Test Report

Applicant	：	Edimax Technology Co., Ltd.
Product Name	：	AC600 Dual-Band Nano USB Adapter
Trade Name	：	EDIMAX
Model Number	：	EW-7811ULC
Applicable Standard	：	47 CFR Part §2.1093
Received Date	：	Jul. 11, 2022
Test Period	：	Jul. 27, 2022
Issued Date	：	Sep. 08, 2022

Issued by

Approved By ： Kris Pan

(Kris Pan)

A Test Lab Techno Corp.
No. 140-1, Changan Street, Bade District,
Taoyuan City 334025, Taiwan (R.O.C.)
Tel：+886-3-2710188 / Fax：+886-3-2710190

Testing Laboratory
1330

Taiwan Accreditation Foundation accreditation number: 1330
Test Firm MRA designation number: TW0010

Note:
1. The test results are valid only for samples provided by customers and under the test conditions described in this report.
2. This report shall not be reproduced except in full, without the written approval of A Test Lab Technology Corporation.
3. The relevant information is provided by customers in this test report. According to the correctness, appropriateness or completeness of the information provided by the customer, if there is any doubt or error in the information which affects the validity of the test results, the laboratory does not take the responsibility.

Revision History

Rev.	Issue Date	Revisions	Revised By
00	Sep. 08, 2022	Initial Issue	Nina Lin

Contents

1. General Information

1.1 Reference Testing Standards

Standard	Description	Version
47 CFR Part §2.1093	Radiofrequency radiation exposure evaluation: portable devices	-
IEC/IEEE 62209-1528	Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Part 1528: Human models, instrumentation, and procedures (Frequency range of 4 MHz to 10 GHz)	2020
IEEE 1528	Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques	2013
IEEE C95.1	IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz	1992
KDB 248227 D01	SAR guidance for IEEE 802.11 (Wi-Fi) transmitters	v02r02
KDB 447498 D02	SAR measurement procedures for dongle transmitters	v02r01
KDB 447498 D04	RF exposure procedures and equipment authorization policies for mobile and portable devices	v01
KDB 865664 D01	SAR measurement requirement for 100 MHz to 6 GHz	v01r04
KDB 865664 D02	RF exposure compliance reporting and documentation considerations	v01r02

2. Description of Device Under Test (DUT)

Applicant	Edimax Technology Co., Ltd. No. 278, Xinhu 1st Rd., Neihu Dist., Taipei City, Taiwan
Product Name	AC600 Dual-Band Nano USB Adapter
Trade Name	EDIMAX
Model Number	EW-7811ULC
SN No.	25CC00031
FCC ID	NDD9578112202
Frequency Range	WLAN 2.4 GHz Band：2412 - 2462 MHz WLAN 5.2 GHz Band：5180 - 5240 MHz WLAN 5.8 GHz Band：5745 - 5825 MHz
Supported Modulations	WLAN 2.4 GHz : 802.11 b / g / n HT20 / HT40
	WLAN 5 GHz : 802.11 a / n / ac HT20 / HT40 / VHT20 / VHT40 / VHT80
Device Category	Portable Device

Note:

1. The above information of DUT was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

Antenna Information			
Model	Type	Max. Gain (dBi)	
ALX18M-222AA6	PIFA Antenna	2.4 GHz	0.98 dBi
		5 GHz	3.93 dBi

3. Summary of Maximum Value

Equipment Class	Mode	Highest Reported SAR
		Hotspot standalone $SAR_{1\,g}$ (W/kg)
DTS	WLAN 2.4 GHz ANT 0	1.18
NII	WLAN 5 GHz ANT 0	0.44

Note:

1. The SAR limit for general population / uncontrolled exposure is specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992.
2. The test procedures, as described in American National Standards, Institute ANSI/IEEE C95.1 were employed and they specify the maximum exposure limit of tissue for portable devices being used within 20 cm between user and EUT in the uncontrolled environment. A description of the product and operating configuration, detailed summary of the test results, methodology and procedures used in the equipment used are included within this test report.

