SAR EVALUATION REPORT

FCC 47 CFR § 2.1093
IEEE Std 1528-2013

For
OVER-THE-AIR, DISTANCE CHARGING TRANSMITTER

FCC ID: 2ADNG-MS550
Model Name: MS-550

Report Number: 13119172-S1V5
Issue Date: 2/4/2020

Prepared for

Energous Corporation
3590 NORTH FIRST STREET
SAN JOSE, CA 95134

Prepared by

UL VERIFICATION SERVICES INC.
47173 BENICIA STREET
FREMONT, CA 94538, U.S.A.
TEL: (510) 319-4000
FAX: (510) 661-0888

NVLAP LAB CODE 200065-0

Revision History

Rev.	Date	Revisions	Revised By
	12/17/2019		
V2	12/18/2019	Section 4.3 – corrected DAE calibration due date.	Dave Weaver
V3	12/19/2019	Section 13.2 – Updated Bluetooth frequency	Remi Rodberg
V4	1/30/2020	Various sections updated based upon FCC feedback	Dave Weaver
V5	2/4/2020	Section 11 – Updated following tilt switch modification and retest	Dave Weaver

Table of Contents

1. Attestation of Test Results 5

2. Test Specification, Methods and Procedures 6

3. Facilities and Accreditation 6

4. SAR Measurement System & Test Equipment 7

4.1. SAR Measurement System 7

4.2. SAR Scan Procedures 8

4.3. Test Equipment 10

5. Measurement Uncertainty 10

6. Device Under Test (DUT) Information 11

6.1. DUT Description 11

6.2. Wireless Technologies 11

6.3. Operational Description 11

7. Test Rationale 12

8. RF Exposure Conditions (Test Configurations) 13

9. Verification of the Charging Zone 13

10. Keep-Out Zone 14

10.1. Description 14

10.2. Verification of the Keep-Out Zone Range 14

10.3. Verification of Keep-Out Zone detection speed. 15

11. Tilt Sensor Operation 15

12. Dielectric Property Measurements & System Check 16

12.1. Dielectric Property Measurements 16

12.2. System Check 17

13. Conducted Output Power Measurements 18

14. Measured and Reported (Scaled) SAR Results 18

14.1. CW 917.5MHz 18

14.2. Standalone SAR Test Exclusion Considerations & Estimated SAR 19

15. SAR Measurement Variability 20

16. Simultaneous Transmission Conditions 20

Appendixes 21

Appendix A: SAR Setup Photos 21

Appendix B: SAR System Check Plots 21
Appendix C: SAR Highest Test Plots 21
Appendix D: SAR Tissue Ingredients 21
Appendix E: SAR Probe Certificates 21
Appendix F: SAR Dipole Certificates 21

1. Attestation of Test Results

Applicant Name	Energous Corporation	
FCC ID	2ADNG-MS550	
Model Name	MS-550	
Applicable Standards	Published RF exposure KDB procedures IEEE Std 1528-2013	
Exposure Category	SAR Limits (W/Kg)	
	Peak spatial-average (1g of tissue)	Extremities (hands, wrists, ankles, etc.) (10g of tissue)
General population / Uncontrolled exposure	1.6	4
RF Exposure Conditions	Equipment Class - Highest Reported SAR (W/kg)	
	8CC	DSS
Body	0.723	N/A
Simultaneous TX	0.727	
Date Tested	11/21/2019, 11/22/2019, 12/10/2019, and 2/4/2020	
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.

This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. 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 NVLAP, NIST, any agency of the Federal Government, or any agency of the U.S. government.

Approved & Released By:	Prepared By:
Dave Weaver Operations Leader UL Verification Services Inc.	Remi Rodberg Laboratory Technician 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, IEEE STD 1528-2013, the following FCC Published RF exposure KDB 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
- 447498 D03 Supplement C Cross-Reference v01
- 865664 D01 SAR measurement 100 MHz to 6 GHz v01r04
- 865664 D02 RF Exposure Reporting v01r02

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

- TCB workshop October, 2016; Page 7, RF Exposure Procedures (Bluetooth Duty Factor)
- TCB workshop April 2019; RF Exposure Procedures (Tissue Simulating Liquids (TSL)

