SAR Test Report

Product	:	Cordless Wi-Fi IP Phone
Trade mark	:	GRANDSTREAM
Model/Type reference	:	WP810
Add. Model No.	:	N/A
Report Number	:	191026006SAR-1
Date of Issue	:	November 26, 2019
FCC ID	:	YZZWP810
IC		11964A-WP810
Test Standards	:	FCC 47 CFR Part 2 §2.1093 ANSI/IEEE C95.1-1992 IEEE Std 1528-2013 RSS-102 Issue 5:March 2015 IEC 62209-1:2016/ IEC 62209-2:2010
Test result	:	PASS

Prepared for:

Grandstream Networks, Inc.
126 Brookline Ave., 3rd Floor, Boston, MA 02215, USA

Prepared by:

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UnionTrust Laboratories Certified

Version

Version No.	Date	Description
V1.0	November 26, 2019	Original

Contents

1 General Information

1.1 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for the EUT are as follows:

Equipment Class	Mode	Highest Reported Head SAR_{1g} (W/kg)	Highest Reported Body-worn SAR_{1g} (1.0 cm Gap) (W/kg)
DTS	2.4G WLAN	0.23	0.07
NII	5.2G WLAN	N/A	N/A
	5.3G WLAN	1.12	0.32
	5.6G WLAN	1.18	0.25
	5.8G WLAN	1.19	0.29

1.2 EUT Description

1.2.1 General Description

Product Name	Cordless Wi-Fi IP Phone
Trade mark	GRANDSTREAM
Model No.(EUT)	WP810
Add. Model No.:	N/A
FCC ID	YZZWP810
IC	11964A-WP810
HW Version	V1.3
SW Version	1.0.0.26
Tx Frequency Bands (Unit: MHz)	WLAN: 2412 ~ 2462, 5180 ~ 5240, 5260 ~ 5320, 5500 ~ 5700,5745 ~ 5825
Antenna Type	PIFA Antenna
EUT Stage	Identical Prototype

1.2.2 Wireless Technologies

2.4G WLAN	802.11b 802.11g 802.11n (HT20)
5G WLAN	802.11a 802.11n (HT20/HT40) 802.11ac (VHT20/VHT40/VHT80)

1.2.3 List of Accessory

Battery	**Model Name**	GS-01
	Power Rating	3.8Vdc, 1500mAh
	Type	Li-ion

1.3 Maximum Conducted Power

The maximum conducted average power (Unit: dBm) including tune-up tolerance is shown as below.

Mode	2.4G WLAN
802.11b	16.0
802.11g	15.5
802.11n HT20	15.0

Mode	5.2G WLAN	5.3G WLAN	5.6G WLAN	5.8G WLAN
802.11a	16.5	17.5	17.3	17.4
802.11n HT20	16.5	17.0	17.0	17.0
802.11n HT40	16.5	16.5	16.5	16.5
802.11ac VHT20	16.5	17.0	17.0	17.0
802.11ac VHT40	16.5	16.5	16.5	16.5
802.11ac VHT80	12.5	12.5	15.5	15.5

1.4 Other Information

Sample Received Date:	October 26, 2019
Sample tested Date:	November 1, 2019 to November 25, 2019

1.5 Testing Location

Shenzhen UnionTrust Quality and Technology Co., Ltd.
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Telephone: +86-755-28230888 Fax: +86-755-28230886
Mail: info@uttlab.com Website: Http://www.uttlab.com

1.6 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

CNAS-Lab Code: L9069

The measuring equipment utilized to perform the tests documented in this report has been calibrated once a year or in accordance with the manufacturer's recommendations, and is traceable under the ISO/IEC/EN 17025 to international or national standards. Equipment has been calibrated by accredited calibration laboratories.

FCC Accredited Lab.
Designation Number: CN1194
Test Firm Registration Number: 259480

A2LA-Lab Certificate No.: 4312.01

Shenzhen UnionTrust Quality and Technology Co., Ltd. has been accredited by A2LA for technical competence in the field of electrical testing, and proved to be in compliance with ISO/IEC 17025: 2005 General Requirements for the Competence of Testing and Calibration Laboratories and any additional program requirements in the identified field of testing.

ISED Wireless Device Testing Laboratories

CAB identifier: CN0032

1.7 Guidance Standard

The tests documented in this report were performed in accordance with FCC 47 CFR Part 2 §2.1093, IEEE Std 1528-2013, ANSI/IEEE C95.1-1992, IC RSS-102 Issue 5, IEC 62209-1:2016, IEC 62209-2:2010, the following FCC Published RF exposure KDB procedures:

KDB 865664 D01 v01r04
KDB 865664 D02 v01r02
KDB 248227 D01 v02r02
KDB 447498 D01 v06

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2 Specific Absorption Rate (SAR)

2.1 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, by appropriate techniques, to produce specific absorption rates (SARs) as averaged over the whole-body, any 1 g or any 10 g of tissue (defined as a tissue volume in the shape of a cube). All SAR values are to be averaged over any six-minute period. When portable device was used within 20 cm of the user's body, SAR evaluation of the device will be required. The SAR limit in chapter 2.3.

2.2 SAR Definition

The SAR definition is 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). The equation description is as below:

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

SAR is expressed in units of Watts per kilogram (W/kg)

SAR measurement can be related to the electrical field in the tissue by

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

2.3 SAR Limits

(A) Limits for Occupational/Controlled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.4	8.0	20.0

(B) Limits for General Population/Uncontrolled Exposure (W/kg)

Whole-Body	Partial-Body	Hands, Wrists, Feet and Ankles
0.08	1.6	4.0

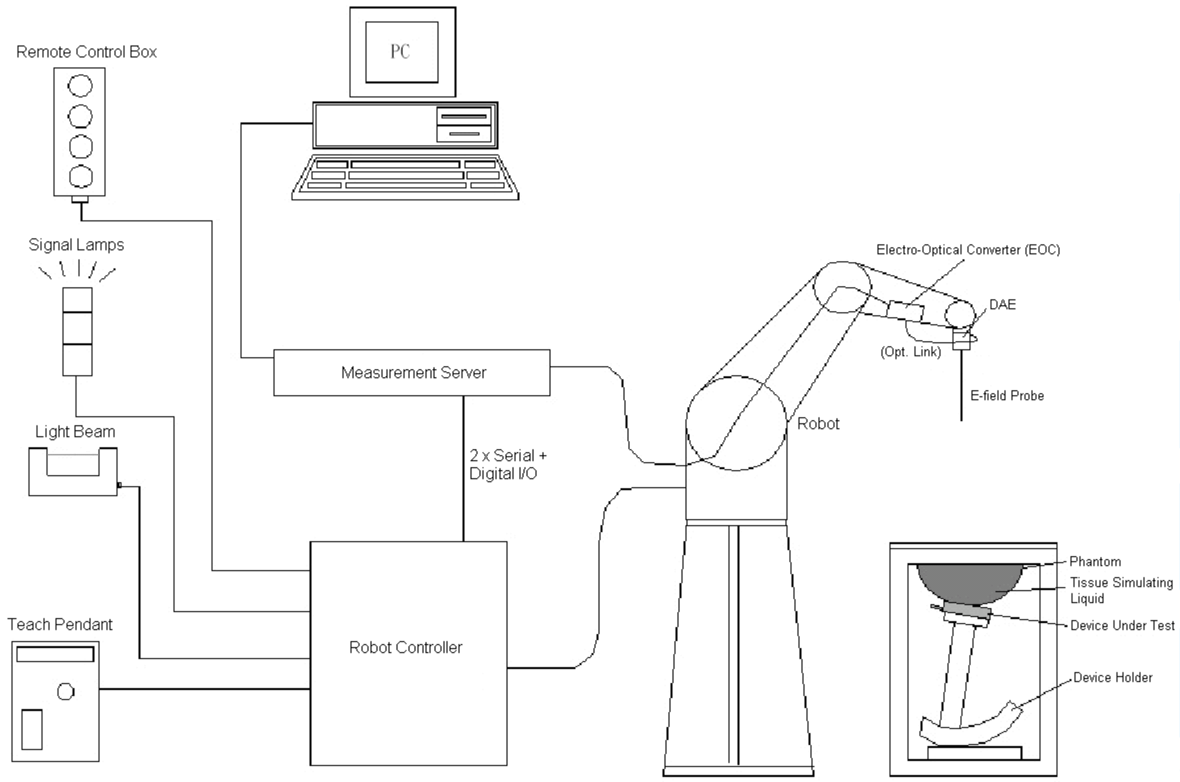
Note:

1. Whole-Body SAR is averaged over the entire body, partial-body SAR is averaged over any 1 gram of tissue defined as a tissue volume in the shape of a cube. SAR for hands, wrists, feet and ankles is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.
2. At frequencies above 6.0 GHz, SAR limits are not applicable and MPE limits for power density should be applied at 5 cm or more from the transmitting device.
3. The SAR limit is specified in FCC 47 CFR Part 2 §2.1093, ANSI/IEEE C95.1-1992.