4. Introduction

4.1 SAR Definition

Specific Absorption Rate (SAR) 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). The equation description is as below:

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

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

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

Where：

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue (kg/m^3)

E = RMS electric field strength (V/m)

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

4.2 RF Exposure Limits

Table 1 Safety Limits for Controlled / Uncontrolled Environment Exposure

SAR Exposure Limit		
	General Population / Uncontrolled Exposure [1] (W/kg)	**Occupational / Controlled Exposure [2] (W/kg)**
Spatial Peak SAR [3] (head or Body)	1.60	8.00
Spatial Peak SAR [4] (Whole Body)	0.08	0.40
Spatial Peak SAR [5] (Hands / Feet / Ankle / Wrist)	4.00	20.00

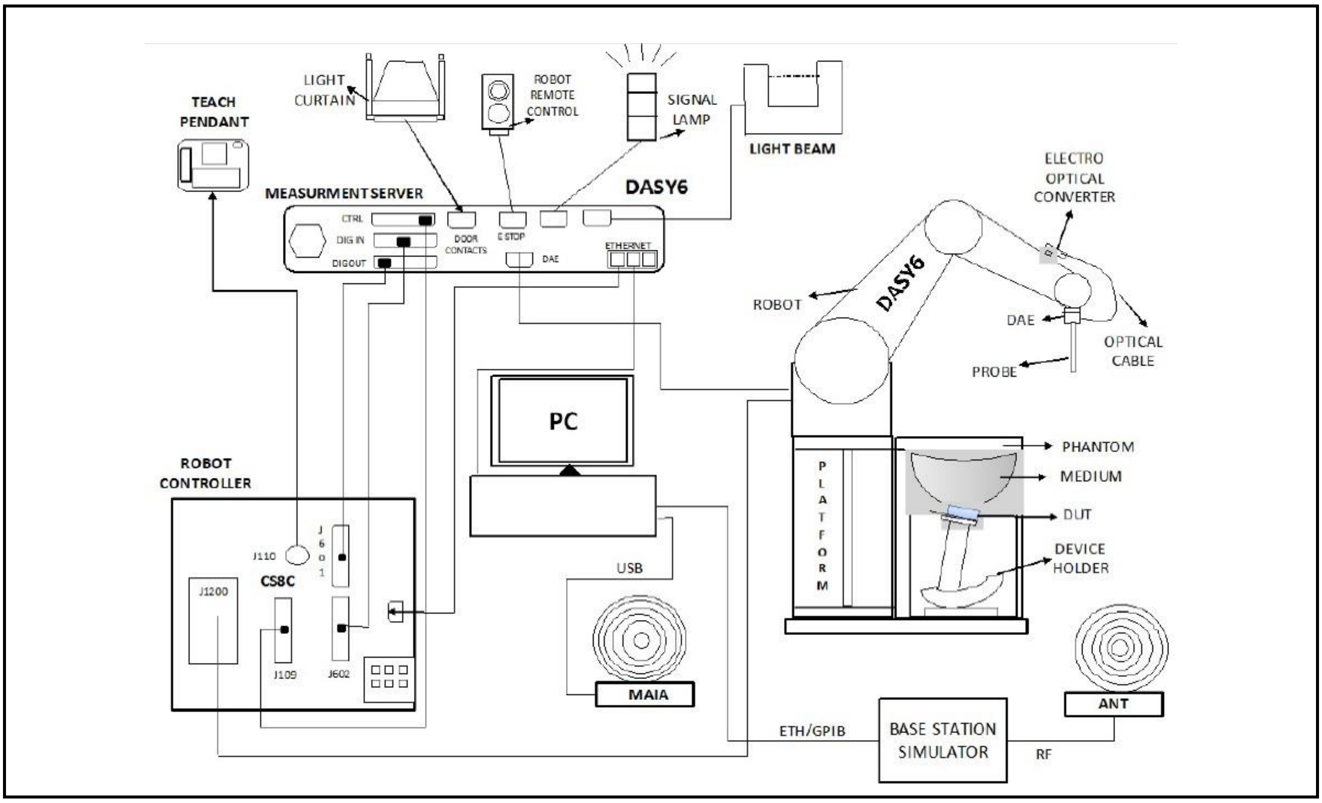
Notes：

1. **General Population / Uncontrolled Environments** are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.
2. **Occupational / Controlled Environments** are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation).
3. The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
4. The Spatial Average value of the SAR averaged over the whole body.
5. The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