3. Facilities and Accreditation

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

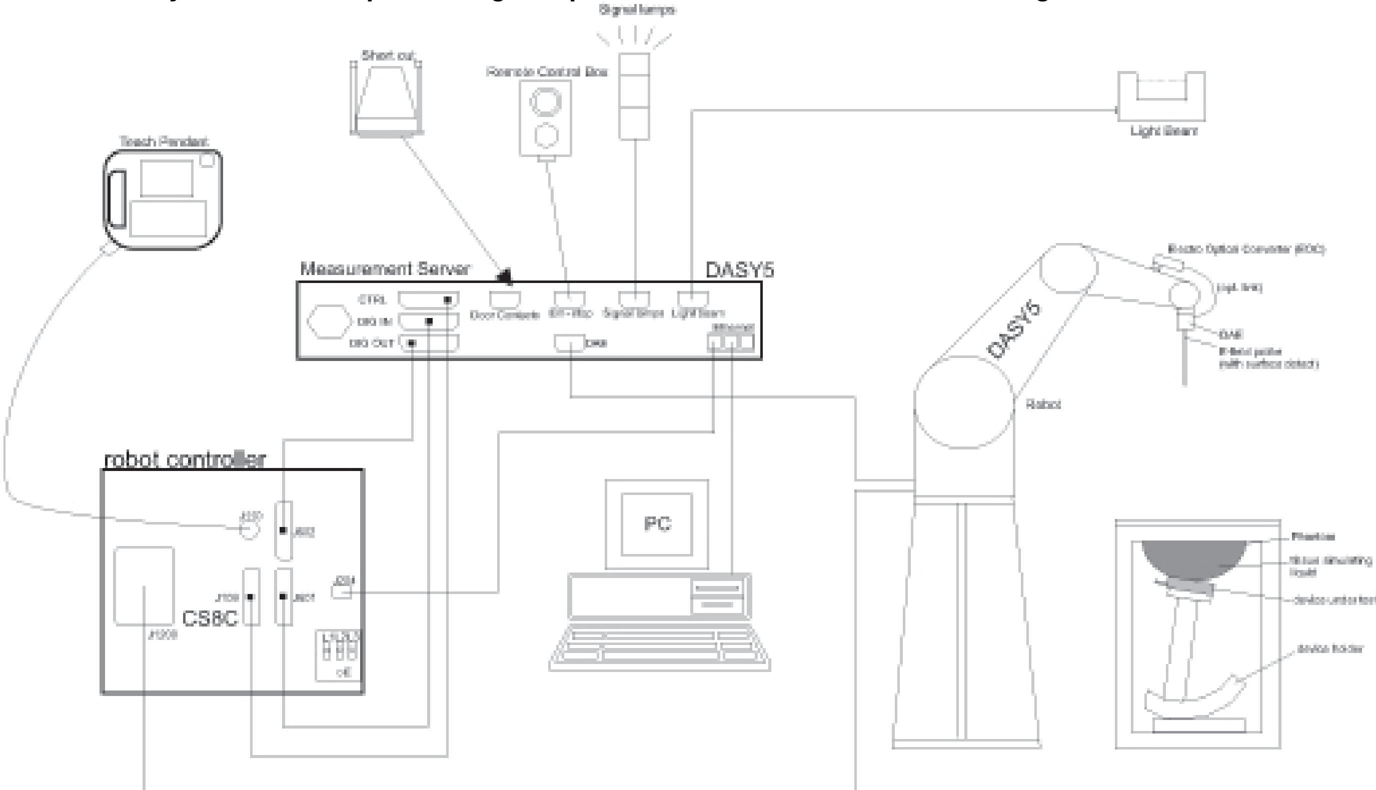
47173 Benicia Street	47266 Benicia Street
SAR Lab A	SAR Lab 1
SAR Lab B	SAR Lab 2
SAR Lab C	SAR Lab 3
SAR Lab D	SAR Lab 5
SAR Lab E	SAR Lab 6
SAR Lab F	SAR Lab 7
SAR Lab G	SAR Lab 8
SAR Lab H	SAR Lab 9

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 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 WinXP or Win7 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.