3 SAR Measurement System

3.1 SPEAG DASY System

DASY system consists of high precision robot, probe alignment sensor, phantom, robot controller, controlled measurement server and near-field probe. The robot includes six axes that can move to the precision position of the DASY5 software defined. The DASY software can define the area that is detected by the probe. The robot is connected to controlled box. Controlled measurement server is connected to the controlled robot box. The DAE includes amplifier, signal multiplexing, AD converter, offset measurement and surface detection. It is connected to the Electro-optical coupler (ECO). The ECO performs the conversion form the optical into digital electric signal of the DAE and transfers data to the PC.



DASY Measurement System

3.1.1 Robot

The DASY system uses the high precision robots from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY4: CS7MB) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ±0.02 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)

3.1.2 Probe

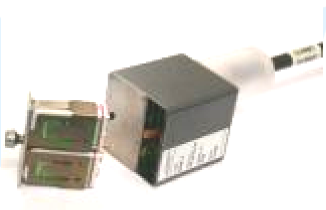
The SAR measurement is conducted with the dosimetric probe. The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency.

Model	EX3DV4
Construction	Symmetrical design with triangular core. Built-in shielding against static charges. PEEK enclosure material (resistant to organic solvents, e.g., DGBE).
Frequency	10 MHz to 6 GHz Linearity: ± 0.2 dB
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)
Dynamic Range	10 µW/g to 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 µW/g)
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm

Model	ES3DV3
Construction	Symmetrical design with triangular core. Interleaved sensors. Built-in shielding against static charges. PEEK enclosure material (resistant to organic solvents, e.g., DGBE).
Frequency	10 MHz to 4 GHz Linearity: ± 0.2 dB
Directivity	± 0.2 dB in HSL (rotation around probe axis) ± 0.3 dB in tissue material (rotation normal to probe axis)
Dynamic Range	5 µW/g to 100 mW/g Linearity: ± 0.2 dB
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 3.9 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.0 mm

3.1.3 Data Acquisition Electronics (DAE)

Model	DAE3, DAE4
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV)
Input Offset Voltage	< 5µV (with auto zero)
Input Bias Current	< 50 fA
Dimensions	60 x 60 x 68 mm



3.1.4 Phantom

Model	Twin SAM	
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It 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 evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching three points with the robot.	
Material	Vinylester, glass fiber reinforced (VE-GF)	
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)	
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet	
Filling Volume	approx. 25 liters	

Model	ELI	
Construction	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is compatible with all SPEAG dosimetric probes and dipoles.	
Material	Vinylester, glass fiber reinforced (VE-GF)	
Shell Thickness	2.0 ± 0.2 mm (bottom plate)	
Dimensions	Major axis: 600 mm Minor axis: 400 mm	
Filling Volume	approx. 30 liters	

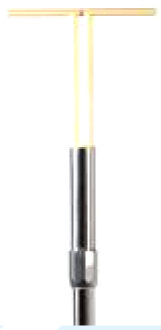
3.1.5 Device Holder

Model	Mounting Device
Construction	In combination with the Twin SAM Phantom or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).
Material	POM

Model	Laptop Extensions Kit
Construction	Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner.
Material	POM, Acrylic glass, Foam

3.1.6 System Validation Dipoles

Model	D-Serial
Construction	Symmetrical dipole with l/4 balun. Enables measurement of feed point impedance with NWA. Matched for use near flat phantoms filled with tissue simulating solutions.
Frequency	750 MHz to 5800 MHz
Return Loss	> 20 dB
Power Capability	> 100 W (f < 1GHz), > 40 W (f > 1GHz)



3.2 SAR Scan Procedure

3.2.1 SAR Reference Measurement (drift)

Prior to the SAR test, local SAR shall be measured at a stationary reference point where the SAR exceeds the lower detection limit of the measurement system.

3.2.2 Area Scan

Measurement procedures for evaluating the SAR of wireless device start with a coarse measurement grid to determine the approximate location of the local peak SAR values. This is known as the area-scan procedure. All antennas and radiating structures that may contribute to the measured SAR or influence the SAR distribution must be included in the area scan. The area scan measurement resolution must enable the extrapolation algorithms of the SAR system to correctly identify the peak SAR location(s) for subsequent zoom scan measurements to correctly determine the 1-g SAR. Area scans are performed at a constant distance from the phantom surface, determined by the measurement frequencies. When a measured peak is closer than ½ the zoom scan volume dimension (x, y) from the edge of the area scan region, unless the entire peak and gram-averaging volume are both captured within the zoom scan volume, the area scan must be repeated by shifting and expanding the area scan region to ensure all peaks are away from the area scan boundary. The area scan resolutions specified in the table below must be applied to the SAR measurements.

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 mm ± 1 mm	½·δ·ln(2) mm ± 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.	

3.2.3 Zoom Scan

To evaluate the peak spatial-average SAR values with respect to 1 g or 10 g cubes, fine resolution volume scans, called zoom scans, are performed at the peak SAR locations identified during the area scan. If the cube volume within the zoom scan chosen to calculate the peak spatial-average SAR touches any boundary of the zoom-scan volume, the zoom scan shall be repeated with the center of the zoom-scan volume shifted to the new maximum SAR location. For any secondary peaks found in the area scan that are within 2 dB of the maximum peak and are not within this zoom scan, the zoom scan shall be performed for such peaks, unless the peak spatial-average SAR at the location of the maximum peak is more than 2 dB below the applicable SAR limit (i.e., 1 W/kg for a 1.6 W/kg 1 g limit, or 1.26 W/kg for a 2 W/kg 10 g limit). The zoom scan resolutions specified in the table below must be applied to the SAR measurements.

<table>
<tr><td colspan="3"></td><td>≤ 3 GHz</td><td>> 3 GHz</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Zoom}, Δy_{Zoom}</td><td>≤ 2 GHz: ≤ 8 mm
2 – 3 GHz: ≤ 5 mm*</td><td>3 – 4 GHz: ≤ 5 mm*
4 – 6 GHz: ≤ 4 mm*</td></tr>
<tr><td rowspan="3">Maximum zoom Scan spatial resolution, normal to phantom surface</td><td colspan="2">uniform grid: ΔZ_{Zoom}(n)</td><td>≤ 5 mm</td><td>3 – 4 GHz: ≤ 4 mm
4 – 5 GHz: ≤ 3 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td rowspan="2">graded grid</td><td>ΔZ_{Zoom}(1): between 1^{ST} two points closest to phantom surface</td><td>≤ 4 mm</td><td>3 – 4 GHz: ≤ 3 mm
4 – 5 GHz: ≤ 2.5 mm
5 – 6 GHz: ≤ 2 mm</td></tr>
<tr><td>ΔZ_{Zoom}(n>1): between subsequent points</td><td colspan="2">≤ 1.5·ΔZ_{Zoom}(n-1) mm</td></tr>
<tr><td>Minimum zoom scan volume</td><td colspan="2">x, y, z</td><td>≥ 30 mm</td><td>3 – 4 GHz: ≥ 28 mm
4 – 5 GHz: ≥ 25 mm
5 – 6 GHz: ≥ 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 IEEE Std 1528-2013 for details.
* When zoom scan is required and the reported SAR from the area scan based 1-g SAR estimation procedures of KDB Publication 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.</td></tr>
</table>

3.2.4 SAR Drift Measurement

The local SAR (or conducted power) shall be measured at exactly the same location as in 3.2.1 section. The absolute value of the measurement drift (the difference between the SAR measured in 3.2.1 and 3.2.4 section) shall be recorded. The SAR drift shall be kept within ± 5%.

