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Phone: +1 (949) 393-1123
Web: www.vista-compliance.com
Email: info@vista-compliance.com

SAR Test Report

Test Report Number	STA-21092042-LC-FCC-IC-C-SAR
FCC ID	U6YRDNA135201
IC	216P-RDNA135201
Applicant	Panasonic Avionics Corporation
Applicant Address	26200 Enterprise Way Lake Forest, California, United States 92630
Product Name	WSCU Cradle Docking station
Model (s)	RD-NA1352-01
Date of Receipt	03/08/2022
Date of Test	04/26/2022-04/27/2022
Report Issue Date	05/02/2022
Test Standards	IEEE Std 1528-2013 IEC/IEEE 62209-1528: 2020 47CFR2.1093 RSS-102 Issue 5, Feb 2021 447498 D01 General RF Exposure Guidance v06 248227 D01 802 11 Wi-Fi SAR v02r02 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
Test Result	**PASS**

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Issued by:

Vista Compliance Laboratories
1261 Puerta Del Sol, San Clemente, CA 92673 USA
www.vista-compliance.com

Devin Tai (Test Engineer)	**David Zhang (Engineering Reviewer)**

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REVISION HISTORY

Report Number	Version	Description	Issued Date
STA-21092042-LC-FCC-IC-C-SAR	01	Initial report	05/02/2022

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1 Test Summary

Test Requirement	Test Item	Test Method	Result
47CFR2.1093 RSS-102 Issue 5, Feb 2021	SAR measurement	IEEE Std 1528-2013 IEC/IEEE 62209-1528: 2020 47CFR2.1093 RSS-102 Issue 5, Feb 2021 447498 D01 General RF Exposure Guidance v06 248227 D01 802 11 Wi-Fi SAR v02r02 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04	Pass

2 General Information

2.1 Applicant

Applicant	Panasonic Avionics Corporation
Applicant address	26200 Enterprise Way Lake Forest, California, United States 92630
Manufacturer	Panasonic Avionics Corporation
Manufacturer Address	26200 Enterprise Way Lake Forest, California, United States 92630

2.2 Product information

Product Name	WSCU Cradle Docking station
Model Number	RD-NA1352-01
Family Models	N/A
Serial Number	RD12484 RD12485
Frequency Band	WLAN_5G: 5180 ~ 5240MHz; 5260 ~5320MHz 5500 ~ 5720MHz; 5745 ~ 5825MHz
Type of modulation	CCK, DQPSK, DBPSK for DSSS 64QAM, 16QAM, QPSK, BPSK for OFDM
Equipment Class	U-NII
Antenna Information	Internal PCB antenna with 2.8 dBi Peak gain
Clock Frequencies	N/A
Input Power	28 Vdc 2A
Power Adapter Manufacturer/Model	N/A
Power Adapter SN	N/A
Hardware version	N/A
Software version	N/A
Simultaneous Transmission	N/A
Additional Info	The device uses the certified RF module. (Model No.: SX-PCEAC2, FCC ID: N6C-SXPCEAC2; IC ID: 4908A-SXPCEAC2).

2.3 Test standard and method

Test standard	47CFR 2.1093 RSS-102 Issue 5, Feb 2021
Test method	IEEE Std 1528-2013 447498 D01 General RF Exposure Guidance v06 248227 D01 802 11 Wi-Fi SAR v02r02 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04

Lab performing tests	Vista Laboratories, Inc.
Lab Address	1261 Puerta Del Sol, San Clemente, CA 92673 USA
Phone Number	+1 (949) 393-1123
Website	www.vista-compliance.com

Test Condition	Temperature	Humidity	Atmospheric Pressure
RF Testing	22°C	56%	1008 mbar
SAR Testing	22°C	56%	1008 mbar

3 Modification of EUT / Deviations from Standards

The EUT is an engineering test sample loaded with RF testing firmware specifically designed to support the RF TX/RX measurement in different aspects.

4 Test Configuration and Operation

4.1 EUT Test Configuration

EUT is powered by power supply with DC 28V. EUT's RF antenna port is connected to spectrum analyzer through RF test cable for output power measurement; a regular sample with original antenna was used for SAR measurement. The test software is used to set EUT to different transmission mode in terms of radio mode, test channel, data rate, etc.

4.2 Supporting Equipment

Description	Manufacturer	Model #	Serial #	Remark
AC/DC Adapter	MANGNING	WT2402500	N/A	Provide by Lab

5 SAR Introduction

5.1 Introduction

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field.

The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

5.2 SAR Definition

Specific Absorption Rate is defined as the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of a given density (ρ).

$$SAR = \frac{d}{dt}\left(\frac{dW}{dm}\right) = \frac{d}{dt}\left(\frac{dW}{\rho dV}\right)$$

SAR is expressed in units of watts per kilogram (W/kg). SAR can be related to the electric field at a point by

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

Where:

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m3)

E = RMS electric field strength (V/m)

6 SAR Measurement Setup

6.1 Dosimetric Assessment System

These measurements were performed with the automated near-field scanning system OPENSAR from SATIMO. The system is based on a high precision robot (working range: 850 mm), which positions the probes with a positional repeatability of better than ± 0.02 mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit.

6.2 Measurement System

The OPENSAR system for performing compliance tests consist of the following items:

- A standard high precision 6-axis robot (KUKA) with controller and software.
- KUKA Control Panel (KCP).
- A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- A computer operating Windows XP.
- OPENSAR software.
- Remote control with teaches pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM phantom enabling testing left-hand right-hand and body usage.
- The Position device for handheld EUT.
- Tissue simulating liquid mixed according to the given recipes.
- System validation dipoles to validate the proper functioning of the system.

6.3 Probe

The SAR measurements were conducted with dosimetric probe (manufactured by SATIMO), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in SAR standard with accuracy of better than ±10%.

It is connected to the KRC box on the robot arm and provides an automatic detection of the phantom surface. The 3D file of the phantom is included in OpenSAR software. The Video Positioning System allow the system to take the automatic reference and to move the probe safely and accurately on the phantom.

Parameter	Description
Frequency Range	100 MHz to 6 GHz
Linearity	0.25 dB (100 MHz to 6 GHz)
Directivity	0.25 dB in brain tissue (rotation around probe axis) 0.5 dB in brain tissue (rotation normal probe axis)
Dynamic	0.001W/kg to > 100W/kg
Range Linearity	0.25 dB
Surface	0.2 mm repeatability in air and liquids
Dimensions Overall length	330 mm
Tip length	16 mm
Body diameter	8 mm
Tip diameter	2.5 mm
Distance from probe tip to dipole	1 mm

E-Field Probe Calibration

Each probe is calibrated according to a dosimetric assessment procedure described in SAR standard with accuracy better than +/- 10%. The spherical isotropy was evaluated with the procedure described in SAR standard and found to be better than +/-0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested.

The free space E-field from probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 0.8 GHz, and in a waveguide above 0.8 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. E-field correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue.

6.4 SAM Phantom

The SAR measurements were conducted with dosimetric probe (manufactured by SATIMO), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in SAR standard with accuracy of better than ±10%.

The SAM Phantom SAM29 is constructed of a fiberglass shell Integrated in a wooden table. The shape of the shell is in compliance with the specification set in IEEE P1528 and CENELEC EN62209-1.
The phantom enables the dosimetric evaluation of left- and right-hand phone usage as well as body mounted usage at the flat phantom region.
A cover prevents the evaporation of the liquid.
Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot.

Shell Thickness: 0.2 mm
Filling Volume: Approx. 25 liters
Dimensions (H x L x W): 810 x 1000 x 500 mm

Liquid is filled to at least 15mm from the bottom of Phantom.

6.5 Device Holder

In combination with the Generic Twin Phantom V3.0, the Mounting Device enables the rotation of the mounted transmitter in spherical coordinates whereby the rotation points is the ear opening. The devices can be easily, accurately, and repeatedly positioned according to the FCC and CENELEC specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).

Note: A simulating human hand is not used due to the complex anatomical and geometrical structure of the hand that may produce infinite number of configurations [10]. To produce the worst-case condition. (the hand absorbs antenna output power), the hand is omitted during the tests.

6.6 Data Evaluation

The OPENSAR software automatically executes the following procedure to calculate the field units from the microvolt readings at the probe connector. The parameters used in the valuation are stored in the configuration modules of the software:

Probe Parameters	- Sensitivity	$Norm_i$
	- Conversion factor	ConvFi
	- Diode compression	Dcpi
Device Parameter	- Frequency	f
	- Crest factor	cf
Media Parameters	- Conductivity	σ
	- Density	ρ

These parameters must be set correctly in the software. They can either be found in the component documents or are imported into the software from the configuration files issued for the OPENSAR components.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

Where V_i *= Compensated signal of channel i (i = x, y, z)*
U_i *= Input signal of channel i (i = x, y, z)*
cf = Crest factor of exciting field (DASY parameter)
dcp_i *= Diode compression point (DASY parameter)*

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes: $$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

H-field probes: $$H_i = \sqrt{Vi} \cdot \frac{a_{i10} + a_{i11} f + a_{i12} f^2}{f}$$

Where V_i *= Compensated signal of channel i (i = x, y, z)*
$Norm_i$ *= Sensor sensitivity of channel i (i = x, y, z)*
µV/(V/m)2 for E0field Probes
ConvF = Sensitivity enhancement in solution
a_{ij} *= Sensor sensitivity factors for H-field probes*

f = *Carrier frequency (GHz)*
E_i = *Electric field strength of channel i in V/m*
H_i = *Magnetic field strength of channel i in A/m*

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

where SAR = *local specific absorption rate in mW/g*
E_{tot} = *total field strength in V/m*
σ = *conductivity in [mho/m] or [siemens/m]*
ρ = *equivalent tissue density in g/cm3*

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid.