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 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 (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

<table>
<tr><th colspan="3"></th><th>$\leq$ 3 GHz</th><th>> 3 GHz</th></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>$\leq$ 2 GHz: $\leq$ 8 mm
2 – 3 GHz: $\leq$ 5 mm*</td><td>3 – 4 GHz: $\leq$ 5 mm*
4 – 6 GHz: $\leq$ 4 mm*</td></tr>
<tr><td rowspan="3">Maximum zoom scan spatial resolution, normal to phantom surface</td><td colspan="2">uniform grid: $\Delta z_{Zoom}(n)$</td><td>$\leq$ 5 mm</td><td>3 – 4 GHz: $\leq$ 4 mm
4 – 5 GHz: $\leq$ 3 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>$\Delta z_{Zoom}(1)$: between 1st two points closest to phantom surface</td><td>$\leq$ 4 mm</td><td>3 – 4 GHz: $\leq$ 3 mm
4 – 5 GHz: $\leq$ 2.5 mm
5 – 6 GHz: $\leq$ 2 mm</td></tr>
<tr><td>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>$\geq$ 30 mm</td><td>3 – 4 GHz: $\geq$ 28 mm
4 – 5 GHz: $\geq$ 25 mm
5 – 6 GHz: $\geq$ 22 mm</td></tr>
<tr><td colspan="5">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 <u>reported</u> SAR from the area scan based 1-g SAR estimation procedures of KDB 447498 is $\leq$ 1.4 W/kg, $\leq$ 8 mm, $\leq$ 7 mm and $\leq$ 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.</td></tr>
</table>

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.

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
S-Parameter Network Analyzer	R&S	ZNLE6	101273-VA	4/24/2020
Dielectric Probe kit	SPEAG	DAK-3.5	1087	2/6/2020
Shorting Block	SPEAG	DAK-3.5 Short	SM DAK 200 BA	2/6/2020
Thermometer	Fisher Scientific	Traceable	181062309	2/21/2020

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Signal Generator	Rhode & Schwarz	SMB 100A	180970-zC	2/13/2020
Power Sensor	Rhode & Schwarz	NRP18A	100994-RE	2/15/2020
Power Sensor	HP	8481A	1926A27048	2/7/2020
Power Meter	HP	437B	3125U11364	1/29/2020
Bi-Directional Coupler	Werlatone	4063	C8060-102	N/A

Lab Equipment

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
E-Field Probe (SAR Lab 4)	SPEAG	EX3DV4	3990	8/28/2020
Data Acquisition Electronics (SAR Lab 4)	SPEAG	DAE4	1544	3/19/2020
System Validation Dipole	SPEAG	D900V2	1d143	10/15/2020

Other

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Power Meter	Agilent	N1912A	MY55196004	1/30/2020
Power Sensor	Agilent	N1921A	MY53260010	2/6/2020
Receiver	Energous	Nb4402E	N/A	N/A
EUT AC/DC Adapter	Anker	PD-30	AFZFD51915301545	N/A

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 ≤ 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.

6. Device Under Test (DUT) Information

6.1. DUT Description

Device Dimension	Overall (Length x Width x Depth): 320 mm x 120 mm x 55 mm	
Test sample information	**S/N**	**Notes**
	2004	(WPT) Conducted Unit
	2032	(WPT) Radiated Unit
Hardware Version	4.0.1.255.	
Software Version	WattUp app V 4.0.0.	

6.2. Wireless Technologies

Wireless technologies	Frequency bands	Operating mode	Duty Cycle used for SAR testing
CW	917.5 MHz	Charging Client Device	100%
BLE	2.4 GHz	N/A	N/A[1]

Notes:

1. Measured Duty Cycle is not required due to SAR test exemption.

6.3. Operational Description

The MS-550 is a wireless power charger that delivers RF energy to an authorized Client Device seeking to be charged when positioned in the charging zone. The charging zone is a region up to 40 cm directly in front of the MS-550 . Client Devices further than 40 cm away will not be charged.

The MS-550 monitors the presence of the user and will switch off the charging signal if a user is detected within 20 cm of the front of the MS-550.

7. Test Rationale

The MS-550 is designed not to charge a Client Device when the user is closer than 20 cm from the middle of the MS-550 center section (See Figure 1).

Unless otherwise specified, the reference point for distances relative to the MS-550 are measured from the middle of the MS-550 center section as denoted by the yellow dot shown in figure 1.