3.3 Test Equipment

Equipment	Manufacturer	Model	SN	Cal. Date	Cal. Interval
System Validation Dipole	SPEAG	D2450V2	1014	Jun. 07, 2018	3 Year
System Validation Dipole	SPEAG	D5GHzV2	1280	Jun. 24, 2019	3 Year
Dosimetric E-Field Probe	SPEAG	EX3DV4	7506	Jun. 27, 2019	1 year
Data Acquisition Electronics	SPEAG	DAE4	1557	Jun. 18, 2019	1 year
Dosimetric E-Field Probe	SPEAG	ES3DV3	3090	Apr. 12, 2019	1 Year
Data Acquisition Electronics	SPEAG	DAE4	662	Apr. 11, 2019	1 Year
Radio Communication Analyzer	Anritsu	MT8820C	6200918396	Nov. 24, 2019	1 Year
ENA Series Network Analyzer	Agilent	8753ES	US39170317	Nov. 24, 2019	1 Year
Dielectric Assessment Kit	SPEAG	DAK-3.5	1056	N/A	N/A
USB/GPIB Interface	Agilent	82357B	N10149	N/A	N/A
Signal Generator	R&S	SMT06	100796	May. 14, 2019	1 Year
POWER METER	R&S	NRP	101293	May. 14, 2019	1 Year
Thermometer	Shanghai Gao Zhi Precision Instrument Co., Ltd.	HB6801	120100323	May. 16, 2019	1 Year
Coupler	REBES	TC-05180-10S	161221001	N/A	N/A
Amplifier	Mini-Circuit	ZHL42	QA1252001	N/A	N/A
DC Source	Agilent	66319B	MY43000795	N/A	N/A

3.4 Measurement Uncertainty

Source of Uncertainty	Tolerance (± %)	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)	Vi Veff
Measurement System								
Probe Calibration	6.55	Normal	1	1	1	± 6.0 %	± 6.0 %	∞
Axial Isotropy	4.7	Rectangular	√3	0.7	0.7	± 1.9 %	± 1.9 %	∞
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	0.7	± 3.9 %	± 3.9 %	∞
Boundary Effects	2	Rectangular	√3	1	1	± 0.6 %	± 0.6 %	∞
Linearity	4.7	Rectangular	√3	1	1	± 2.7 %	± 2.7 %	∞
Detection Limits	0.25	Rectangular	√3	1	1	± 0.1 %	± 0.1 %	∞
Modulation Response	2.4	Rectangular	√3	1	1	± 1.4%	± 1.4%	∞
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response Time	0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Integration Time	1.7	Rectangular	√3	1	1	± 1.0 %	± 1.0 %	∞
RF Ambient – Noise	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient – Reflections	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %	∞
Probe Positioning	6.7	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Max. SAR Evaluation	4	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Test Sample Related								
Device Positioning	2.2 / 2.6	Normal	1	1	1	± 2.2 %	± 2.6 %	30
Device Holder	3.3 / 3.4	Normal	1	1	1	± 3.3 %	± 3.4 %	30
Power Drift	5	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
Power Scaling	0	Rectangular	√3	1	1	± 0 %	± 0 %	∞
Phantom and Setup								
Phantom Uncertainty	7.9	Rectangular	√3	1	1	± 4.3 %	± 4.3 %	∞
SAR correction	1.2 / 0.97	Rectangular	√3	1	0.84	± 0.7 %	± 0.5 %	∞
Liquid Conductivity (Meas.)	2.5	Rectangular	√3	0.78	0.71	± 1.1 %	± 1 %	∞
Liquid Permittivity (Meas.)	2.5	Rectangular	√3	0.26	0.26	± 0.4 %	± 0.4 %	∞
Temp. unc. - Conductivity	3.4	Rectangular	√3	0.78	0.71	± 2.3 %	± 2.1 %	∞
Temp. unc. - Permittivity	0.4	Rectangular	√3	0.23	0.26	± 0.1 %	± 0.1 %	∞
Combined Standard Uncertainty (K = 1)						± 12.2 %	± 12.3 %	
Expanded Uncertainty (K = 2)						**± 24.5 %**	**± 24.6 %**	

EXPOSURE ASSESSMENT UNCERTAINTY FOR HEAD SAR

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Source of Uncertainty	Tolerance (± %)	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)	Vi Veff
Measurement System								
Probe Calibration	6.55	Normal	1	1	1	± 6.0 %	± 6.0 %	∞
Axial Isotropy	4.7	Rectangular	√3	0.7	0.7	± 1.9 %	± 1.9 %	∞
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	0.7	± 3.9 %	± 3.9 %	∞
Boundary Effects	2	Rectangular	√3	1	1	± 0.6 %	± 0.6 %	∞
Linearity	4.7	Rectangular	√3	1	1	± 2.7 %	± 2.7 %	∞
Detection Limits	0.25	Rectangular	√3	1	1	± 0.1 %	± 0.1 %	∞
Modulation Response	2.4	Rectangular	√3	1	1	± 1.4%	± 1.4%	∞
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response Time	0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Integration Time	1.7	Rectangular	√3	1	1	± 1.0 %	± 1.0 %	∞
RF Ambient – Noise	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient – Reflections	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %	∞
Probe Positioning	6.7	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Max. SAR Evaluation	4	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Test Sample Related								
Deviation of experimental dipole	5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
Input power and SAR drift measurement	5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
Dipole axis to liquid distance	2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Phantom and Setup								
Phantom Uncertainty	7.9	Rectangular	√3	1	1	± 4.3 %	± 4.3 %	∞
SAR correction	1.2 / 0.97	Rectangular	√3	1	0.84	± 0.7 %	± 0.5 %	∞
Liquid Conductivity (Meas.)	2.5	Rectangular	√3	0.78	0.71	± 1.1 %	± 1 %	∞
Liquid Permittivity (Meas.)	2.5	Rectangular	√3	0.26	0.26	± 0.4 %	± 0.4 %	∞
Temp. unc. - Conductivity	3.4	Rectangular	√3	0.78	0.71	± 2.3 %	± 2.1 %	∞
Temp. unc. - Permittivity	0.4	Rectangular	√3	0.23	0.26	± 0.1 %	± 0.1 %	∞
Combined Standard Uncertainty (K = 1)						± 12.0 %	± 12.0 %	
Expanded Uncertainty (K = 2)						**± 24.0 %**	**± 23.9 %**	

SYSTEM VALIDATION MEASUREMENT UNCERTAINTY FOR HEAD

Source of Uncertainty	Tolerance (± %)	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)	Vi Veff
Measurement System								
Probe Calibration	6.55	Normal	1	1	1	± 6.0 %	± 6.0 %	∞
Axial Isotropy	4.7	Rectangular	√3	0.7	0.7	± 1.9 %	± 1.9 %	∞
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	0.7	± 3.9 %	± 3.9 %	∞
Boundary Effects	2	Rectangular	√3	1	1	± 0.6 %	± 0.6 %	∞
Linearity	4.7	Rectangular	√3	1	1	± 2.7 %	± 2.7 %	∞
Detection Limits	0.25	Rectangular	√3	1	1	± 0.1 %	± 0.1 %	∞
Modulation Response	2.4	Rectangular	√3	1	1	± 1.4%	± 1.4%	∞
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response Time	0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Integration Time	1.7	Rectangular	√3	1	1	± 1.0 %	± 1.0 %	∞
RF Ambient – Noise	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient – Reflections	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %	∞
Probe Positioning	6.7	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Max. SAR Evaluation	4	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Test Sample Related								
Device Positioning	2.2 / 2.6	Normal	1	1	1	± 2.2 %	± 2.6 %	30
Device Holder	3.3 / 3.4	Normal	1	1	1	± 3.3 %	± 3.4 %	30
Power Drift	5	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
Power Scaling	0	Rectangular	√3	1	1	± 0 %	± 0 %	∞
Phantom and Setup								
Phantom Uncertainty	7.9	Rectangular	√3	1	1	± 4.3 %	± 4.3 %	∞
SAR correction	1.2 / 0.97	Rectangular	√3	1	0.84	± 0.7 %	± 0.5 %	∞
Liquid Conductivity (Meas.)	2.5	Rectangular	√3	0.78	0.71	± 1.1 %	± 1 %	∞
Liquid Permittivity (Meas.)	2.5	Rectangular	√3	0.26	0.26	± 0.4 %	± 0.4 %	∞
Temp. unc. - Conductivity	3.4	Rectangular	√3	0.78	0.71	± 2.3 %	± 2.1 %	∞
Temp. unc. - Permittivity	0.4	Rectangular	√3	0.23	0.26	± 0.1 %	± 0.1 %	∞
Combined Standard Uncertainty (K = 1)						± 12.2 %	± 12.3 %	
Expanded Uncertainty (K = 2)						**± 24.5 %**	**± 24.6 %**	