The power flow density is calculated assuming the excitation field as a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{3770} \quad or \quad P_{pwe} = H_{tot}^2 \cdot 37.7$$

where P_{pwe} = *Equivalent power density of a plane wave in mW/cm2*
E_{tot} = *total electric field strength in V/m*
H_{tot} = *total magnetic field strength in A/m*

6.7 SAR Evaluation – Peak Spatial - Average

The procedure for assessing the peak spatial-average SAR value consists of the following steps

- **Power Reference Measurement**
  The reference and drift jobs are useful jobs for monitoring the power drift of the device under test in the batch process. Both jobs measure the field at a specified reference position, at a selectable distance from the phantom surface. The reference position can be either the selected section's grid reference point or a user point in this section. The reference job projects the selected point onto the phantom surface, orients the probe perpendicularly to the surface, and approaches the surface using the selected detection method.

- **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 finer measurement around the hot spot. The sophisticated interpolation routines implemented in OPENSAR software can find the maximum locations even in relatively coarse grids. The scan area is defined by an editable grid. This grid is anchored at the grid reference point of the selected section in the phantom. When the area scan's property sheet is brought-up, grid was at to 15 mm by 15 mm and can be edited by a user.

- **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 default zoom scan measures 5 x 5 x 7 points within a cube whose base faces are centered on the maximum found in a preceding area scan job within the same procedure. If the preceding Area Scan job indicates more than one maximum, the number of Zoom Scans has to be enlarged accordingly (The default number inserted is 1).

- **Power Drift measurement**
  The drift job measures the field at the same location as the most recent reference job within the same procedure, and with the same settings. The drift measurement gives the field difference in dB from the reading conducted within the last reference measurement. Several drift measurements are possible for one reference measurement. This allows a user to monitor the power drift of the device under test within a batch process. In the properties of the Drift job, the user can specify a limit for the drift and have OPENSAR software stop the measurements if this limit is exceeded.

6.8 SAR Evaluation – Peak SAR

The SAR measurements were conducted with dosimetric probe (manufactured by SATIMO), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in SAR standard with accuracy of better than ±10%.

The procedure for spatial peak SAR evaluation has been implemented according to the IEEE1529 standard. It can be conducted for 1 g and 10 g. The OPENSAR system allows evaluations that combine measured data and robot positions, such as:

- Maximum search
- Extrapolation
- Boundary correction
- Peak search for averaged SAR

During a maximum search, global and local maximum searches are automatically performed in 2-D after each Area Scan measurement with at least 6 measurement points. It is based on the evaluation of the local SAR gradient calculated by the Quadratic Shepard's method. The algorithm will find the global maximum and all local maxima within -2 dB of the global maxima for all SAR distributions.

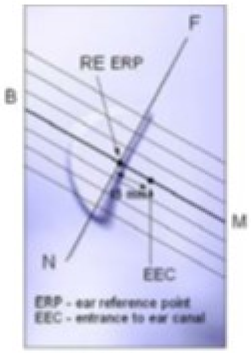
Extrapolation

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. Several measurements at different distances are necessary for the extrapolation.
They are used in the Cube Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the fourth order least square polynomial method for extrapolation. For a grid using 5x5x7 measurement points with 5mm resolution amounting to 343 measurement points, the uncertainty of the extrapolation routines is less than 1% for 1 g and 10 g cubes.

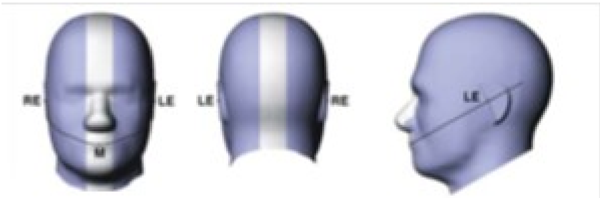
6.9 Device Reference Points

Definition of Reference Points

Ear Reference Point
Figure 6.2 shows the front, back and side views of the SAM Phantom. The point "M" is the reference point for the center of the mouth, "LE" is the left ear reference point (ERP), and "RE" is the right ERP. The ERPs are 15mm posterior to the entrance to the ear canal (EEC) along the B-M line (Back-Mouth), as shown in Figure 6.1. The plane passing through the two ear canals and M is defined as the Reference Plane. The line N-F (Neck-Front) is perpendicular to the reference plane and passing through the RE (or LE) is called the Reference Pivoting Line (see Figure 6.1). Line B-M is perpendicular to the N-F line. Both N-F and B-M lines are marked on the external phantom shell to facilitate handset positioning [5].

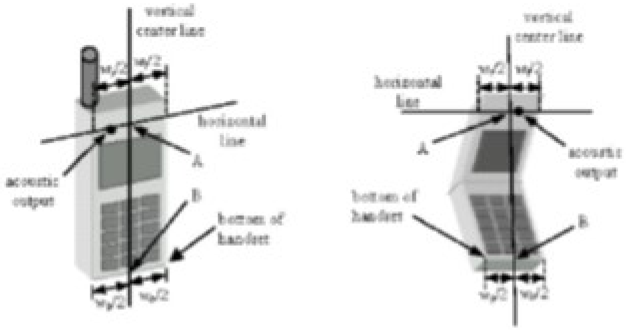


Close-up side view of ERP's



Front, back and side view of SAM

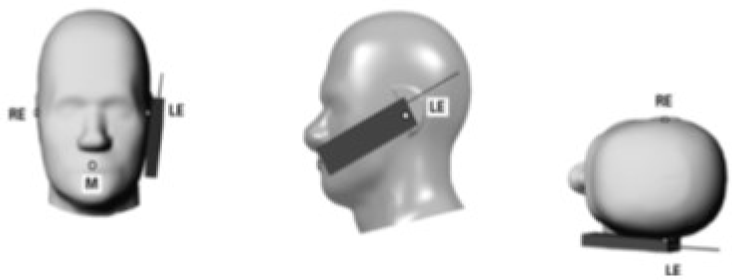
Two imaginary lines on the device need to be established: the vertical centerline and the horizontal line. The test device is placed in a normal operating position with the "test device reference point" located along the "vertical centerline" on the front of the device aligned to the "ear reference point" (See Fig. 6.3). The "test device reference point" is than located at the same level as the center of the ear reference point. The test device is positioned so that the "vertical centerline" is bisecting the front surface of the device at it's top and bottom edges, positioning the "ear reference point" on the outer surface of both the left and right head phantoms on the ear reference point.



Handset Vertical Center & Horizontal Line Reference Points

6.10 Test Configuration – Positioning for Cheek / Touch

1. Position the device close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Figure below), such that the plane defined by the vertical center line and the horizontal line of the device is approximately parallel to the sagittal plane of the phantom

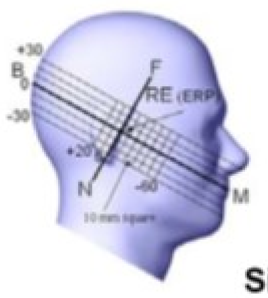


Front, Side and Top View of Cheek/Touch Position

2. Translate the device towards the phantom along the line passing through RE and LE until the device touches the ear.

3. While maintaining the device in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane).
4. Rotate the device around the vertical centerline until the device (horizontal line) is symmetrical with respect to the line NF.

5. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE and maintaining the device contact with the ear, rotate the device about the line NF until any point on the device is in contact with a phantom point below the ear (cheek). See Figure below.

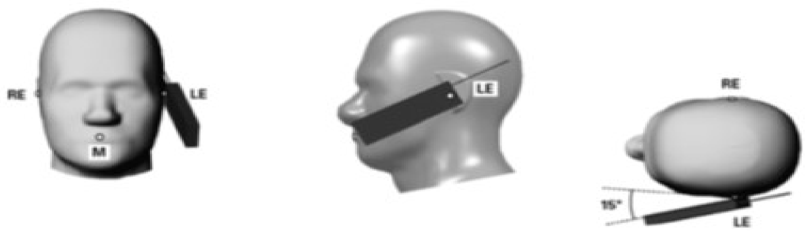


Side view w/ relevant markings

6.11 Test Configuration – Positioning for Ear / 15° Tilt

With the test device aligned in the Cheek/Touch Position":

1. While maintaining the orientation of the device, retracted the device parallel to the reference plane far enough to enable a rotation of the device by 15 degrees.
2. Rotate the device around the horizontal line by 15 degrees.
3. While maintaining the orientation of the device, move the device parallel to the reference plane until any part of the device touches the head. (In this position, point A is located on the line RE-LE). The tilted position is obtained when the contact is on the pinna. If the contact is at any location other than the pinna, the angle of the device shall be reduced. The tilted position is obtained when any part of the device is in contact with the ear as well as a second part of the device is in contact with the head (see Figure below).



