tx	0.103
Date Tested	3/24/2023 to 3/24/2023
Test Results	Pass
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Note: The charger device covered in this report (FCC ID: 2AJ2X-WP40) is used in conjunction with a strap device (FCC ID: 2AJ2X-WS40), which is capable of Bluetooth transmission. As such, an estimated SAR value for the strap device (FCC ID: 2AJ2X-WS40) is taken into consideration for simultaneous transmission conditions.

The charger device (FCC ID: 2AJ2X-WP40) was tested in its real-world use condition of being connected to the wrist-worn strap device (FCC ID: 2AJ2X-WS40).

UL LLC 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.

This report contains data provided by the customer which can impact the validity of results. UL LLC is only responsible for the validity of results after the integration of the data provided by the customer.

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.

This document may not be altered or revised in any way unless done so by UL LLC and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL LLC will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by A2LA, NIST, or any agency of the U.S. Government, or any agency of the U.S. government.

Approved & Released By:	Prepared By:
Jan Cery	Richard Jankovies
Devin Chang	Richard Jankovics
Senior Test Engineer	Operations Leader
UL Verification Services Inc.	UL LLC

2. Test Specification, Methods and Procedures

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093, IEEE Std 1528-2013, the following FCC Published RF exposure KDB procedures:

- 447498 D01 General RF Exposure Guidance v06
- o 447498 D03 Supplement C Cross-Reference v01
- o 680106 D01 RF Exposure Wireless Charging Apps v03r01
- o 865664 D02 RF Exposure Reporting v01r02

In addition to the above, the following information was used:

- o TCB Workshop October 2016; RF Exposure Procedures (DUT Holder Perturbations)
- o TCB Workshop April 2019; RF Exposure Procedures (Tissue Simulating Liquids (TSL))

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3. Facilities and Accreditation

UL LLC is accredited by A2LA, cert. # 0751.06 for all testing performed within the scope of this report. Testing was performed at the locations noted below.

The test sites and measurement facilities used to collect data are located at 2800 Perimeter Park Dr, Morrisville, NC, USA.

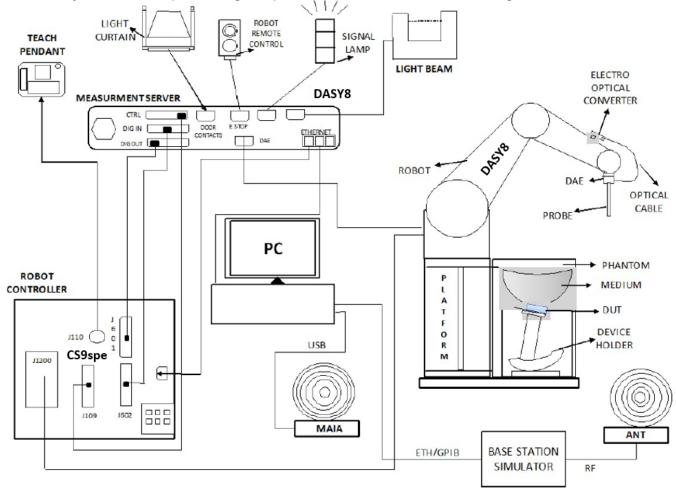
SAR Lab 1A

	Address	ISED CABID	ISED Company Number	FCC Registration
	Building: 12 Laboratory Dr RTP, NC 27709, U.S.A	US0067	2180C	825374
\boxtimes	Building: 2800 Perimeter Park Dr. Suite B Morrisville, NC 27560, U.S.A	US0067	27265	825374

4. SAR Measurement System & Test Equipment

4.1. SAR Measurement System

The DASY system used for performing compliance tests consists of the following items:



- 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 Win10 and the DASY8¹ 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.

¹ DASY8 software used: DASY16.0.2.83 and older generations.

4.2. SAR Scan Procedures

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 IEC/IEEE 62209-1528, 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	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5 \text{ mm}$	
Maximum probe angle from probe axis to phantom surface normal at the measurement location	30° ± 1°	20° ± 1°	
	≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	$3 - 4 \text{ GHz}$: $\leq 12 \text{ mm}$ $4 - 6 \text{ GHz}$: $\leq 10 \text{ mm}$	
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}	_	tion, is smaller than the above, in must be \leq the corresponding it device with at least one	