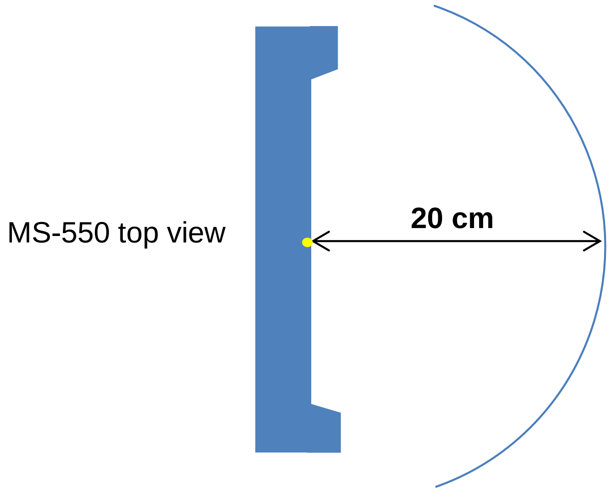


Figure 1: Location of reference point and Keep-Out Zone

The MS-550 will only charge a Client Device if it is placed within a pre-defined Charging Zone. The extent of the Charging Zone was verified and the results are reported in Section 9.

The MS-550 features a Keep-Out Zone that will disable charging if the user is detected within a predefined zone in front of the MS-550. SAR testing is not required within the Keep-Out Zone. The extent of the Keep-Out Zone was verified and the results are reported in Section 10.

The MS-550 uses a tilt sensor to disable WPT if it is tilted forwards or backwards beyond 15°. Operation was verified and reported in section 11.

8. RF Exposure Conditions (Test Configurations)

The DUT is a desktop Wireless Power transfer device and is not intended for handheld or body worn use.

The DUT was assessed at 20 cm directly in front of the MS-550 and 5 cm from the top, back and sides in accordance with FCC guidance.

The tests in sections 9, 10 and 11 were performed to verify the charging and keep out zones. Presence or absence of charging signal was monitored using a spectrum analyzer connected to an antenna.

9. Verification of the Charging Zone

The MS-550 will not enable the charging signal if the Client Device is outside of the nominal Charging Zone shown in Figure 2.

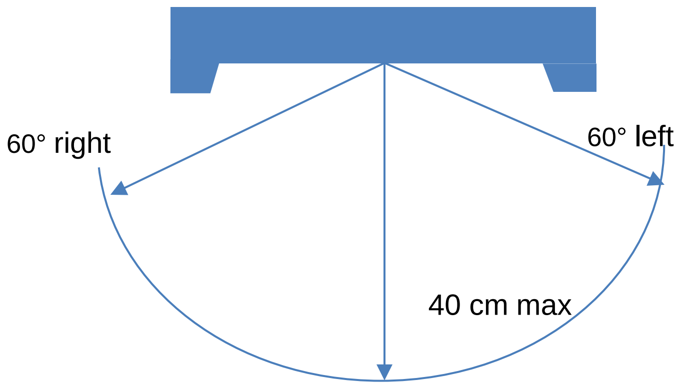


Figure 2: Nominal Charging Zone

The Charging Zone was verified by placing a client device at a distance of 45 cm from the reference point and incrementally moving the client device toward the MS-550 until charging was initiated. The test was performed with the client device directly in front of the MS-550 and at 60° to the left and right of a centerline protruding from the front of the MS-550.

Client location	Distance charging commenced (cm)
Centerline	36
60° right	28
60° left	26

10. Keep-Out Zone.

10.1. Description

To mitigate RF exposure the MS-550 uses infra-red sensors to detect the presence of a user. The sensors are positioned on either side of the front of the MS-550 in the protrusions

Figure 3: Keep-Out-Zone Sensor Locations

The keep-out-zone is defined as a 20 cm arc centered upon the reference point in front of the MS-550.