Front, Side and Top View of Ear/15° Tilt Position

6.12 Test Position – Body Worn Configurations

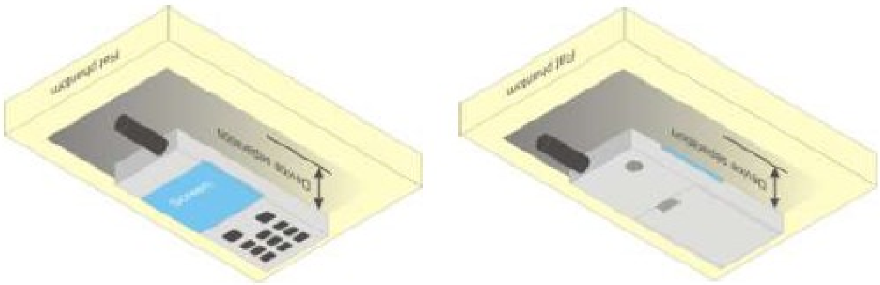
Body-worn operating configurations are tested with the accessories attached to the device and positioned against a flat phantom in a normal use configuration. A device with a headset output is tested with a headset connected to the device. Body dielectric parameters are used.

Accessories for Body-worn operation configurations are divided into two categories: those that do not contain metallic components and those that do contain metallic components. When multiple accessories that do not contain metallic components are supplied with the device, the device is tested with only the accessory that dictates the closest spacing to the body. Then, when multiple accessories that contain metallic components are supplied with the device, the device is tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (i.e. the same metallic belt-clip used with different holsters with no other metallic components) only the accessory that dictates the closest spacing to the body is tested.

Body-worn accessories may not always be supplied or available as options for some devices intended to be authorized for body-worn use. In this case, a test configuration where a separation distance between the back of the device and the flat phantom is used. All test position spacing are documented.

Transmitters that are designed to operate in front of a person's face, as in push-to-talk configurations, are tested for SAR compliance with the front of the device positioned to face the flat phantom. For devices that are carried next to the body such as a shoulder, waist or chest-worn transmitters, SAR compliance is tested with the accessory(ies), including headsets and microphones, attached to the device and positioned against a flat phantom in a normal use configuration.

In all cases SAR measurements are performed to investigate the worst-case positioning. Worst-case positioning is then documented and used to perform Body SAR testing.



7 Measurement Uncertainly

The component of uncertainty may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainty by the statistical analysis of a series of observations is termed a Type An evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variant

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience and specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table below:

Uncertainty Distribution	*Normal*	*Rectangle*	*Triangular*	*U Shape*
Multi-plying Factor[(a)]	*1/k*[(b)]	*1 / √3*	*1 / √6*	*1 / √2*

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) κ is the coverage factor

Standard Uncertainty for Assumed Distribution

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type -sum-by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %.

The COMOSAR Uncertainty Budget is show in below table:

Uncertainty Budget of COMOSAR for frequency range 300 MHz to 6 GHz

Uncertainty Component	Tolerances %	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Uncertainty 1g(%)	Uncertainty 10g(%)
Measurement System Related							
Probe Calibration	6	N	1	1	1	6	6
Axial Isotropy	3	R	√3	√ (1-Cp)	√ (1-Cp)	1.22474	1.22474
Hemispherical Isotropy	4	R	√3	√ Cp	√ Cp	1.63299	1.63299
Boundary Effect	1	R	√3	1	1	0.57735	0.57735
Linearity	5	R	√3	1	1	2.88675	2.88675
System Detection Limits	1	R	√3	1	1	0.57735	0.57735
Readout Electronics	0.5	N	1	1	1	0.5	0.5
Response Time	0.2	R	√3	1	1	0.11547	0.11547
Integration Time	2	R	√3	1	1	1.1547	1.1547
RF Ambient Conditions	3	R	√3	1	1	1.73205	1.73205
Probe Positioner Mechanical Tolerances	2	R	√3	1	1	1.1547	1.1547
Probe Positioning with respect to Phantom Shell	1	R	√3	1	1	0.57735	0.57735
Extrapolation, Interpolation and integration Algorithms for Max. SAR Evaluation.	1.5	R	√3	1	1	0.86603	0.86603
Test Sample Related							
Test Sample Positioning	1.5	N	1	1	1	1.5	1.5
Device Holder Uncertainty	5	N	1	1	1	5	5
Output Power Variation – SAR Drift measurement	3	R	√3	1	1	1.73205	1.73205
Phantom and Tissue Parameters Related							
Phantom Uncertainty (Shape and thickness Tolerances)	4	R	√3	1	1	2.3094	2.394
Liquid Conductivity – deviation from target value	5	R	√3	0.64	0.43	1.84752	1.2413
Liquid Conductivity – Measurement Uncertainty	2.5	N	1	0.64	0.43	1.6	1.075
Liquid Permittivity – deviation from target value	3	R	√3	0.6	0.49	1.03923	0.8487
Liquid Permittivity – Measurement Uncertainty	2.5	N	1	0.6	0.49	1.5	1.225
Combined Standard Uncertainty						9.66051 %	9.52428 %
Expanded Standard Uncertainty (K=2, confidence 95%)						18.9346 %	18.6676 %

8 Liquid Validation

8.1 Liquid Validation

The dielectric parameters were checked prior to assessment using the HP85070C dielectric probe kit. The dielectric parameters measured are reported in each correspondent section.

Photo of Liquid Height for 2.4GHz Body liquid

Photo of Liquid Height for 5GHz Body liquid

IEEE SCC-34/SC-2 P1528/IEC 62209-1 recommended Tissue Dielectric Parameters

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in P1528 and IEC 62209-1 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head and body tissue parameters that have not been specified in P1528 and IEC 62209-1 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations and extrapolated according to the head parameters specified in P1528 and IEC 62209-1

Target Frequency	Head		Body	
MHz	εr	σ (S/m)	εr	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
5800	35.3	5.27	48.2	6.00

Note: *ε_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m^3*

8.2 Liquid Confirmation Result

Body liquid per IEC 62209-1

Frequency (MHz)	Target Permittivity	Target Conductivity	Measured Permittivity	Measured Conductivity	Permittivity Deviation	Conductivity Deviation	Limit (%)
5200	49.0	5.30	48.13	5.38	-1.78	1.51	±5
5600	48.5	5.77	49.05	5.89	1.13	2.08	±5
5800	48.2	6.00	47.87	5.86	-0.68	-2.33	±5
Remark	Measure Date 04/26/2022 Relative Humidity 58%			Temperature 22 oC Atmospheric Pressure 1008 mbar			

9 System Validation and System Verification

9.1 System Validation

The dielectric parameters were checked prior to assessment using the HP85070C dielectric probe kit. The dielectric parameters measured are reported in each correspondent section.

The system validation procedure evaluates the system against reference SAR values and the performance of the probe, readout electronics, and software. The test setup utilizes a flat phantom and a reference dipole.

Thus, the system validation process does not include data scatter due to the use of anthropomorphic phantoms or uncertainty due to handset positioning variability. System validation should be performed annually, or when a new system is put into operation, or whenever modifications have been made to the system, such as a new software release, different readout electronics or different types of probes. The probe used in the test system to be validated should be properly calibrated.

System validation provides a means of system-level validation. The test system utilizes a flat phantom and a reference dipole. Thus, system validation verifies the system accuracy against its specifications but does not include the uncertainty due to the use of anthropomorphic phantoms, nor does it include the uncertainty due to handset positioning variability. This test is performed annually (e.g., after probe calibration), before measurements related to inter laboratory comparison and every time modifications have been made to the system, such as a new software release, different readout electronics, and for different types of probes.

System Validation procedure is at below,

a) **SAR evaluation**: A complete 1 g or 10 g averaged SAR measurement is performed. The reference dipole input power is adjusted to produce a 1 g averaged SAR value falling in the range of 0.4–10 W/kg. The 1 g or 10 g averaged SAR is measured at frequencies in reference table within the range to be used in compliance tests. The results are normalized to 1 W forward input power and compared with the reference SAR values shown in reference value. The differences from the reference values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for the system validation.
b) **Extrapolation routine**: Local SAR values are measured along a vertical axis directly above the reference dipole feed-point using the same test grid-point spacing as used for handset SAR evaluations. This measurement is repeated along another vertical axis with a 2 cm transverse offset from the reference dipole feed-point. SAR values at the phantom surface are extrapolated and compared with the numerical values given in reference table. The difference from the reference values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for system validation.
c) **Probe linearity**: The measurement in step a) is repeated using different reference dipole input power levels. The power levels are selected for each frequency to produce 1 g averaged SAR values of approximately 10 W/kg, 2 W/kg, and 0.4 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized value from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for the linearity component.

d) **Modulation response**: The measurements in step a) are repeated with pulse-modulated signals having a duty factor of 0.1 and pulse repetition rate of 10 Hz. The power is adjusted to produce a 1 g-averaged SAR of approximately 8 W/kg with the pulse modulated signal (corresponding to a peak spatial-average SAR of approximately 80 W/kg). The measured SAR values are normalized to 1 W forward input power and duty factor of 1, and compared with the 1 W normalized values from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for system validation.

e) **System offset**: The measurements in step a) are repeated with a reference dipole input forward power that produces a 1 g or 10 g averaged SAR of approximately 0.05 W/kg. The measured SAR values are normalized to 1 W forward input power and compared with the 1 W normalized values from step a). The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for system validation.