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 (refer to table below) 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}			\leq 2 GHz: \leq 8 mm 2 - 3 GHz: \leq 5 mm [*]	$3 - 4 \text{ GHz: } \le 5 \text{ mm}^*$ $4 - 6 \text{ GHz: } \le 4 \text{ mm}^*$
	uniform grid: $\Delta z_{Zoom}(n)$		≤ 5 mm	$3 - 4 \text{ GHz: } \le 4 \text{ mm}$ $4 - 5 \text{ GHz: } \le 3 \text{ mm}$ $5 - 6 \text{ GHz: } \le 2 \text{ mm}$
Maximum zoom scan spatial resolution, normal to phantom surface	$\begin{array}{c} \Delta z_{Zoom}(1)\text{: between} \\ 1^{st} \text{ two points closest} \\ \text{to phantom surface} \\ \\ \Delta z_{Zoom}(n>1)\text{:} \\ \text{between subsequent} \\ \text{points} \end{array}$	1st two points closest	≤ 4 mm	$3 - 4 \text{ GHz: } \le 3 \text{ mm}$ $4 - 5 \text{ GHz: } \le 2.5 \text{ mm}$ $5 - 6 \text{ GHz: } \le 2 \text{ mm}$
		$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$		
Minimum zoom scan volume	X V 7		≥ 30 mm	$3 - 4 \text{ GHz:} \ge 28 \text{ mm}$ $4 - 5 \text{ GHz:} \ge 25 \text{ mm}$ $5 - 6 \text{ GHz:} \ge 22 \text{ mm}$

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.

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.

When zoom scan is required and the <u>reported</u> SAR from the <u>area scan based 1-g SAR estimation</u> 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.

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
Netw ork Analyzer	Keysight	E5063A	MY54100681	9/30/2023
Dielectric Probe	SPEAG	DAK-12	1128	1/30/2024
Shorting Block	SPEAG	DAK-12 Short	N/A	1/30/2024
Thermometer	Fisher Scientific	15-078-181	210204689	3/31/2023

System Check

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Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Signal Generator	Keysight	N5181A	MY 50140788	1/12/2024
3-Path Diode Pow er Sensor	Rohde & Schwarz	NRP8S	112236	5/31/2023
3-Path Diode Pow er Sensor	Rohde & Schwarz	NRP8S	112237	5/31/2023
Dual Directional Coupler	Werlatone	C5100-10	92249	N/A

Lab Equipment

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
E-Field Probe	SPEAG	EX3DV4	7710	2/3/2024
Data Acquisition Electronics	SPEAG	DAE4	1715	1/23/2024
System Validation Dipole	SPEAG	CLA13	1008	1/12/2024
Environmental Indicator	Control Company	06-662-4	200037635	2/24/2024

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 expanded SAR measurement uncertainty must be \leq 30%, for a confidence interval of k = 2. If these conditions are met, extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

Therefore, the measurement uncertainty is not required.

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6. Device Under Test (DUT) Information

6.1. DUT Description

Device Dimension	Overall (Length x Width x Depth): 36.64 mm x 42.21 mm x 20.50 mm Overall Diagonal: 47.65 mm This is a wrist-worn device	
Back Cover	The Back Cover is not removable	
Battery Options	The rechargeable battery is not user accessible.	
Accessory	Wearable Strap	
Test sample information	S/N Notes	
	P4CE002423 N/A	
Hardware Version	А	
Software Version	171-25-02-00	

6.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating mode	Duty Cycle used for SAR testing
WPT	13.56 MHz	N/A	N/A

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7. RF Exposure Conditions (Test Configurations)

Refer to "SAR Photos and Ant locations" Appendix for the specific details of the antenna-to-antenna and antenna-to-edge(s) distances.

Wireless technologies	RF Exposure Conditions	DUT-to-User Separation	Test Position	Antenna-to- edge/surface	SAR Required	Note
NFC/WPT	Extremity (Hand/Wrist/Ankle)	0	Rear	N/A	Yes	

8. Dielectric Property Measurements & System Check

8.1. Dielectric Property Measurements

The temperature of the tissue-equivalent medium used during measurement must also be within 18° C to 25° C and within $\pm 2^{\circ}$ 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 \pm 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 \pm 10%. This is limited to frequencies \leq 3 GHz.

Tissue Dielectric Parameters

FCC KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

Torget Frequency (MHz)	Н	ead	Body		
Target Frequency (MHz)	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:

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SAR	Band Tissue Frequency		Relative Permittivity (cr)			Conductivity (σ)						
Lab	Date	(MHz)	Type	(MHz)	Measured	Target	Delta (%)	Measured	Target	Delta (%)		
				13	57.60	55.00	4.73	0.74	0.75	-1.99		
1A	2023-03-23	13	Head	12	57.60	55.00	4.73	0.74	0.75	-1.99		
				14	57.58	55.00	4.69	0.74	0.75	-1.99		

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8.2. 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 TWIN SAM or ELI 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 B for the SAR System Check Plots.

SAR		Tissue		Dipole Dipole Power		Measured Results for 1g SAR Measured Results for 10g S				ts for 10g SA				
SAR Lab	Date	Type	Dinole Type Serial #	Cal. Due Data	(dBm)	Zoom Scan	Normalize to 1 W	Target (Ref. Value)	Delta ±10 %	Zoom Scan	Normalize to 1 W	Target (Ref. Value)	Delta ±10 %	Plot No.
1A	3/23/2023	Head	CLA13 SN: 1008	1/12/2024	16.50	0.024	0.54	0.54	-1.23	0.015	0.34	0.34	-0.65	1

9. Conducted Output Power Measurements

Conducted output power cannot be measured for NFC/WPT, so a 2dB scaling factor shall be used to account for potential variations between devices.