EXPOSURE ASSESSMENT UNCERTAINTY FOR Body SAR

Source of Uncertainty	Tolerance (± %)	Probability Distribution	Divisor	Ci (1g)	Ci (10g)	Standard Uncertainty (1g)	Standard Uncertainty (10g)	Vi Veff
Measurement System								
Probe Calibration	6.55	Normal	1	1	1	± 6.0 %	± 6.0 %	∞
Axial Isotropy	4.7	Rectangular	√3	0.7	0.7	± 1.9 %	± 1.9 %	∞
Hemispherical Isotropy	9.6	Rectangular	√3	0.7	0.7	± 3.9 %	± 3.9 %	∞
Boundary Effects	2	Rectangular	√3	1	1	± 0.6 %	± 0.6 %	∞
Linearity	4.7	Rectangular	√3	1	1	± 2.7 %	± 2.7 %	∞
Detection Limits	0.25	Rectangular	√3	1	1	± 0.1 %	± 0.1 %	∞
Modulation Response	2.4	Rectangular	√3	1	1	± 1.4%	± 1.4%	∞
Readout Electronics	0.3	Normal	1	1	1	± 0.3 %	± 0.3 %	∞
Response Time	0	Rectangular	√3	1	1	± 0.0 %	± 0.0 %	∞
Integration Time	1.7	Rectangular	√3	1	1	± 1.0 %	± 1.0 %	∞
RF Ambient – Noise	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
RF Ambient – Reflections	3	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Probe Positioner	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %	∞
Probe Positioning	6.7	Rectangular	√3	1	1	± 1.7 %	± 1.7 %	∞
Max. SAR Evaluation	4	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Test Sample Related								
Deviation of experimental dipole	5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
Input power and SAR drift measurement	5.0	Rectangular	√3	1	1	± 2.9 %	± 2.9 %	∞
Dipole axis to liquid distance	2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %	∞
Phantom and Setup								
Phantom Uncertainty	7.9	Rectangular	√3	1	1	± 4.3 %	± 4.3 %	∞
SAR correction	1.2 / 0.97	Rectangular	√3	1	0.84	± 0.7 %	± 0.5 %	∞
Liquid Conductivity (Meas.)	2.5	Rectangular	√3	0.78	0.71	± 1.1 %	± 1 %	∞
Liquid Permittivity (Meas.)	2.5	Rectangular	√3	0.26	0.26	± 0.4 %	± 0.4 %	∞
Temp. unc. - Conductivity	3.4	Rectangular	√3	0.78	0.71	± 2.3 %	± 2.1 %	∞
Temp. unc. - Permittivity	0.4	Rectangular	√3	0.23	0.26	± 0.1 %	± 0.1 %	∞
Combined Standard Uncertainty (K = 1)						± 12.0 %	± 12.0 %	
Expanded Uncertainty (K = 2)						**± 24.0 %**	**± 23.9 %**	

SYSTEM VALIDATION MEASUREMENT UNCERTAINTY FOR Body

3.5 Tissue Dielectric Parameter Measurement & System Verification

3.5.1 Tissue Simulating Liquids

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.

The depth of tissue-equivalent liquid in a phantom must be ≥ 15.0 cm with ≤ ± 0.5 cm variation for SAR measurements ≤ 3 GHz and ≥ 10.0 cm with ≤ ± 0.5 cm variation for measurements > 3 GHz. The nominal dielectric values of the tissue simulating liquids in the phantom and the tolerance of 5% are listed in Table-3.1.

Photo of Liquid Height

Table-3.1 Tissue Dielectric Parameters for Head and Body

Target Frequency (MHz)	Head		Body	
	εr	σ (S/m)	εr	σ (S/m)
750	*41.9*	*0.89*	*55.5*	*0.96*
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
1450	*40.5*	*1.20*	*54.0*	*1.30*
1640	*40.3*	*1.29*	*53.8*	*1.40*
1750	*40.1*	*1.37*	*53.4*	*1.49*
1800	40.0	1.40	53.3	1.52
1900	40.0	1.40	53.3	1.52
2000	40.0	1.40	53.3	1.52
2300	*39.5*	*1.67*	*52.9*	*1.81*
2450	39.2	1.80	52.7	1.95
2600	*39.0*	*1.96*	*52.5*	*2.16*
3500	*37.9*	*2.91*	*51.3*	*3.31*
5200	*36.0*	*4.66*	*49.0*	*5.30*
5300	*35.9*	*4.76*	*48.9*	*5.42*
5500	*35.6*	*4.96*	*48.6*	*5.65*
5600	*35.5*	*5.07*	*48.5*	*5.77*
5800	35.3	5.27	48.2	6.00
(εr = relative permittivity, σ = conductivity and ρ = 1000 kg/m3)				

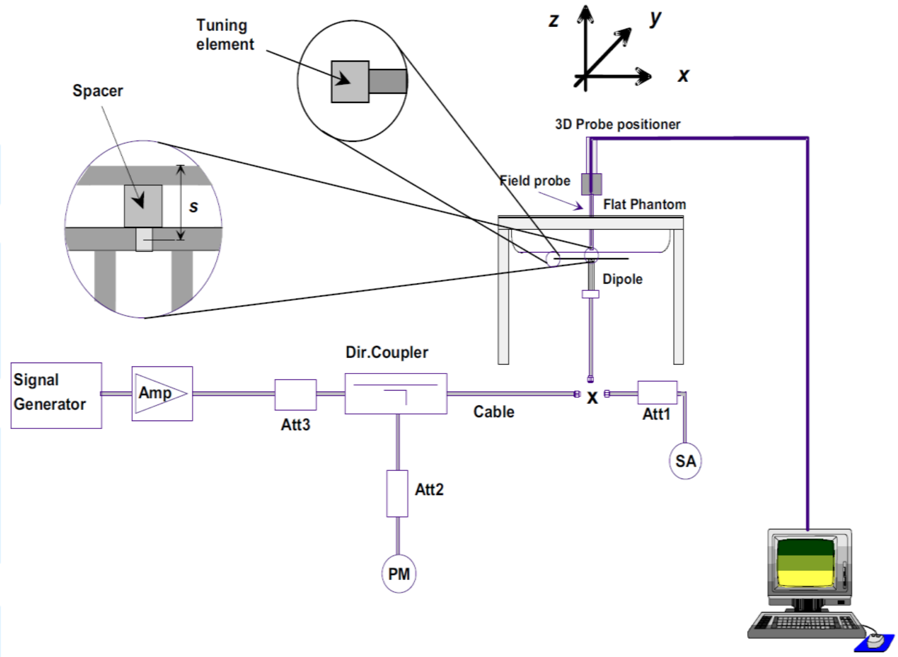
The following table gives the recipes for tissue simulating liquids.