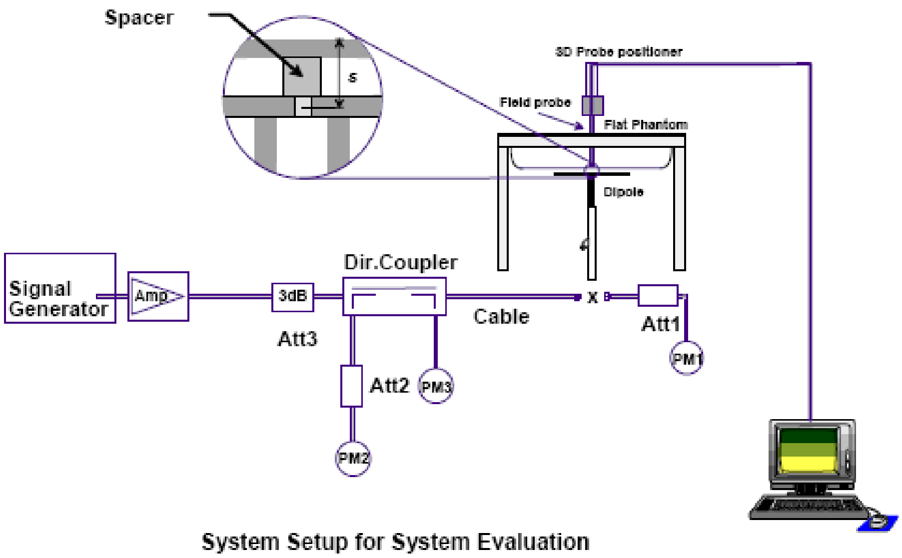
f) **Probe axial isotropy**: The center point of the probe's sensors is placed directly above the reference dipole center at a measurement distance of approximately 5–10 mm from the phantom inner surface. The probe (or reference dipole, if precise rotations are supported by the dipole fixture) is rotated around its axis ± 180° in steps no larger than 15°. The maximum and minimum SAR readings are recorded. The difference between these values should be less than the tolerance specified for the SAR measurement system by the manufacturer or designer, i.e., within the expanded uncertainty for the axial isotropy component.

9.2 System Verification

9.2.1 Requirement(s):

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal SAR measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

In the simplified setup for system evaluation, the DUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave that comes from a signal generator. The calibrated dipole must be placed beneath the flat phantom section of the SAM twin phantom with the correct distance holder. The distance holder should touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The equipment setup is shown below:



System Setup for System Evaluation

Note: Equipment description

1. Signal Generator
2. Amplifier
3. Directional Coupler
4. Power Meter
5. Calibrated Dipole

9.2.2 System Verification Results

Date	Temp (oC)	Humidity (%)	Freq. (MHz)	Phantom /Liquid	Target SAR1g (W/kg)	Input Power (mW)	Measured SAR1g (W/kg)	1W Normalized SAR1g (W/kg)	Deviation (%)	Limit (%)
04/26/22	22.4	56	5200	Body	152.11	20	3.107	155.35	2.13	±10
04/27/22	23.1	53	5600	Body	169.48	100	17.24	172.40	1.72	±10
04/27/22	23.1	53	5750	Body	175.88	100	17.529	175.29	-0.34	±10

Note: Comparing to the target SAR value, the validation data should be within its specification of 10 %.

10 Measurement, Examination and Derived Results

10.1 Output Power Measurement Result

5GHz band

UNII-1 Band

Mode	Frequency (MHz)	Data rate	Measured Average Output Power (dBm)		Tune-Up Power (dBm)
			Chain 0	Chain 1	
11a	5180	6Mbps	13.92	14.11	15.0
	5200	6Mbps	15.23	15.89	16.0
	5240	6Mbps	15.11	15.76	16.0
11n-20M	5180	HT20-MCS0	13.55	13.83	14.0
	5200	HT20-MCS0	14.57	14.90	15.0
	5240	HT20-MCS0	13.89	14.34	15.0
11n-40M	5190	HT40-MCS0	9.48	10.25	11.0
	5230	HT40-MCS0	10.72	10.84	11.0
11ac-80M	5210	VHT80-MCS0	8.42	9.32	10.0

UNII-2a Band

Mode	Frequency (MHz)	Data rate	Measured Average Output Power (dBm)		Tune-Up Power (dBm)
			Chain 0	Chain 1	
11a	5260	6Mbps	14.66	15.08	16.0
	5280	6Mbps	15.23	15.13	16.0
	5320	6Mbps	13.14	13.57	14.0
11n-20M	5260	HT20-MCS0	13.82	14.02	15.0
	5280	HT20-MCS0	14.02	14.89	15.0
	5320	HT20-MCS0	13.47	14.24	15.0
11n-40M	5270	HT40-MCS0	12.11	12.57	13.0
	5310	HT40-MCS0	11.42	11.48	12.0
11ac-80M	5290	VHT80-MCS0	8.99	9.32	10.0

UNII-2c Band

Mode	Frequency (MHz)	Data rate	Measured Average Output Power (dBm)		Tune-Up Power (dBm)
			Chain 0	Chain 1	
11a	5500	6Mbps	13.29	13.84	14.0
	5580	6Mbps	14.18	14.57	15.0
	5700	6Mbps	13.47	13.41	14.0
	5720	6Mbps	9.24	9.96	10.0
11n-20M	5500	HT20-MCS0	14.13	14.42	14.5
	5580	HT20-MCS0	14.01	14.09	14.5
	5700	HT20-MCS0	13.93	14.01	14.5
	5720	HT20-MCS0	8.11	8.64	9.0
11n-40M	5510	HT40-MCS0	12.98	12.78	13.0
	5550	HT40-MCS0	11.98	12.57	13.0
	5670	HT40-MCS0	12.17	12.84	13.0
	5710	HT40-MCS0	10.79	10.87	11.0
11ac-80M	5530	VHT80-MCS0	10.72	10.21	11.0
	5690	VHT80-MCS0	9.82	10.31	11.0

UNII-3 Band

Mode	Frequency (MHz)	Data rate	Measured Peak Output Power (dBm)		Tune-Up Power (dBm)
			Chain 0	Chain 1	
11a	5745	6Mbps	20.51	21.51	22.0
	5785	6Mbps	20.23	20.98	21.0
	5825	6Mbps	21.14	20.98	22.0
11n-20M	5745	HT20-MCS0	21.1	21.03	22.0
	5785	HT20-MCS0	21.13	21.01	22.0
	5825	HT20-MCS0	20.57	20.29	21.0
11n-40M	5755	HT40-MCS0	19.87	19.25	20.0
	5795	HT40-MCS0	19.25	19.38	20.0
11ac-80M	5775	VHT80-MCS0	17.49	17.77	18.0

Mode	Frequency (MHz)	Data rate	Measured Average Output Power (dBm)		Tune-Up Power (dBm)
			Chain 0	Chain 1	
11a	5745	6Mbps	13.41	13.53	14.0
	5785	6Mbps	14.88	15.14	16.0
	5825	6Mbps	14.75	15.01	16.0
11n-20M	5745	HT20-MCS0	12.88	13.42	14.0
	5785	HT20-MCS0	14.09	13.48	15.0
	5825	HT20-MCS0	14.21	14.73	15.0
11n-40M	5755	HT40-MCS0	11.42	11.20	12.0
	5795	HT40-MCS0	12.72	12.83	13.0
11ac-80M	5775	VHT80-MCS0	9.89	10.25	11.0

10.2 SAR Measurement Result

10.2.1 Standalone SAR Test Result

Mode	Freq (MHz)	Position	Tune-Up Power (dBm)	Measured Output Power (dBm)	Raw SAR 1g(W/kg)	Power Drift (%)	Scaled SAR (W/kg)	1g SAR Limit (W/kg)
802.11a	5280	Top	16	15.23	0.1384	-2.16	0.1652	1.6
802.11a	5580	Top	15	14.09	0.1447	-1.73	0.1784	1.6
802.11a	5785	Top	16	15.14	0.1902	-0.92	**0.2319**	1.6

Note:
1. Separation distance to phantom is 0 cm from test side (direct touch position)
2. Only Top side that the antenna is close to the enclosure surface were tested. See the EUT external photos for reference.