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10. Measured and Reported (Scaled) SAR Results

SAR Test Reduction criteria are as follows:

Reported SAR(W/kg) for WPT = Measured SAR * Power Scaling Factor

KDB 447498 D01 General RF Exposure Guidance:

Testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is:

• ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz

10.1. WPT

RF Exposure	Dist. Test Position		From (MIII-)	Pow er Scaling	10-g SA	Plot	
Conditions	(mm)	Test Position	Freq. (MHz)	Factor (dB)	Meas.	Scaled	No.
Extremity	0	Back	13.56	2.0	0.001	0.002	1

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11. SAR Measurement Variability

In accordance with published RF Exposure KDB 865664 D01 SAR measurement 100 MHz to 6 GHz. These additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

- Repeated measurement is not required when the original highest measured SAR is < 0.8 or 2 W/kg (1-g or 10-g respectively); steps 2) through 4) do not apply.
- 2) When the original highest measured SAR is ≥ 0.8 or 2 W/kg (1-g or 10-g respectively), repeat that measurement once.
- 3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 or 3.6 W/kg (~ 10% from the 1-g or 10-g respective SAR limit).
- 4) Perform a third repeated measurement only if the original, first, or second repeated measurement is ≥ 1.5 or 3.75 W/kg (1-g or 10-g respectively) and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

Note(s):

Repeated measurement is not required since the original highest measured SAR is <0.8 W/kg (1-g) or 2 W/kg (10-g) .

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12. Simultaneous Transmission Conditions

RF Exposure Condition	Item	Capable Transmit Configurations					
Extremity	1	WPT	+	DSS			
Notes:							
Charger device supports WPT, and strap accessory supports DSS.							

The WPT device (2AJ2X-WP40) is used in conjunction with a wearable strap, which includes a Bluetooth radio. The simultaneous transmission of the two devices in close proximity to the body increase the RF exposure to the wearer. In this section, the RF exposure from the wearable strap is estimated to calculate the Sim of SAR for simultaneous transmission.

12.1. Simultaneous transmission SAR test exclusion considerations

KDB 447498 D01 General RF Exposure Guidance provides two procedures for determining simultaneous transmission SAR test exclusion: Sum of SAR and SAR to Peak Location Ratio (SPLSR)

Sum of SAR

To qualify for simultaneous transmission SAR test exclusion based upon Sum of SAR the sum of the reported standalone SARs for all simultaneously transmitting antennas shall be below the applicable standalone SAR limit. If the sum of the SARs is above the applicable limit then simultaneous transmission SAR test exclusion may still apply if the requirements of the SAR to Peak Location Ratio (SPLSR) evaluation are met.

12.2. Estimated SAR for Simultaneous Transmission SAR Analysis

Considerations for SAR estimation

- 1. When standalone SAR test exclusion applies, standalone SAR must also be estimated to determine simultaneous transmission SAR test exclusion.
- 2. Dedicated Host Approach criteria for SAR test exclusion is likewise applied to SAR estimation, with certain distinctions between test exclusion and SAR estimation:
 - o When the separation distance from the antenna to an adjacent edge is ≤ 5 mm, a distance of 5 mm is applied for SAR estimation; this is the same between test exclusion and SAR estimation calculations.
 - o When the separation distance from the antenna to an adjacent edge is > 5 mm but ≤ 50 mm, the actual antenna-to-edge separation distance is applied for SAR estimation.
 - When the minimum test separation distance is > 50 mm, the estimated SAR value is 0.4 W/kg
- Please refer to <u>Estimated SAR Tables</u> to see which test positions are inherently compliant as they consist of only estimated SAR values for all applicable transmitters and consequently will always have sum of SAR values < 1.2 W/kg. Simultaneous transmission SAR analysis was therefore not performed for these test positions.

Estimated SAR for BT

Tx	Frequency	Output Power		Separation Distance (mm)	Estimated 10-g SAR Value (W/kg)	
Interface	(MHz)	dBm mW		Back	Back	
Bluetooth	2480	8.00	6	0	0.101	

12.3. Sum of the SAR for WPT & BT

		Standalone	Σ 10-g SAR (W/kg)	
RF Exposure	Test Position	1	2	
Conditions	100110011011	Charger WPT	Strap BT	1+2
		***	Di	
Extremity	Back	0.002	0.101	0.103

Appendixes

Refer to separated files for the following appendixes.

Appendix A: SAR Setup Photos

Appendix B: SAR System Check Plots

Appendix C: SAR Highest Test Plots

Appendix D: SAR Tissue Ingredients

Appendix E: SAR Probe Certificates

Appendix F: SAR Dipole Certificates

END OF REPORT