Table-3.2 Recipes of Tissue Simulating Liquid

Tissue Type	Bactericide	DGBE	HEC	NaCl	Sucrose	Triton X-100	Water	Diethylene Glycol Mono-hexylether
H750	0.2	-	0.2	1.4	57.0	-	41.1	-
H835	0.1	-	1.0	1.4	57.0	-	40.5	-
H900	0.1	-	1.0	1.5	56.5	-	40.9	-
H1450	-	45.5	-	0.7	-	-	53.8	-
H1640	-	45.8	-	0.5	-	-	53.7	-
H1750	-	44.5	-	0.3	-	-	55.2	-
H1800	-	44.9	-	0.2	-	-	54.9	-
H1900	-	44.9	-	0.2	-	-	54.9	-
H2000	-	50	-	-	-	-	50	-
H2300	-	44.9	-	0.1	-	-	55.0	-
H2450	-	45.0	-	0.1	-	-	54.9	-
H2600	-	45.1	-	0.1	-	-	54.8	-
H3500	-	8.0	-	0.2	-	20.0	71.8	-
H5G	-	-	-	-	-	17.2	65.52	17.3
B750	0.2	-	0.2	0.8	48.8	-	50.0	-
B835	0.2	-	0.2	0.9	48.5	-	50.2	-
B900	0.2	-	0.2	0.9	48.2	-	50.5	-
B1450	-	34.0	-	0.3	-	-	65.7	-
B1640	-	32.5	-	0.3	-	-	67.2	-
B1750	-	29.4	-	0.4	-	-	70.2	-
B1800	-	29.5	-	0.4	-	-	70.1	-
B1900	-	29.5	-	0.3	-	-	70.2	-
B2000	-	30.0	-	0.2	-	-	69.8	-
B2300	-	31.0	-	0.1	-	-	68.9	-
B2450	-	31.4	-	0.1	-	-	68.5	-
B2600	-	31.8	-	0.1	-	-	68.1	-
B3500	-	28.8	-	0.1	-	-	71.1	-
B5G	-	-	-	-	-	10.7	78.6	10.7

3.5.2 System Check Description

The system check procedure provides a simple, fast, and reliable test method that can be performed daily or before every SAR measurement. The objective here is to ascertain that the measurement system has acceptable accuracy and repeatability. This test requires a flat phantom and a radiating source. The system verification setup is shown as below.



System Verification Setup

3.5.3 Tissue Verification

The measuring results for tissue simulating liquid are shown as below.

Test Date	Tissue Type	Frequency (MHz)	Liquid Temp. (℃)	Measured Conductivity (σ)	Measured Permittivity (ε_r)	Target Conductivity (σ)	Target Permittivity (ε_r)	Conductivity Deviation (%)	Permittivity Deviation (%)
Nov. 01, 2019	Head	2450	22.1	1.780	40.200	1.80	39.20	-1.11	2.55
Nov. 25, 2019	Head	5250	22.2	4.735	36.296	4.71	35.90	0.53	1.10
Nov. 25, 2019	Head	5600	22.2	5.092	35.786	5.07	35.50	0.43	0.81
Nov. 25, 2019	Head	5750	22.2	5.305	35.501	5.22	35.40	1.63	0.29
Nov. 01, 2019	Head	2437	22.1	1.760	40.200	1.80	39.20	-2.22	2.55
Nov. 25, 2019	Head	5300	22.2	4.788	36.220	4.71	35.90	1.66	0.89
Nov. 25, 2019	Head	5320	22.2	4.804	36.210	4.71	35.90	2.00	0.86
Nov. 25, 2019	Head	5520	22.2	5.009	35.900	5.07	35.50	-1.20	1.13
Nov. 25, 2019	Head	5580	22.2	5.071	35.810	5.07	35.50	0.02	0.87
Nov. 25, 2019	Head	5700	22.2	5.199	35.64	5.22	35.40	-0.40	0.68
Nov. 25, 2019	Head	5785	22.2	5.286	35.52	5.22	35.40	1.26	0.34

Note:

The dielectric properties of the tissue simulating liquid must be measured within 24 hours before the SAR testing and within ± 5% of the target values. The variation of the liquid temperature must be within ± 2 °C during the test.

3.5.4 System Verification

The measuring result for system verification is tabulated as below.

Test Date	Tissue Type	Frequency (MHz)	1W Target SAR-1g (W/kg)	Measured SAR-1g (W/kg)	Normalized to 1W SAR-1g (W/kg)	Deviation (%)	Dipole S/N	Probe S/N	DAE S/N
Nov. 01, 2019	Head	2450	52.40	5.550	55.50	5.92	1014	3090	662
Nov. 25, 2019	Head	5250	78.90	8.430	84.30	6.84	1280	7506	1557
Nov. 25, 2019	Head	5600	80.30	8.260	82.60	2.86	1280	7506	1557
Nov. 25, 2019	Head	5750	79.30	8.000	80.00	0.88	1280	7506	1557

Note:

Comparing to the reference SAR value, the validation data should be within its specification of 10%. The result indicates the system check can meet the variation criterion and the plots can be referred to Appendix A of this report.

3.5.5 System Validation

The SAR measurement system was validated according to procedures in KDB 865664 D01. The validation status in tabulated summary is as below.

Test Date	Probe S/N	Calibration Point		Measured Conductivity (σ)	Measured Permittivity (ε_r)	Validation for CW			Validation for Modulation		
						Sensitivity Range	Probe Linearity	Probe Isotropy	Modulation Type	Duty Factor	PAR
Apr. 23, 2019	3090	Head	2450	1.825	37.945	Pass	Pass	Pass	OFDM	N/A	Pass
Aug. 05, 2019	7506	Head	5250	4.696	37.050	Pass	Pass	Pass	OFDM	N/A	Pass
Aug. 05, 2019	7506	Head	5600	4.819	36.840	Pass	Pass	Pass	OFDM	N/A	Pass
Aug. 05, 2019	7506	Head	5750	5.199	36.180	Pass	Pass	Pass	OFDM	N/A	Pass

4 SAR Measurement Evaluation

4.1 EUT Configuration and Setting

4.1.1 WLAN Configuration and Testing

In general, various vendor specific external test software and chipset based internal test modes are typically used for SAR measurement. These chipset based test mode utilities are generally hardware and manufacturer dependent, and often include substantial flexibility to reconfigure or reprogram a device. A Wi-Fi device must be configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools for SAR measurement. The test frequencies established using test mode must correspond to the actual channel frequencies. When 802.11 frame gaps are accounted for in the transmission, a maximum transmission duty factor of 92 - 96% is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. In addition, a periodic transmission duty factor is required for current generation SAR systems to measure SAR correctly. The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

According to KDB 248227 D01, this device has installed WLAN engineering testing software which can provide continuous transmitting RF signal. During WLAN SAR testing, this device was operated to transmit continuously at the maximum transmission duty with specified transmission mode, operating frequency, lowest data rate, and maximum output power.

Initial Test Configuration

An initial test configuration is determined for OFDM transmission modes in 2.4 GHz and 5 GHz bands according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel in the initial test configuration, for each frequency band.

Subsequent Test Configuration

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units. Additional power measurements may be required to determine if SAR measurements are required for subsequent highest output power channels in a subsequent test configuration. When the highest reported SAR for the initial test configuration according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for that subsequent test configuration.

SAR Test Configuration and Channel Selection

When multiple channel bandwidth configurations in a frequency band have the same specified maximum output power, the initial test configuration is using largest channel bandwidth, lowest order modulation, lowest data rate, and lowest order 802.11 mode (i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over

802.11n). After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following.
1) The channel closest to mid-band frequency is selected for SAR measurement.
2) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

Test Reduction for U-NII-1 (5.2 GHz) and U-NII-2A (5.3 GHz) Bands

For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following.
1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition).
2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration.

4.2 EUT Testing Position

4.2.1 Head Exposure Conditions

RF Exposure Conditions	Test Position	Separation Distance	SAR test exclusion
Head	Right Cheek	0 cm	N/A
	Right Tilted		
	Left Cheek		
	Left Tilted		

Note:

1. Head exposure for voice mode of handset is limited to next to the ear exposure conditions.
2. Devices that are designed to transmit next to the ear must be tested using the SAM phantom.
3. Other head exposure conditions, for example, in-front-of the face, should be tested using a flat phantom according to the required published RF exposure KDB procedures.
4. When data mode operates in next to the ear configurations, either data alone or in conjunction with voice transmissions, SAR evaluation is required for such use conditions.
5. When device supports VoIP, SAR evaluation for head Exposure Conditions using the most appropriate wireless data mode configurations is required.