Test reduction table for 5 GHz

Mode	Freq (MHz)	Position	Tested/Reduced
802.11a	5180	Top	Reduced
802.11a	5200	Top	Reduced
802.11a	5240	Top	Reduced
802.11a	5260	Top	Reduced
802.11a	5280	Top	Tested
802.11a	5320	Top	Reduced
802.11a	5500	Top	Reduced
802.11a	5580	Top	Tested
802.11a	5700	Top	Reduced
802.11a	5745	Top	Reduced
802.11a	5785	Top	Tested
802.11a	5825	Top	Reduced
802.11n-20MHz	All Channels	Top	Reduced
802.11n-20MHz	All Channels	Top	Reduced
802.11n-20MHz	All Channels	Top	Reduced
802.11n-20MHz	All Channels	Top	Reduced
802.11n-40MHz	All Channels	Top	Reduced
802.11n-40MHz	All Channels	Top	Reduced
802.11n-40MHz	All Channels	Top	Reduced
802.11n-40MHz	All Channels	Top	Reduced
802.11ac-80MHz	All Channels	Top	Reduced
802.11ac-80MHz	All Channels	Top	Reduced
802.11ac-80MHz	All Channels	Top	Reduced
802.11ac-80MHz	All Channels	Top	Reduced

Note:

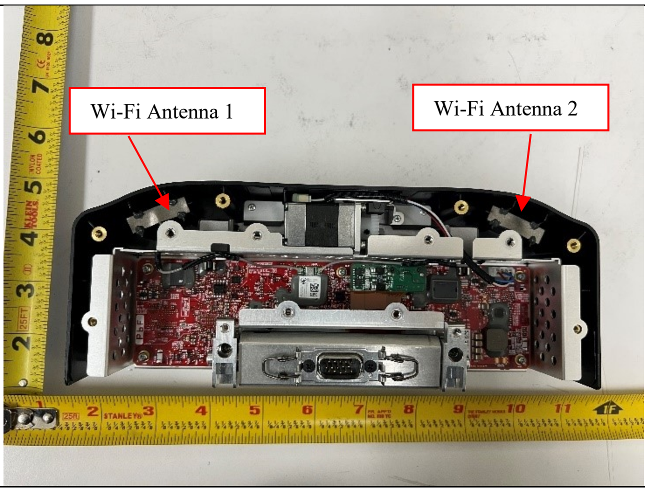
(1) Per KDB 248227 D01v02r02, U-NII-1 SAR testing is not required when the U-NII-2A band highest reported SAR for a test configuration is s 1.2 W/kg, SAR is not required for U-NII-1 band.

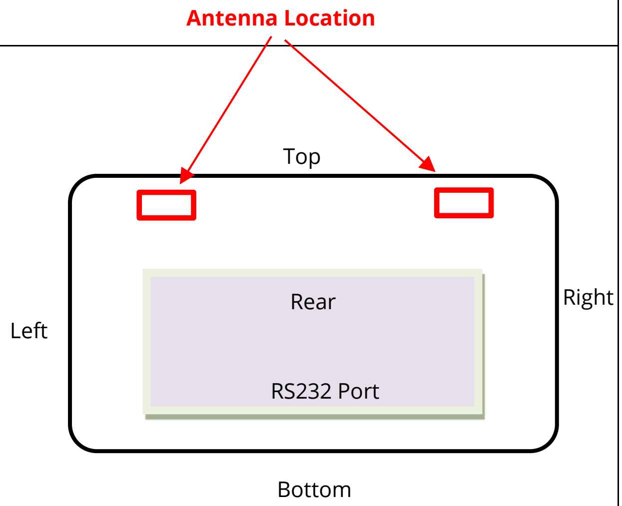
(2) Reduced when the reported SAR is ≤ 0.4 W/kg, SAR is not required for the remaining test configuration per KDB 248227 D1 802.11 Wi-Fi SAR v02r02, section 5.1.1, a)

(3) For all positions configurations, when the reported SAR is > 0.8 W/kg, SAR is measured for these test positions configurations on the subsequent next highest measured output power channel(s)until the reported SAR is ⩽ 1.2 W/kg or all required channels are tested.

10.2.2 Antenna Location & Separation distance

Antenna Location & Separation distance





The separation distance for antenna to edge:

Antenna	To Top Side (mm)	To Bottom Side (mm)	To Left Side (mm)	To Right Side (mm)	To Front Side (mm)	To Rear Side (mm)
Antenna 1	5	60	35	180	30	30
Antenna 2	5	60	180	35	30	30

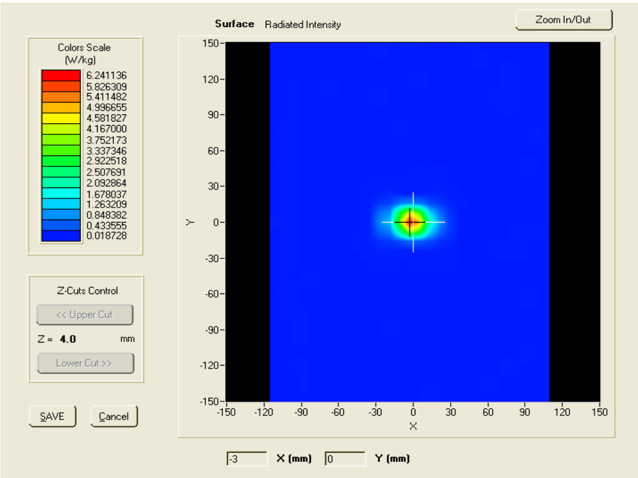
Note: Only 1 side that the antenna is close to the enclosure surface were tested. See the EUT external photos for reference.

- EUT-External-Top Side

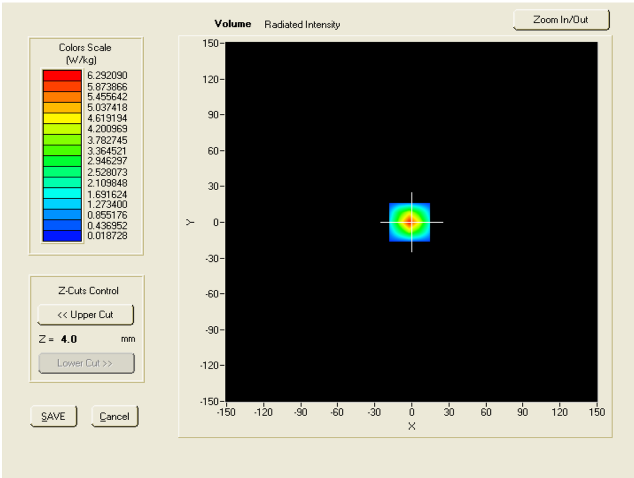
10.2.3 SAR Test Plots

Test specification:	System Verification			
Environ Conditions:	Temp(°C):	23	Result:	Pass
	Humidity(%):	57		
	Atmospheric(mPa):	1021		
Mains Power:	N/A			
Test Date:	4/27/2022			
Tested by:	Devin Tai			
Remarks:	System Validation, dipole, CW signal, duty cycle =1			

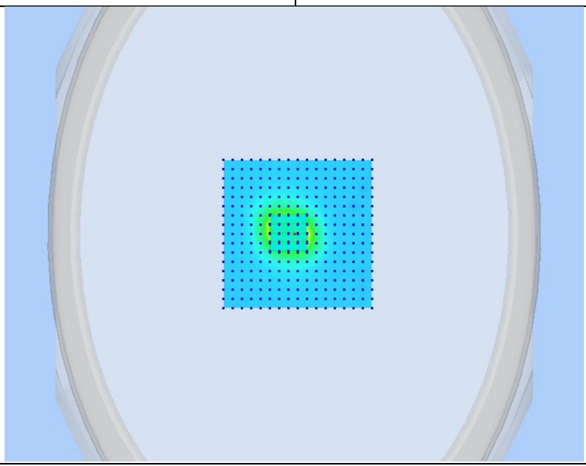
Frequency (MHz)	5200.000000
Relative permittivity (real part)	48.13
Conductivity (S/m)	5.38
Transmission Duty Factor	1.00
Probe SN	SN 31/10/ WGA13
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=4mm, dy=4mm, dz=2mm
Zoom Scan Size	24x24x24 mm
Measurement Drifts (%)	1.800
Highest Extrapolated SAR (W/Kg)	6.146
SAR 1g (W/Kg)	3.107
Peak SAR Location	21mm(x),22mm(y),4mm(z)