5. System Describtion

5.1 SAR Measurement System

The DASY6 system in cDASY6/DASY5 V5.2 SAR Configuration is shown below:



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

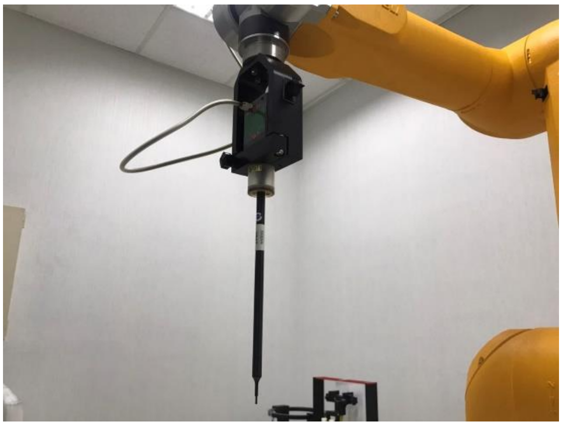
1. A standard high precision 6-axis robot (Stäubli TX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
2. An isotropic field probe optimized and calibrated for the targeted measurements.
3. A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
4. The Electro-optical converter (EOC) performs the conversion from optical to electrical signals for the digital communication to the DAE. To use optical surface detection, a special version of the EOC is required. The EOC signal is transmitted to the measurement server.
5. The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
6. The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
7. A computer running Win7/Win8/Win10 professional operating system and the cDASY6 and DASY5 V5.2 software.
8. Remote controls with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
9. The phantom, the device holder and other accessories according to the targeted measurement.
10. Tissue simulating liquid mixed according to the given recipes.
11. The validation dipole has been calibrated within and the system performance check has been successful.

<DASY E-Field Probe System>

The SAR measurements were conducted with the dosimetric probe (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probes is constructed using the thick film technique; with printed resistive lines on ceramic substrates. The probe is equipped with an optical multi-fiber line ending at the front of the probe tip. It is connected to the EOC box on the robot arm and provides an automatic detection of the phantom surface. Half of the fibers are connected to a pulsed infrared transmitter, the other half to a synchronized receiver. As the probe approaches the surface, the reflection from the surface produces a coupling from the transmitting to the receiving fibers. This reflection increases first during the approach, reaches maximum and then decreases. If the probe is flatly touching the surface, the coupling is zero. The distance of the coupling maximum to the surface is independent of the surface reflectivity and largely independent of the surface to probe angle. The DASY software reads the reflection during a software approach and looks for the maximum using a 2nd order fitting. The approach is stopped when reaching the maximum.

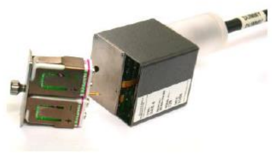
Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Frequency	4 MHz to 10 GHz Linearity: ± 0.2 dB (30 MHz to 10 GHz)
Directivity	±0.1 dB in TSL (rotation around probe axis) ±0.3 dB in TSL (rotation normal to probe axis)
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
Calibration	ISO/IEC 17025 calibration service available

EX3DV4 E-Field Probe



Probe setup on robot

<Data Acquisition Electronic (DAE) System>

Model	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: 4 mV, 400 mV)	
Input Offset Voltage	< 5 μV (with auto zero)	
Input Bias Current	< 50 fA	
Dimensions	60 x 60 x 68 mm	

<Robot>

Positioner	Stäubli Unimation Corp.	
Robot Model	TX90XL	
Number of Axes	6	
Nominal Load	5 kg	
Reach	1450 mm	
Repeatability	± 0.035 mm	

<Device Holder>

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity ε=3 and loss tangent δ=0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

	
Device Holder 1	Device Holder 2

<Oval Flat Phantom – ELI>

The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (Oval Flat) phantom defined in IEEE 1528, IEC 62209-2 and IEC/IEEE 62209-1528. It enables the dosimetric evaluation of wireless portable device 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 manually teaching three points with the robot.