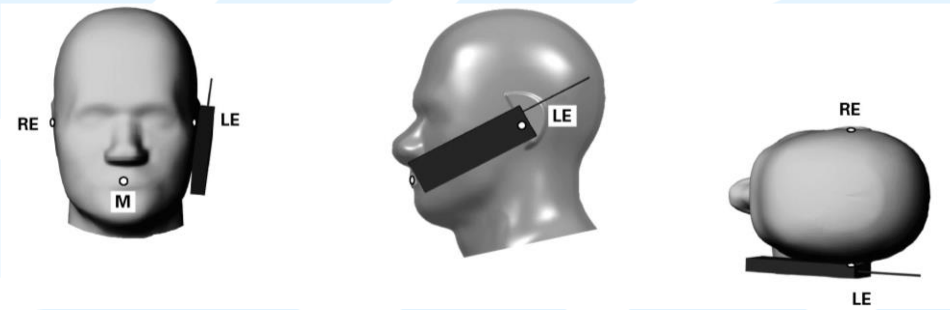


Fig-4.1 Cheek Position

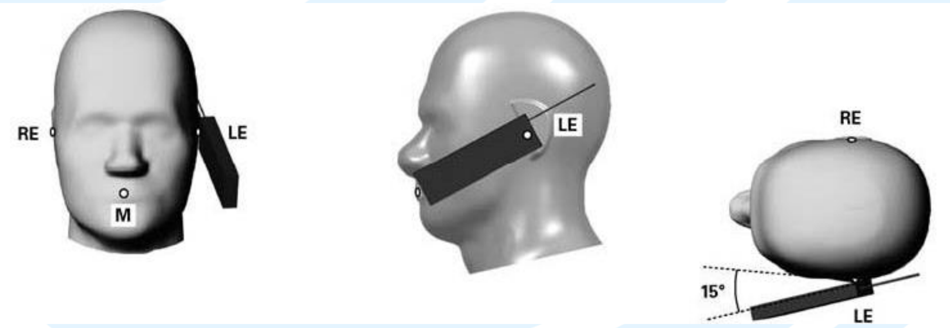


Fig-4.2 Tilted Position

Define two imaginary lines on the handset

a) The vertical centerline passes through two points on the front side of the handset - the midpoint of the width w_t of the handset at the level of the acoustic output, and the midpoint of the width w_b of the bottom of the handset.
b) The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output. The horizontal line is also tangential to the face of the handset at point A.
c) The two lines intersect at point A. Note that for many handsets, point A coincides with the center of the acoustic output; however, the acoustic output may be located elsewhere on the horizontal line. Also note that

the vertical centerline is not necessarily parallel to the front face of the handset, especially for clamshell handsets, handsets with flip covers, and other irregularly shaped handsets.

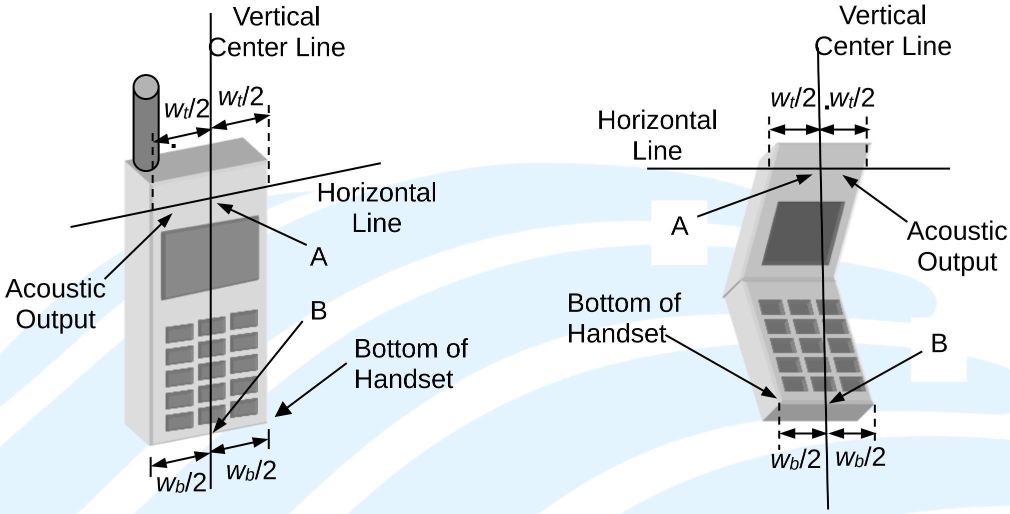


Fig-4.3 Handset Vertical and Horizontal Reference Lines

4.2.2 Body-worn Accessory Exposure Conditions

RF Exposure Conditions	Test Position	Separation Distance	SAR test exclusion
Body-worn	Front Face	0 ~ 2.5 cm	N/A
	Rear Face		

Note:

1. Body-worn accessories that do not contain metallic or conductive components may be tested according to worst-case exposure configurations, typically according to the smallest test separation distance required for the group of body-worn accessories with similar operating and exposure characteristics. All body-worn accessories containing metallic components are tested in conjunction with the host device.
2. Body-worn accessory SAR compliance is based on a single minimum test separation distance for all wireless and operating modes applicable to each body-worn accessory used by the host, and according to the relevant voice and/or data mode transmissions and operations. If a body-worn accessory supports voice only operations in its normal and expected use conditions, testing of data mode for body-worn compliance is not required.
3. A conservative minimum test separation distance for supporting off-the-shelf body-worn accessories that may be acquired by users of consumer handsets should be used to test for body-worn accessory SAR compliance. This distance is determined by the handset manufacturer according to the typical body-worn accessories users may acquire at the time of equipment certification, but not more than 2.5 cm, to enable users to purchase aftermarket body-worn accessories with the required minimum separation.
4. Devices that are designed to operate on the body of users using lanyards and straps or without requiring additional body-worn accessories must be tested for SAR compliance using a conservative minimum test separation distance ≤ 5 mm to support compliance.
5. When device supports VoIP, SAR evaluation for body-worn accessory Exposure Conditions using the most appropriate wireless data mode configurations is required.
6. Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories.
7. When the reported SAR for a body-worn accessory, measured without a headset connected to the handset, is > 1.2 W/kg, the highest reported SAR configuration for that wireless mode and frequency band should be repeated for the body-worn accessory with a headset attached to the handset.

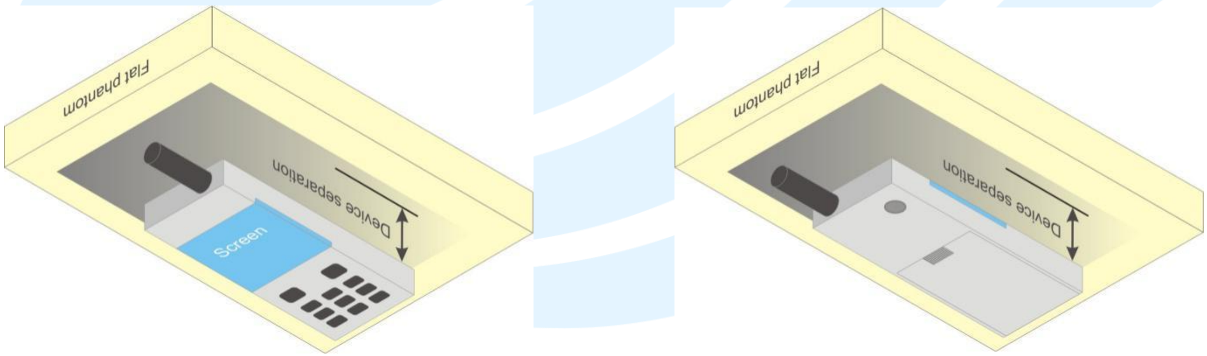


Fig-4.4 Body Worn Position

4.3 Measured Conducted Power Result

4.3.1 Conducted Power of WLAN

Mode		Channel	Frequency (MHz)	Average Power (dBm)
2.4G	802.11b	1	2412	15.06
		6	2437	15.26
		11	2462	15.19
	802.11g	1	2412	14.65
		6	2437	14.95
		11	2462	15.07
	802.11n (HT20)	1	2412	14.01
		6	2437	14.31
		11	2462	14.48

Mode		Channel	Frequency (MHz)	Average Power (dBm)
802.11a	5.2G	36	5180	15.89
		40	5200	16.07
		44	5220	15.92
		48	5240	16.14
	5.3G	52	5260	16.79
		56	5280	16.89
		60	5300	16.94
		64	5320	17.11
	5.6G	100	5500	16.62
		104	5520	16.80
		108	5540	16.70
		112	5560	16.55
		116	5580	16.71
		132	5660	16.59
		136	5680	16.34
		140	5700	15.37
	5.8G	149	5745	16.93
		153	5765	16.34
		157	5785	16.58
		161	5805	16.27
		165	5825	16.03