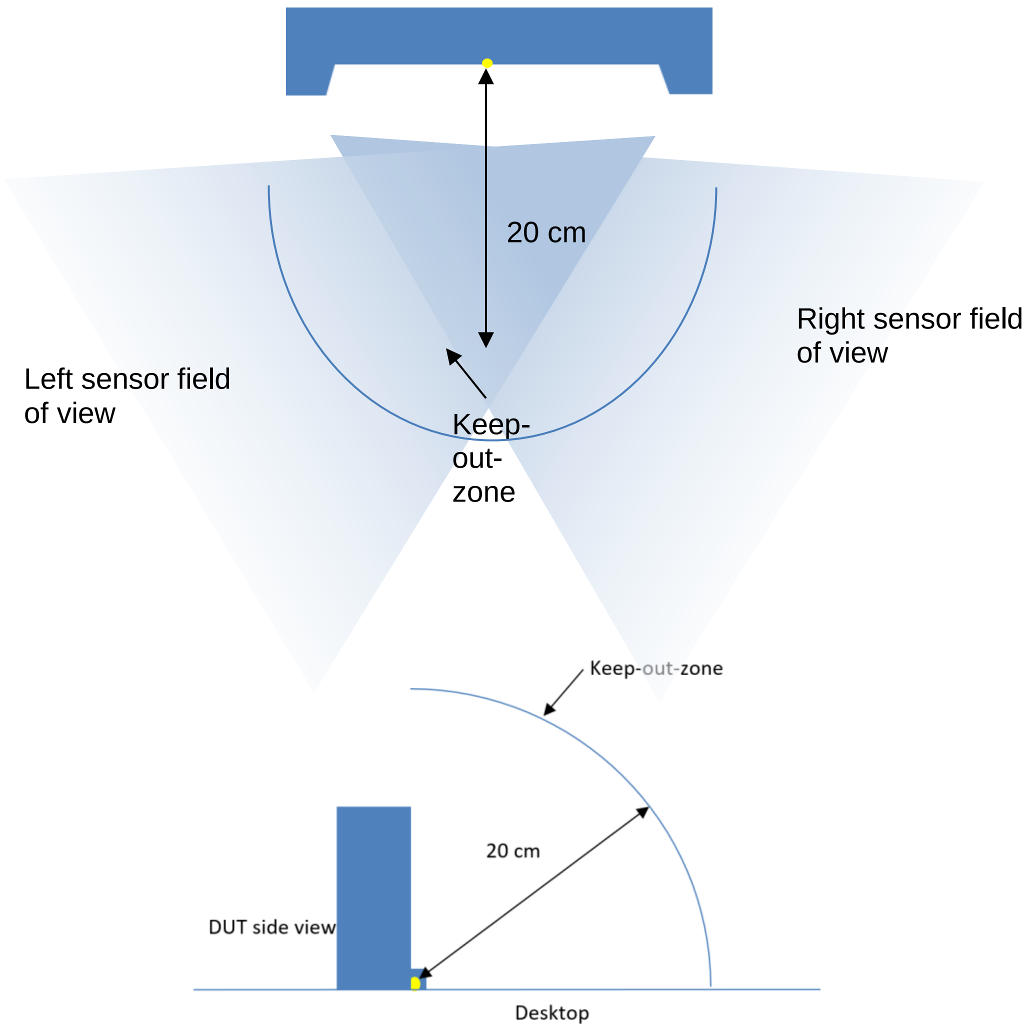


Figure 4: Location of Keep-Out Zone

10.2. Verification of the Keep-Out Zone Range

A client device was placed inside the charging area and charging initiated. The keep-out-zone was verified by moving a wooden hand toward the MS-550 along the centerline until charging was disabled. The hand was attached to a linear actuator to allow precise positioning. The hand was covered with a heated sock to simulate body temperature so that the infra-red detectors could detect its presence. It was verified that charging was disabled at 20 cm. The hand was moved along the 20 cm arc and the charging remained disabled along the extent of the keep-out-zone.

Additional testing was performed over a curved plane at a distance of 20 cm in front of the reference point. The hand was placed at various locations on the curved plane and charging was not enabled at any time. Figure 4 shows the side view

As SAR testing was performed at 5cm from the top, rear and sides further investigation of the keep out zone was deemed unnecessary.

10.3. Verification of Keep-Out Zone detection speed.

Testing was performed to measure how quickly the charging was disabled once the Keep-Out-Zone was breeched. The hand attached to the linear actuator was translated toward the MS-550 at a speed of 0.75 m/s. As the hand reached 20 cm from the MS-550 a microswitch was operated. This was used to trigger an oscilloscope. The oscilloscope was monitoring the charging signal from the MS-550. The following trace shows the charging signal (red trace) being disabled less than 20 ms after the trigger signal (Yellow trace).

Figure 5: Keep-Out-Zone detection speed trace

11. Tilt Sensor Operation

The DUT is equipped with a tilt sensor to prevent a DUT that is tilted either forwards or backwards from transmitting energy. The DUT was placed upon a desktop and slowly tilted forwards or backwards to an angle of 15°. It was verified that with a client device in the charging area the charging state switched from enabled to disabled before the tilt angle exceeded 15° in either direction.