SURFACE SAR



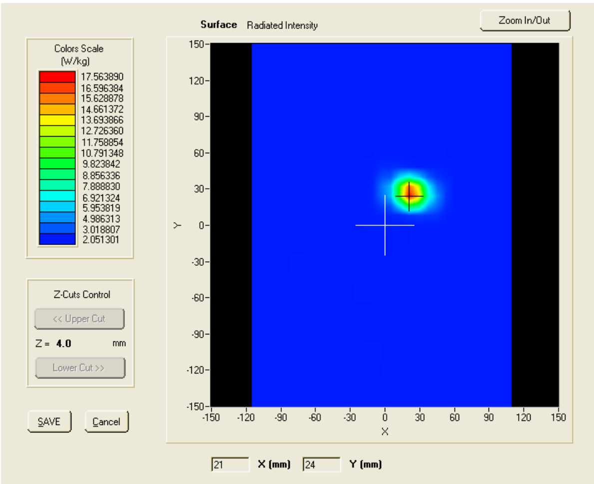
VOLUME SAR



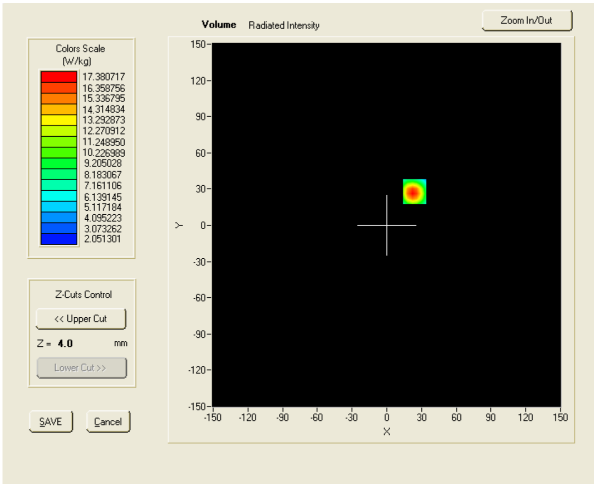
3D View

Test specification:	System Verification			
Environ Conditions:	Temp(°C):	23	Result:	Pass
	Humidity (%):	57		
	Atmospheric(mPa):	1021		
Mains Power:	N/A			
Test Date:	4/27/2022			
Tested by:	Devin Tai			
Remarks:	System Validation, dipole, CW signal, duty cycle =1			

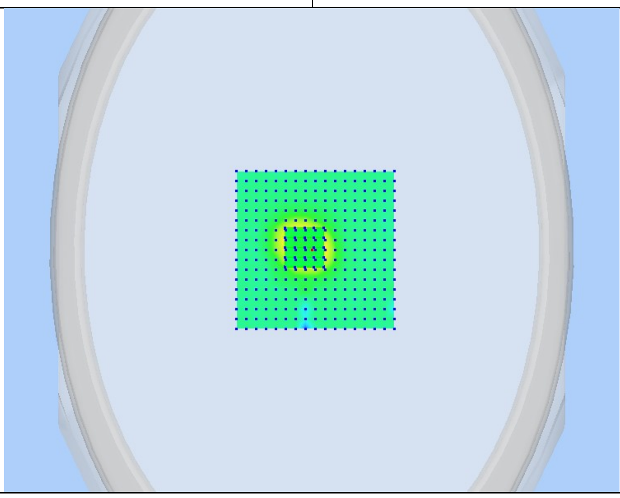
Frequency (MHz)	5600.000000
Relative permittivity (real part)	49.05
Conductivity (S/m)	5.89
Transmission Duty Factor	1.00
Probe SN	SN 31/10/ WGA13
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=4mm, dy=4mm, dz=2mm
Zoom Scan Size	24x24x24 mm
Measurement Drifts (%)	1.832
Highest Extrapolated SAR (W/Kg)	27.356
SAR 1g (W/Kg)	17.240
Peak SAR Location	13mm(x),0mm(y),4mm(z)



SURFACE SAR



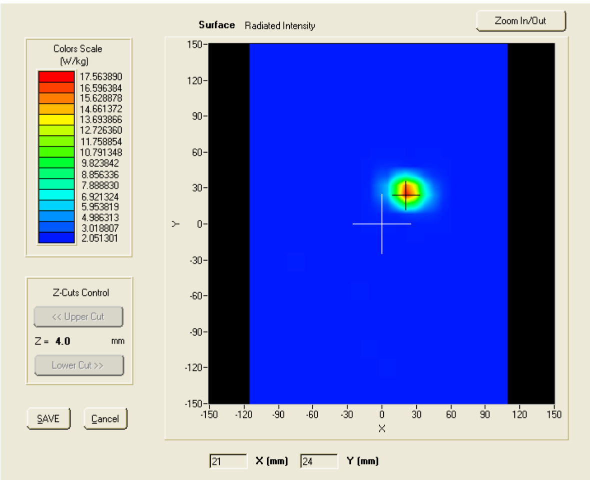
VOLUME SAR



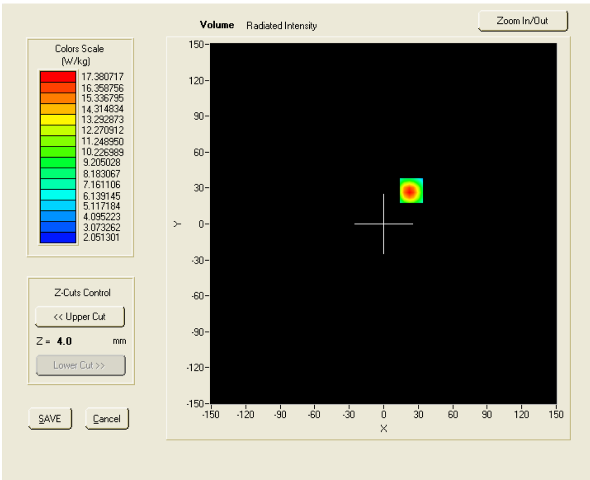
3D View Plot

Test specification:	System Verification			
Environ Conditions:	Temp(°C):	23	Result:	Pass
	Humidity (%):	57		
	Atmospheric(mPa):	1021		
Mains Power:	N/A			
Test Date:	4/27/2022			
Tested by:	Devin Tai			
Remarks:	System Validation, dipole, CW signal, duty cycle =1			

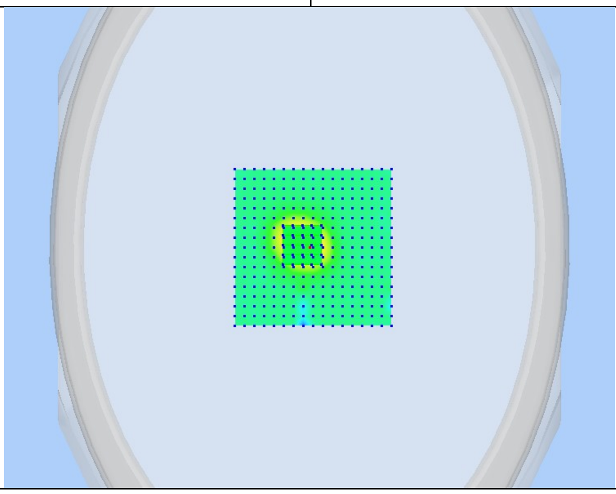
Frequency (MHz)	5750.000000
Relative permittivity (real part)	47.87
Conductivity (S/m)	5.86
Transmission Duty Factor	1.00
Probe SN	SN 31/10/ WGA13
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=4mm, dy=4mm, dz=2mm
Zoom Scan Size	24x24x24 mm
Measurement Drifts (%)	2.091
Highest Extrapolated SAR (W/Kg)	26.743
SAR 1g (W/Kg)	17.529
Peak SAR Location	13mm(x),0mm(y),4mm(z)



SURFACE SAR



VOLUME SAR

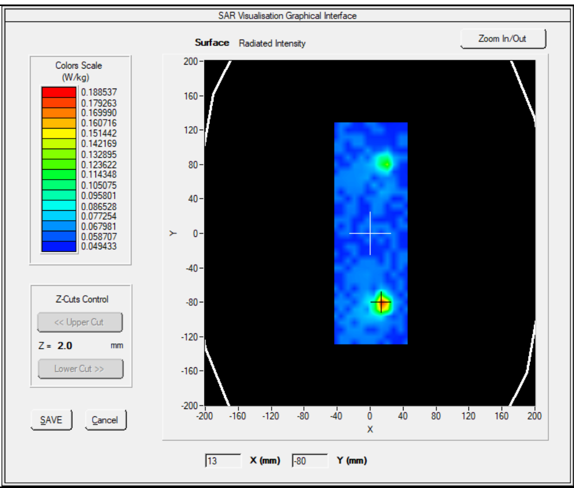


3D View Plot

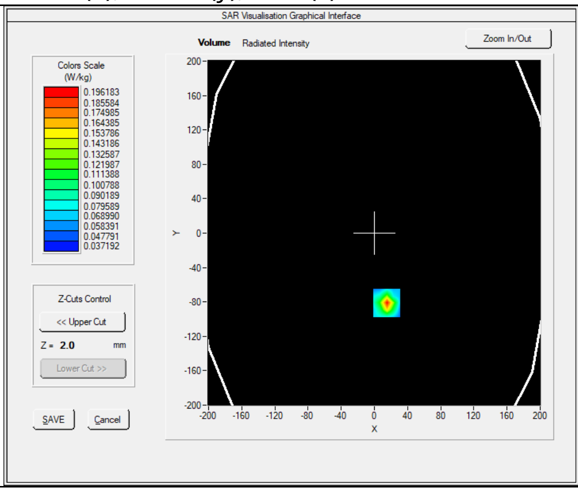
Test results

Test specification:	Plane_Body_Middle_Top-11a-5280MHz			
Environ Conditions:	Temp(oC):	22	Result:	Pass
	Humidity (%):	56		
	Atmospheric(mPa):	1008		
Mains Power:	DC 28V			
Test Date:	04/26/2022-04/27/2022			
Tested by:	Devin Tai			
Remarks:	N/A			