Mode		Channel	Frequency (MHz)	Average Power (dBm)
802.11n (HT20)	5.2G	36	5180	15.68
		40	5200	15.44
		44	5220	15.74
		48	5240	15.50
	5.3G	52	5260	16.66
		56	5280	16.52
		60	5300	16.58
		64	5320	16.43
	5.6G	100	5500	16.36
		104	5520	16.34
		108	5540	16.26
		112	5560	16.20
		116	5580	16.24
		132	5660	16.01
		136	5680	16.07
		140	5700	14.81
	5.8G	149	5745	16.63
		153	5765	16.10
		157	5785	16.19
		161	5805	16.03
		165	5825	15.58

Mode		Channel	Frequency (MHz)	Average Power (dBm)
802.11n (HT40)	5.2G	38	5190	13.18
		46	5230	16.26
	5.3G	54	5270	16.19
		62	5310	13.51
	5.6G	102	5510	13.46
		110	5550	16.30
		134	5670	16.01
	5.8G	151	5755	16.25
		159	5795	15.83

Mode		Channel	Frequency (MHz)	Average Power (dBm)
802.11ac (VHT20)	5.2G	36	5180	15.43
		40	5200	15.65
		44	5220	15.49
		48	5240	15.71
	5.3G	52	5260	16.36
		56	5280	16.52
		60	5300	16.61
		64	5320	16.41
	5.6G	100	5500	16.27
		104	5520	16.33
		108	5540	16.41
		112	5560	16.36
		116	5580	16.31
		132	5660	16.30
		136	5680	16.05
		140	5700	14.95
	5.8G	149	5745	16.58
		153	5765	16.10
		157	5785	16.29
		161	5805	16.06
		165	5825	15.61

Mode		Channel	Frequency (MHz)	Average Power (dBm)
802.11ac (VHT40)	5.2G	38	5190	13.24
		46	5230	16.26
	5.3G	54	5270	16.28
		62	5310	13.41
	5.6G	102	5510	13.35
		110	5550	16.28
		134	5670	16.01
	5.8G	151	5755	16.24
		159	5795	15.85

Mode		Channel	Frequency (MHz)	Average Power (dBm)
802.11ac (VHT80)	5.2G	42	5210	11.58
	5.3G	58	5290	11.98
	5.6G	106	5530	12.63
	5.8G	155	5775	15.20

4.4 SAR Test Exclusion Evaluations

4.4.1 Standalone SAR Test Exclusion Considerations

According to KDB 447498 D01, the SAR test exclusion condition is based on source-based time-averaged maximum conducted output power, adjusted for tune-up tolerance, and the minimum test separation distance required for the exposure conditions. The 1-g and 10-g *SAR test exclusion thresholds* are determined by the following:

a) For 100 MHz to 6 GHz and *test separation distances* ≤ 50 mm:

$$\frac{Max.Tune\ up\ Power_{(mW)}}{Min.Test\ Separation\ Distance_{(mm)}} \times \sqrt{f_{(GHz)}} \leq 3.0 \text{ for SAR-1g}, \leq 7.5 \text{ for SAR-10g}$$

When the minimum *test separation distance* is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

b) For 100 MHz to 1500 MHz and *test separation distances* > 50 mm:

{[Threshold for 50 mm in step a)] + [(test separation distance – 50 mm) · ($f_{(MHz)}$/150)]} mW

c) For > 1500 MHz and ≤ 6 GHz and *test separation distances* > 50 mm:

{[Threshold for 50 mm in step a)] + [(test separation distance – 50 mm) ·10]} mW

When the calculated result in step a) is <= 3.0 for SAR-1g exposure condition, or <= 7.5 for SAR-10g exposure condition, the SAR testing exclusion is applied.
When the device output power is less than the calculated result (power threshold, mW) shown in in step b) and c), the SAR testing exclusion is applied.

4.4.2 Estimated SAR Calculation

According to KDB 447498 D01, when an antenna qualifies for the standalone SAR test exclusion and also transmits simultaneously with other antennas, the standalone SAR value must be estimated according to the following to determine the simultaneous transmission SAR test exclusion criteria:

a) For *test separation distances* ≤ 50 mm:

$$Estimated\ SAR = \frac{Max.Tune\ up\ Power_{(mW)}}{Min.Test\ Separation\ Distance_{(mm)}} \times \frac{\sqrt{f(\mathrm{GHz})}}{x}$$

Where x = 7.5 for 1-g SAR and x = 18.75 for 10-g SAR.

b) For *test separation distances* > 50 mm, 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR.

4.5 SAR Testing Results

4.5.1 SAR Test Reduction Considerations

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* SAR for the mid-band or highest output power channel is:

a) ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
b) ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
c) ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz

KDB 941225 D01 3G SAR Procedures

a) 3G SAR Test Reduction Procedure

The mode tested for SAR is referred to as the primary mode. The equivalent modes considered for SAR test reduction are denoted as secondary modes. Both primary and secondary modes must be in the same frequency band. When the maximum output power and tune-up tolerance specified for production units in a secondary mode is ≤ 1/4 dB higher than the primary mode or when the highest reported SAR of the primary mode is scaled by the ratio of specified maximum output power and tune-up tolerance of secondary to primary mode and the adjusted SAR is ≤ 1.2 W/kg, SAR measurement is not required for the secondary mode.

KDB 248227 D01 Wi-Fi SAR

a) For handsets operating next to ear, hotspot mode or mini-tablet configurations, the initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When the reported SAR of initial test position is <= 0.4 W/kg, SAR testing for remaining test positions is not required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is <= 0.8 W/kg or all test positions are measured.
b) For WLAN 2.4 GHz, the highest measured maximum output power channel for DSSS was selected for SAR measurement. When the reported SAR is <= 0.8 W/kg, no further SAR testing is required. Otherwise, SAR is evaluated at the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel. For OFDM modes (802.11g/n), SAR is not required when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and it is <= 1.2 W/kg.
c) For WLAN 5 GHz, the initial test configuration was selected according to the transmission mode with the highest maximum output power. When the reported SAR of initial test configuration is > 0.8 W/kg, SAR is required for the subsequent highest measured output power channel until the reported SAR result is <= 1.2 W/kg or all required channels are measured. For other transmission modes, SAR is not required when the highest reported SAR for initial test configuration is adjusted by the ratio of subsequent test configuration to initial test configuration specified maximum output power and it is <= 1.2 W/kg.