Shell Thickness	2 ±0.2 mm	
Filling Volume	Approx. 30 liters	
Dimensions	190×600×400 mm (H × L × W)	

<SAM Phantom>

The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528, IEC 62209-1 and IEC/IEEE 62209-1528. 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.

Shell Thickness	2 ±0.2 mm	
Filling Volume	Approx. 25 liters	
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet	

5.2 Tissue Simulating Liquids (TSL)

<Tissue Dielectric Parameters in IEEE 1528-2013 and IEC/IEEE 62209-1528>

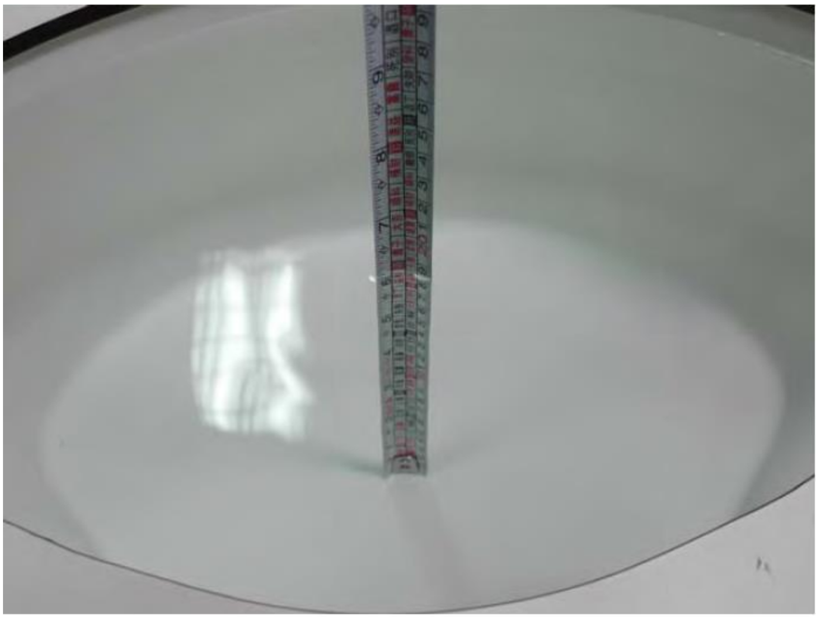
The following table incorporates the tissue dielectric parameters of head recommended by IEEE 1528-2013 and IEC/IEEE 62209-1528. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in human head. Other head and body tissue parameters that have not been specified are derived from the tissue dielectric parameters which computed by the 4-Cole-Cole equation according to the above-mentioned standards.

Table 2 Dielectric properties of the tissue-equivalent liquid material

Frequency (MHz)	Relative Permittivity (ε_r)	Conductivity (σ)
30	55.0	0.75
150	52.3	0.76
300	45.3	0.87
450	43.5	0.87
750	41.9	0.89
835	41.5	0.90
900	41.5	0.97
1450	40.5	1.20
1800	40.0	1.40
1900	40.0	1.40
1950	40.0	1.40
2000	40.0	1.40
2100	39.8	1.49
2450	39.2	1.80
2600	39.0	1.96
3000	38.5	2.40
3500	37.9	2.91
4000	37.4	3.43
4500	36.8	3.94
5000	36.2	4.45
5200	36.0	4.66
5400	35.8	4.86
5600	35.5	5.07
5800	35.3	5.27
6000	35.1	5.48
6500	34.5	6.07
7000	33.9	6.65
7500	33.3	7.24
8000	32.7	7.84
8500	32.1	8.46
9000	31.6	9.08
9500	31.0	9.71
10000	30.4	10.4

<Liquid Depth>

The depth of tissue-equivalent liquid in a phantom must be ≧ 15.0 cm to ensure that the probe is immersed sufficiently in the tissue medium.