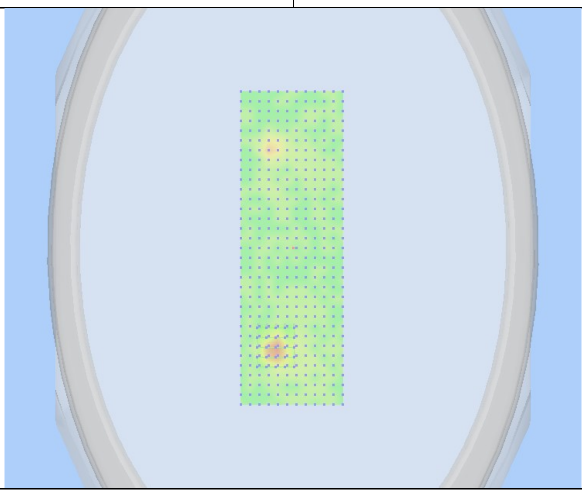
Frequency (MHz)	5280.000000 (Channel 56)
Relative permittivity (real part)	48.15
Conductivity (S/m)	5.36
Probe SN	2715_EPGO259
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=8mm, dy=8mm, dz=5mm
Zoom Scan Size	32x32x34 mm
Measurement Drifts (%)	-2.160
Highest Extrapolated SAR (W/Kg)	0.3141
SAR 1g (W/Kg)	0.1384
Peak SAR Location	15mm(x),-81mm(y),4mm(z)



SURFACE SAR



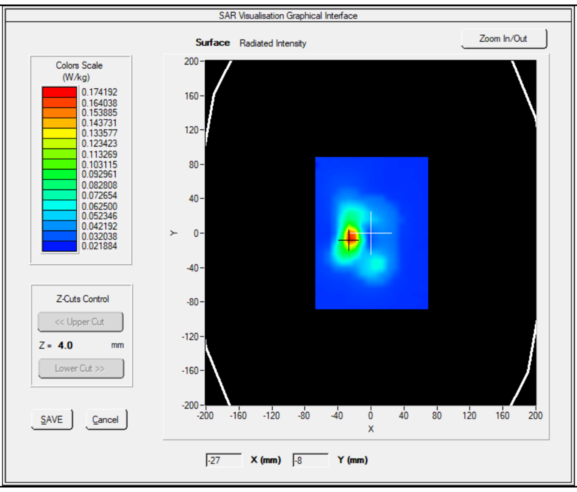
VOLUME SAR



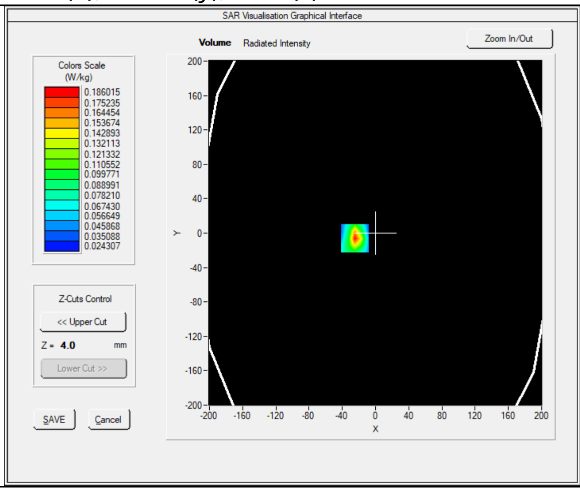
3D View Plot

Test specification:	Plane_Body_High_Top-11a-5580MHz			
Environ Conditions:	Temp(oC):	22	Result:	Pass
	Humidity (%):	56		
	Atmospheric(mPa):	1008		
Mains Power:	DC 28V			
Test Date:	04/26/2022-04/27/2022			
Tested by:	Devin Tai			
Remarks:	N/A			

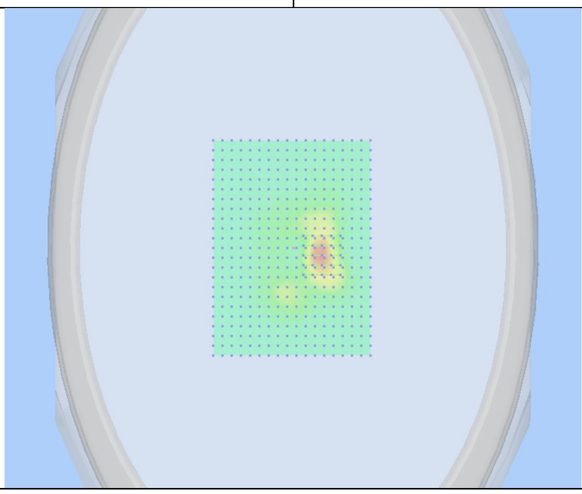
Frequency (MHz)	5580.000000 (Channel 116)
Relative permittivity (real part)	49.05
Conductivity (S/m)	5.89
Probe SN	2715_EPGO259
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=8mm, dy=8mm, dz=5m m
Zoom Scan Size	32x32x34 mm
Measurement Drifts (%)	-1.730
Highest Extrapolated SAR (W/Kg)	0.3355
SAR 1g (W/Kg)	0.1477
Peak SAR Location	14mm(x),-82mm(y),4mm(z)



SURFACE SAR

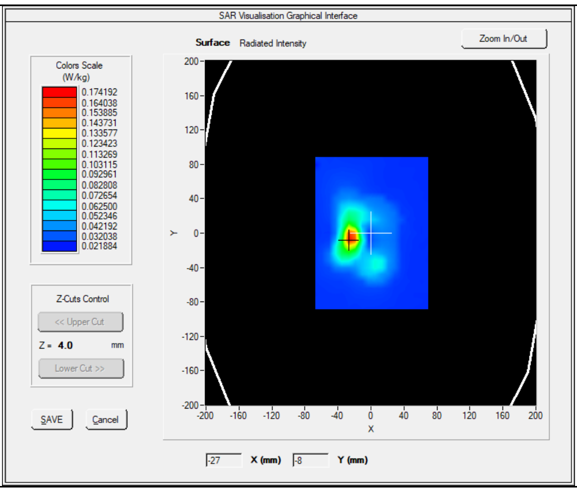
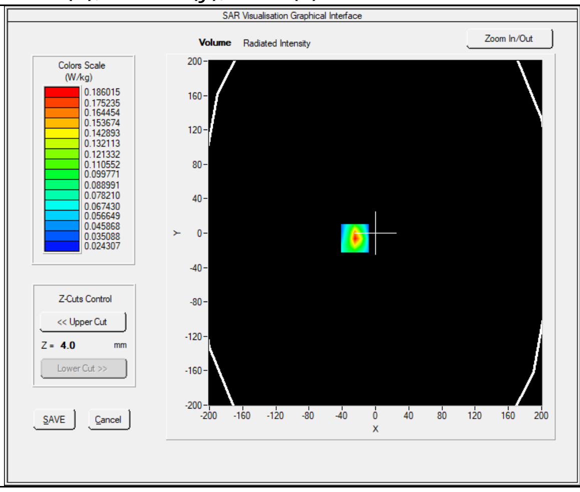