4.5.2 SAR Results for Head Exposure Condition

Plot No.	Band	Mode	Test Position	Ch.	Max. Tune-up Power (dBm)	Measured Conducted Power (dBm)	Power Drift (dB)	Measured SAR-1g (W/kg)	Scaling Factor	Scaled SAR-1g (W/kg)
	802.11b	-	Right Cheek	6	16.0	15.26	0.02	0.137	1.19	0.16
	802.11b	-	Right Tilted	6	16.0	15.26	-0.10	0.104	1.19	0.12
1	802.11b	-	Left Cheek	6	16.0	15.26	-0.09	0.198	1.19	0.23
	802.11b	-	Left Tilted	6	16.0	15.26	0.17	0.118	1.19	0.14
	802.11a	-	Right Cheek	64	17.5	17.11	-0.08	0.89	1.09	0.97
	802.11a	-	Right Tilted	64	17.5	17.11	-0.10	0.907	1.09	0.99
	802.11a	-	Left Cheek	64	17.5	17.11	-0.04	0.91	1.09	1.00
	802.11a	-	Left Tilted	64	17.5	17.11	0.07	0.879	1.09	0.96
	802.11a	-	Right Cheek	60	17.5	16.94	0.03	0.872	1.14	0.99
	802.11a	-	Right Tilted	60	17.5	16.94	0.01	0.915	1.14	1.04
2	802.11a	-	Left Cheek	60	17.5	16.94	-0.12	0.983	1.14	1.12
	802.11a	-	Left Tilted	60	17.5	16.94	0.05	0.886	1.14	1.01
	802.11a	-	Left Cheek	60	17.5	16.94	-0.03	0.962	1.14	1.09
	802.11a	-	Right Cheek	104	17.3	16.80	-0.07	1.01	1.12	1.13
	802.11a	-	Right Tilted	104	17.3	16.80	-0.02	0.907	1.12	1.02
	802.11a	-	Left Cheek	104	17.3	16.80	0.05	0.965	1.12	1.08
	802.11a	-	Left Tilted	104	17.3	16.80	0.06	0.82	1.12	0.92
3	802.11a	-	Right Cheek	116	17.3	16.71	-0.08	1.03	1.15	1.18
	802.11a	-	Right Tilted	116	17.3	16.71	0.02	0.912	1.15	1.04
	802.11a	-	Left Cheek	116	17.3	16.71	0.04	0.974	1.15	1.12
	802.11a	-	Left Tilted	116	17.3	16.71	0.15	0.846	1.15	0.97
	802.11a	-	Right Cheek	116	17.3	16.71	0.03	0.993	1.15	1.14
	802.11a	-	Right Cheek	149	17.4	16.93	-0.03	0.92	1.11	1.03
	802.11a	-	Right Tilted	149	17.4	16.93	-0.05	0.85	1.11	0.95
4	802.11a	-	Left Cheek	149	17.4	16.93	-0.07	1.07	1.11	1.19
	802.11a	-	Left Tilted	149	17.4	16.93	-0.01	0.936	1.11	1.04
	802.11a	-	Right Cheek	157	17.4	16.58	0.02	0.878	1.21	1.06
	802.11a	-	Right Tilted	157	17.4	16.58	0.03	0.841	1.21	1.02
	802.11a	-	Left Cheek	157	17.4	16.58	-0.05	0.892	1.21	1.08
	802.11a	-	Left Tilted	157	17.4	16.58	0.09	0.862	1.21	1.04
	802.11a	-	Left Cheek	165	17.4	16.03	0.07	0.867	1.37	1.19
	802.11a	-	Left Cheek	149	17.4	16.93	0.02	1.03	1.11	1.15

4.5.3 SAR Results for Body-worn Exposure Condition

Plot No.	Band	Mode	Test Position	Separation Distance (cm)	Ch.	Belt Clip	Max. Tune-up Power (dBm)	Measured Conducted Power (dBm)	Power Drift (dB)	Measured SAR-1g (W/kg)	Scaling Factor	Scaled SAR-1g (W/kg)
5	802.11b	-	Front Face	1	6	w/o	16.0	15.26	0.06	0.062	1.19	0.07
	802.11b	-	Rear Face	0	6	w/	16.0	15.26	0.02	0.053	1.19	0.06
	802.11a	-	Front Face	1	64	w/o	17.5	17.11	0.08	0.258	1.09	0.28
6	802.11a	-	Rear Face	0	64	w/	17.5	17.11	0.08	0.293	1.09	0.32
	802.11a	-	Rear Face	0	52	w/	17.5	16.79	0.02	0.275	1.18	0.32
	802.11a	-	Rear Face	0	60	w/	17.5	16.94	0.11	0.274	1.14	0.31
7	802.11a	-	Front Face	1	104	w/o	17.3	16.80	0.01	0.227	1.12	0.25
	802.11a	-	Rear Face	0	104	w/	17.3	16.80	0.08	0.226	1.12	0.25
8	802.11a	-	Front Face	1	149	w/o	17.3	16.93	0.09	0.268	1.09	0.29
	802.11a	-	Rear Face	0	149	w/	17.3	16.93	0.02	0.172	1.09	0.19

Note: w/o means test without belt clip, w/ means test with belt clip.

4.6 SAR Measurement Variability

4.6.1 Repeated Measurement

According to KDB 865664 D01, SAR measurement variability was assessed for each frequency band, which is determined by the SAR probe calibration point and tissue-equivalent medium used for the device measurements. When both head and body tissue-equivalent media are required for SAR measurements in a frequency band, the variability measurement procedures should be applied to the tissue medium with the highest measured SAR, using the highest measured SAR configuration for that tissue-equivalent medium. Alternatively, if the highest measured SAR for both head and body tissue-equivalent media are ≤ 1.45 W/kg and the ratio of these highest SAR values, i.e., largest divided by smallest value, is ≤ 1.10, the highest SAR configuration for either head or body tissue-equivalent medium may be used to perform the repeated measurement. 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.

SAR repeated measurement procedure:

1. When the highest measured SAR is < 0.80 W/kg, repeated measurement is not required.
2. When the highest measured SAR is >= 0.80 W/kg, repeat that measurement once.
3. 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 W/kg, perform a second repeated measurement.
4. If the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20, and the original, first or second repeated measurement is >= 1.5 W/kg, perform a third repeated measurement.

Band	Mode	Test Position	Ch.	Original Measured SAR-1g (W/kg)	1st Repeated SAR-1g (W/kg)	L/S Ratio	2nd Repeated SAR-1g (W/kg)	L/S Ratio	3rd Repeated SAR-1g (W/kg)	L/S Ratio
Head Exposure Condition										
802.11a	-	Left Cheek	60	0.983	0.962	1.02	N/A	N/A	N/A	N/A
802.11a	-	Right Cheek	116	1.03	0.993	1.04	N/A	N/A	N/A	N/A
802.11a	-	Left Cheek	149	1.07	1.03	1.04	N/A	N/A	N/A	N/A

4.7 Simultaneous Multi-band Transmission Evaluation

4.7.1 Simultaneous Transmission SAR Test Exclusion Considerations

a) Sum of SAR

Simultaneous transmission SAR test exclusion is determined for each operating configuration and exposure condition according to the reported standalone SAR of each applicable simultaneous transmitting antenna. When the sum of SAR_{1g} of all simultaneously transmitting antennas in an operating mode and exposure condition combination is within the SAR limit (SAR_{1g} 1.6 W/kg), the simultaneous transmission SAR is not required. When the sum of SAR_{1g} is greater than the SAR limit (SAR_{1g} 1.6 W/kg), SAR test exclusion is determined by the SPLSR.

b) SAR to Peak Location Separation Ratio

The simultaneous transmitting antennas in each operating mode and exposure condition combination are considered one pair at a time to determine the SPLSR.

$$SPLSR = (SAR_1 + SAR_2)^{1.5}/R_i$$

The ratio is rounded to two decimal digits, and must be ≤ 0.04 for all antenna pairs in the configuration to qualify for 1-g SAR test exclusion. When 10-g SAR applies, the ratio must be ≤ 0.10.

SAR_1 and SAR_2 are the highest reported or estimated SAR values for each antenna in the pair, and R_i is the separation distance in mm between the peak SAR locations for the antenna pair

$$peak\ location\ separation\ distance = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}$$

Where (x_1, y_1, z_1) and (x_2, y_2, z_2) are the coordinates of the extrapolated peak SAR locations in the area or zoom scans.

When standalone test exclusion applies, SAR is estimated; the peak location is assumed to be at the feed-point or geometric center of the antenna. Due to curvatures on the SAM phantom, when SAR is estimated for one of the antennas in an antenna pair, the measured peak SAR location will be translated onto the test device to determine the peak location separation for the antenna pair.

When SAR is estimated for both antennas, the peak location separation should be determined by the closest physical separation of the antennas, according to the feed-point or geometric center of the antennas.

c) Volume Scan

When the SPLSR is <= 0.04 for 1-g SAR and <= 0.10 for 10-g SAR, the simultaneous transmission SAR is not required. Otherwise, the enlarged zoom scan and volume scan post-processing procedures will be performed.

4.7.2 Simultaneous Transmission Possibilities

The 2.4G WLAN and 5G WLAN cannot transmit simultaneously.

*** End of Report ***

Appendix A. SAR Plots of System Verification

The plots for system verification with largest deviation for each SAR system combination are shown as follows.

Appendix B. SAR Plots of SAR Measurement

The SAR plots for highest measured SAR in each exposure configuration, wireless mode and frequency band combination, and measured SAR > 1.5 W/kg are shown as follows.

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Appendix C. Calibration Certificate for Probe and Dipole

The calibration certificates are shown as follows.

Appendix D. Photographs of EUT and Setup