Tissue-equivalent Liquid Height

<Test Site Environment>

Item	Requirement	Actual
Temperature (°C)	18 - 25	21 - 23

<Liquid Check>

1. The dielectric parameters of the liquids were verified prior to the SAR evaluation using a DAKS 3.5 Probe Kit.
2. The SAR testing with IEC tissue parameters as an alternative option to Head and body parameters. The head TSL were applied to body SAR tests with restrictions below:

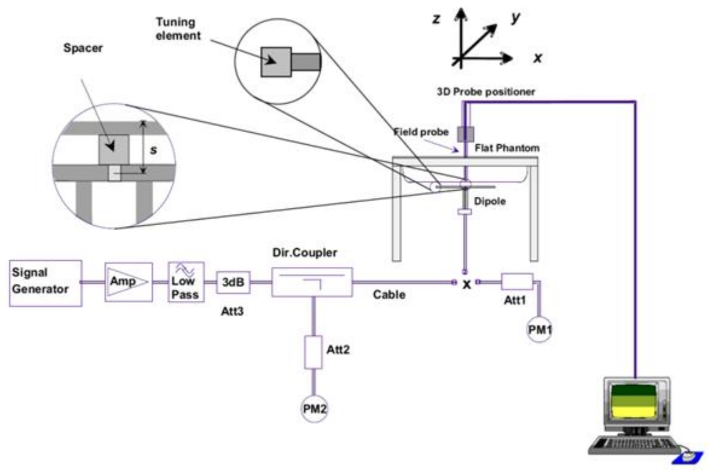
Tissue Temp (°C)	Head / Body	Frequency	Cond. σ	Perm. εr	target Cond. σ	target Perm. εr	σ (Delta)(%)	εr (Delta)(%)	Limit (%)	Date
21.9	Head	2412 MHz	1.77	39.82	1.77	39.27	0.31	1.41	±5	Jul. 27, 2022
21.9	Head	2422 MHz	1.78	39.78	1.78	39.25	0.48	1.35	±5	Jul. 27, 2022
21.9	Head	2437 MHz	1.80	39.75	1.79	39.22	0.72	1.35	±5	Jul. 27, 2022
21.9	Head	2452 MHz	1.82	39.72	1.80	39.20	0.95	1.31	±5	Jul. 27, 2022
21.9	Head	2462 MHz	1.83	39.69	1.81	39.18	1.01	1.29	±5	Jul. 27, 2022
21.9	Head	2467 MHz	1.84	39.67	1.82	39.18	1.07	1.25	±5	Jul. 27, 2022
21.9	Head	2472 MHz	1.84	39.66	1.82	39.17	1.13	1.24	±5	Jul. 27, 2022
21.7	Head	5180 MHz	4.62	36.51	4.64	36.02	-0.37	1.35	±5	Jul. 27, 2022
21.7	Head	5190 MHz	4.63	36.49	4.65	36.01	-0.42	1.34	±5	Jul. 27, 2022
21.7	Head	5200 MHz	4.64	36.47	4.66	36.00	-0.45	1.32	±5	Jul. 27, 2022
21.7	Head	5220 MHz	4.66	36.43	4.68	35.98	-0.51	1.25	±5	Jul. 27, 2022
21.7	Head	5230 MHz	4.67	36.41	4.69	35.97	-0.51	1.21	±5	Jul. 27, 2022
21.7	Head	5240 MHz	4.68	36.38	4.70	35.96	-0.45	1.17	±5	Jul. 27, 2022
21.7	Head	5250 MHz	4.69	36.36	4.71	35.95	-0.40	1.13	±5	Jul. 27, 2022
21.7	Head	5745 MHz	5.19	35.41	5.22	35.36	-0.54	0.13	±5	Jul. 27, 2022
21.7	Head	5755 MHz	5.20	35.38	5.23	35.35	-0.56	0.09	±5	Jul. 27, 2022
21.7	Head	5775 MHz	5.22	35.34	5.25	35.33	-0.54	0.04	±5	Jul. 27, 2022
21.7	Head	5785 MHz	5.23	35.33	5.26	35.32	-0.51	0.02	±5	Jul. 27, 2022
21.7	Head	5795 MHz	5.24	35.31	5.27	35.31	-0.49	0.01	±5	Jul. 27, 2022
21.7	Head	5825 MHz	5.27	35.28	5.30	35.28	-0.56	-0.01	±5	Jul. 27, 2022