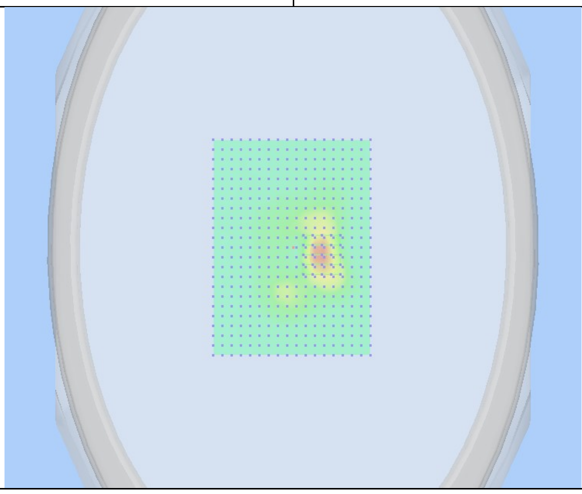
VOLUME SAR



3D View Plot

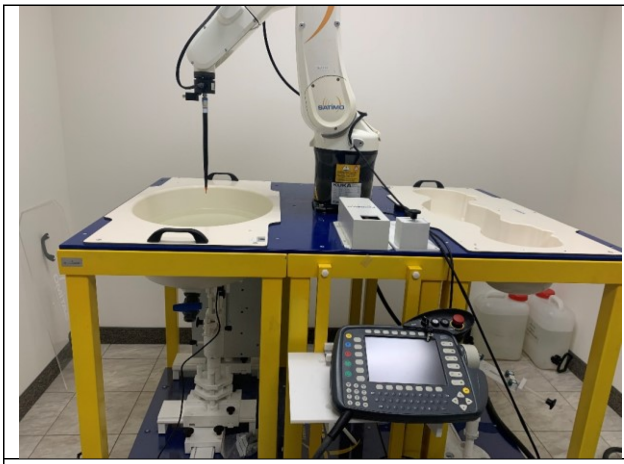
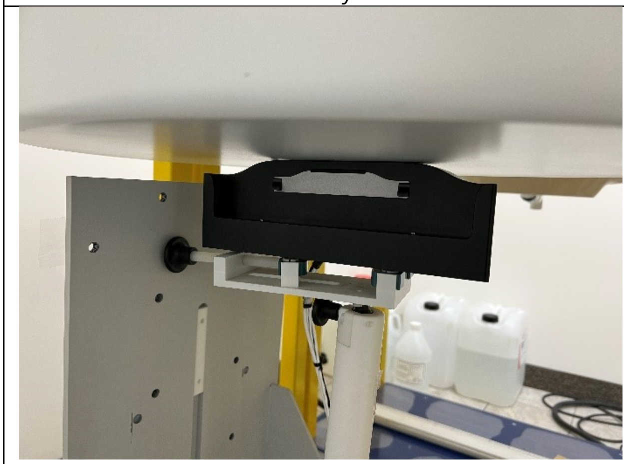
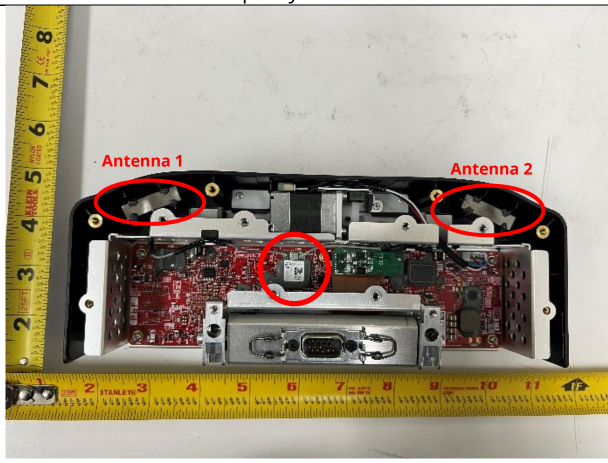
Test specification:	Plane_Body_High_Top-11a-5785MHz			
Environ Conditions:	Temp(oC):	22	Result:	Pass
	Humidity (%):	56		
	Atmospheric(mPa):	1008		
Mains Power:	DC 28V			
Test Date:	04/26/2022-04/27/2022			
Tested by:	Devin Tai			
Remarks:	N/A			

Frequency (MHz)	5785.000000 (Channel 157)
Relative permittivity (real part)	47.87
Conductivity (S/m)	5.86
Probe SN	2715_EPGO259
Area Scan Resolution	8 mm
Zoom Scan Resolution	dx=8mm, dy=8mm, dz=5m m
Zoom Scan Size	32x32x34 mm
Measurement Drifts (%)	-0.920
Highest Extrapolated SAR (W/Kg)	0.4456
SAR 1g (W/Kg)	0.1902
Peak SAR Location	15mm(x),-82mm(y),4mm(z)
	
SURFACE SAR	VOLUME SAR



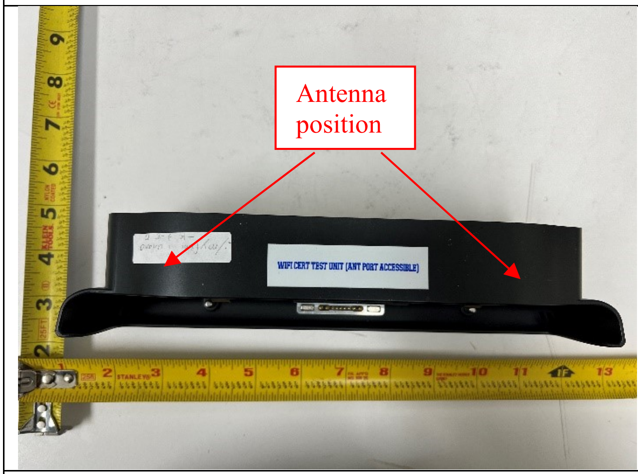
3D View Plot

11 EUT and Test Setup Photos

	
SAR Test System	Test Setup – System verification
	
Test Setup – Top Position	Radio Module and Antenna Position

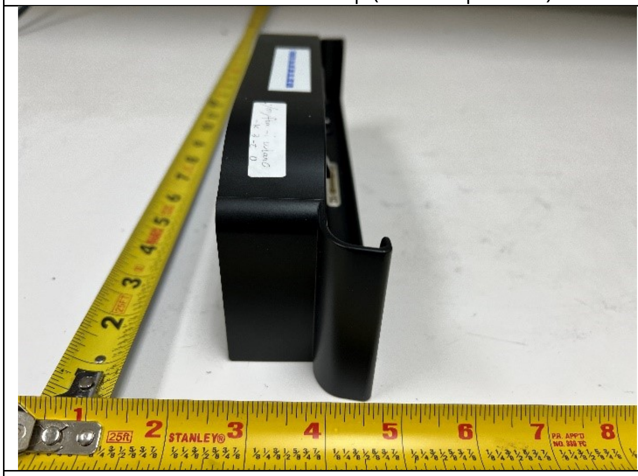

Host Product-External-Front

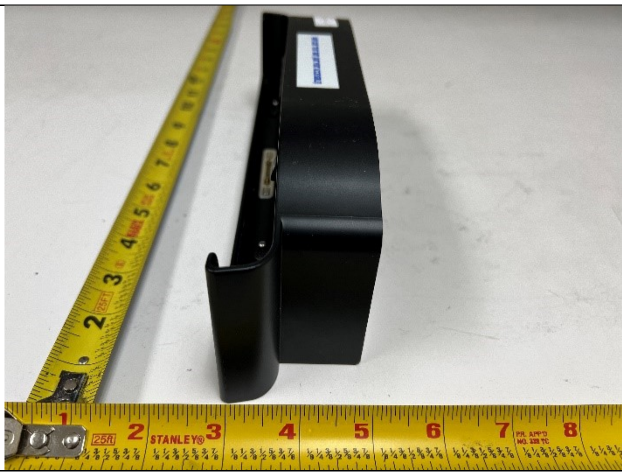

Host Product-External-Back



Host Product-External-Top (SAR test position)


Host Product-External-Bottom


Host Product-External-Left


Host Product-External-Right

12 Test Instrument List

Equipment	Manufacturer	Model	Instrument Number	Cal. Date	Cal. Due
6 Axis Robot	KURA	KR5 KRC2sr	949319	N/A	N/A
MultiMeter	Keithley	MultiMeter 2000	1259033	05/10/2021	05/10/2022
E-Field Probe	SATIMO	SSE2	SN 27/15 EPGO259	08/12/2021	08/12/2022
Dipole 2450	SATIMO	DIPOLE 2450 MHz	SN 31/10 DIPJ138	08/12/2021	08/12/2022
COMOHAC E-Field Probe	MVG	SCE	SN 06/14 EPH44	08/12/2021	08/12/2022
T-Coil Porbe	SATIMO	TCP15	SN 31/10 TCP15	08/12/2021	08/12/2022
Laptop Positioning Device	SATIMO	LSH13	SN 31/10 LSH13	N/A	N/A
Mobile Phone Positioning Device	SATIMO	MSH63	SN 31/10 MSH63	N/A	N/A
COMOHAC TMFS	SATIMO	TMFS08	SN 31/10 TMFS08	N/A	N/A
SAM Phantom	SATIMO	SAM77	SN 31/10 SAM77	N/A	N/A
Elliptic Phantom	MVG	ELLI38	SN 03-16 ELLI38	N/A	N/A
Phantom Table	SATIMO	N/A	N/A	N/A	N/A
Reference tool for VPS	MVG	RT58	SN 03/16 RT 58	N/A	N/A
KUKA Roboter KRC2sr	KUKA	KRC2sr	2057	N/A	N/A
Elliptic Phantom	SATIMO	ELLI17	SN 31-10 ELLI17	N/A	N/A
Network Analyzer 30KHz-6GHz	Agilent	8753ES	US39170256	06/21/2021	06/21/2022
3.5mm Calibration Kit	Agilent	85033E	MY39205936	N/A	N/A
MXG Vector Signal Generator	Keysight	N5182A	US47080548	06/17/2021	06/17/2022
USB RF Power Sensor	ETS-Lindgren	7002-006	SN 00151268	05/15/2021	05/15/2022
EMC Test Receiver	R&S	ESL6	100230	06/14/2021	06/14/2022
Spectrum Analyzer	Keysight	N9020A	MY50110074	06/17/2021	06/17/2022

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