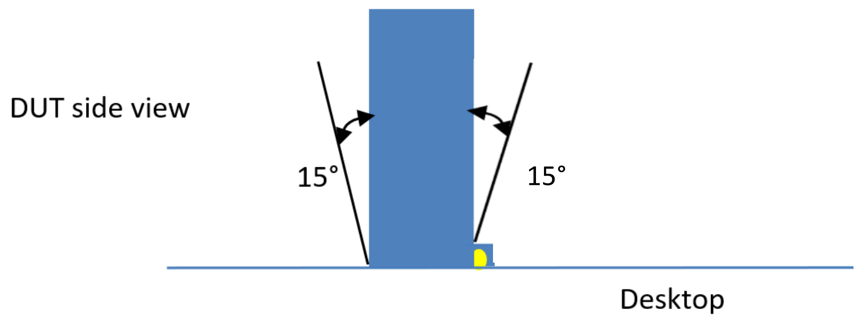


Figure 6: Tilt Sensor Verification

12. Dielectric Property Measurements & System Check

12.1. 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

IEEE Std 1528-2013

Refer to Table 3 within the IEEE Std 1528-2013

IEC 62209-1

Refer to Table A.3 within the IEC 62209-1

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	11/20/2019	900	Head	900	42.88	41.50	3.33	0.97	0.97	0.10
				880	42.95	41.50	3.49	0.97	0.95	2.13
				920	42.84	41.49	3.25	0.98	0.98	-0.55

12.2. 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 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	11/20/2019	Head	D900V2 SN:1d143	10/15/2020	1.060	10.60	11.10	-4.50	0.689	6.89	7.07	-2.55	1,2

13. Conducted Output Power Measurements

Mode	Antenna	Freq. (MHz)	Average Power (dBm)	
			Meas Pwr	Tune-up
CW	1	917.5	37.3	37.4

14. Measured and Reported (Scaled) SAR Results

14.1. CW 917.5MHz

RF Exposure Conditions	Mode	Dist. (cm)	Test Position	Freq. (MHz)	Power (dBm)		1-g SAR (W/kg)		10-g SAR (W/kg)		Plot No.
					Tune-up Limit	Meas.	Meas.	Scaled	Meas.	Scaled	
Standalone	CW	20	Straight	917.5	37.4	37.3	0.475	0.486	0.330	0.338	
		5	Top	917.5	37.4	37.3	0.707	**0.723**	0.530	0.542	1
			Back	917.5	37.4	37.3	0.081	0.083	0.061	0.062	
			Edge 2	917.5	37.4	37.3	0.109	0.112	0.082	0.084	
			Edge 4	917.5	37.4	37.3	0.071	0.073	0.054	0.055	

14.2. Standalone SAR Test Exclusion Considerations & Estimated SAR

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)]·[√f(GHz)] ≤ 3.0, for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where

- $f_{(GHz)}$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

When the standalone SAR test exclusion is applied to an antenna that transmits simultaneously with other antennas, the standalone SAR must be estimated according to following to determine simultaneous transmission SAR test exclusion:

- *(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)]·[√$f_{(GHz)}$/x]* W/kg for test separation distances ≤ 50 mm;
  where x = 7.5 for 1-g SAR, and x = 18.75 for 10-g SAR.
- 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distances is > 50 mm.

RF Air interface	RF Exposure Conditions	Frequency (GHz)	Max. tune-up tolerance Power		Min. test separation distance (mm)	SAR test exclusion Result*	Estimated 1-g SAR (W/kg)
			(dBm)	(mW)			
BLE	Standalone	2.45	-1.6	1	50	0.0	0.004

Conclusion:

*: The computed value is ≤ 3; therefore, BLE qualifies for Standalone SAR test exclusion.

Note. The estimated SAR at 50 mm was used for all simultaneous transmission calculations.

15. 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.

1) 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.

Conclusion:

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

16. Simultaneous Transmission Conditions

According to KDB 447498 D01, General RF Exposure Guidance, simultaneous transmission SAR measurements can be excluded if the sum of the SAR from simultaneously transmitting antennas is less than the SAR limit.

The DUT supports simultaneous transmission between the 917.5 MHz and BLE transmitters.

The maximum reported SAR at **50** mm for 917.5 MHz is 0.723 W/kg

The estimated SAR at **50** mm value for BLE is 0.004 W/kg

The sum of the SAR at **50** mm is 0.723 + 0.004 = 0**.727 W/kg**.

The sum of the SAR is less than 1.6 W/kg therefore simultaneous transmission SAR measurements can be excluded.

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