6. System Verification

6.1 SAR System Verification

<Symmetric Dipoles for SAR System Verification>

Construction	Symmetrical dipole with λ/4 balun enables measurement of feed point impedance with NWA matched for use near flat phantoms filled with head simulating solutions Includes distance holder and tripod adaptor Calibration Calibrated SAR value for specified position and input power at the flat phantom in head simulating solutions.
Return Loss	> 20 dB at specified verification position.
Options	Dipoles for other frequencies or solutions and other calibration conditions are available upon request.



System Verification Setup Diagram

Validation Kit

6.1.1 SAR Verification Summary

Prior to the assessment, the validation data compared to the original value provided by SPEAG should be within its specifications of ±10%. The measured SAR will be normalized to 1 W input power. The result indicates the system check can meet the variation criterion and plots can be referred to Appendix B of this report.

Mixture Type	Frequency (MHz)	Power (dBm)	Probe Model / Serial No.	Dipole Model / Serial No.	SAR_{1g} (W/kg)	1 W Normalize SAR_{1g} (W/kg)	1 W Target SAR1 g (W/kg)	SAR_{10g} (W/kg)	1 W Normalize SAR_{10g} (W/kg)	1 W Target SAR_{10g} (W/kg)	Deviation 1 g (%)	Deviation 10 g (%)	Date
Head	2450	17 dBm	EX3DV4 – SN7647	D2450V2 – SN712	2.51	50.08	52.80	1.19	23.74	24.40	-5.2%	-2.7%	Jul. 27, 2022
Head	5250	17 dBm	EX3DV4 – SN7647	D5250V2 – SN1021	4.15	82.80	78.10	1.2	23.94	22.10	6.0%	8.3%	Jul. 27, 2022
Head	5750	17 dBm	EX3DV4 – SN7647	D5750V2 – SN1021	4.02	80.21	77.30	1.15	22.95	21.50	3.8%	6.7%	Jul. 27, 2022

7. Test Equipment List

7.1 SAR Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Cal. Date	Cal.Period
SPEAG	2450 MHz System Validation Kit	D2450V2	712	Jun. 30, 2022	1 year
SPEAG	5 GHz System Validation Kit	D5GHzV2	1021	Jun. 30, 2022	1 year
SPEAG	Dosimetric E-Field Probe	EX3DV4	7647	Apr. 27, 2022	1 year
SPEAG	Data Acquisition Electronics	DAE4	1253	Dec. 30, 2021	1 year
SPEAG	Measurement Server	SE UMS 011 BB	1241	NCR	
SPEAG	Device Holder	N/A	N/A	NCR	
SPEAG	Phantom	ELI V4.0	1036	NCR	
SPEAG	Robot	Staubli TX90XL	F11/5G9EA1/A/01	NCR	
SPEAG	Software	DASY52 V52.10.4.1535	N/A	NCR	
SPEAG	Software	SEMCAD X V14.6.14(7501)	N/A	NCR	
SPEAG	Network Analyzer	DAKS_VNA R140	0010318	May. 23, 2022	1 year
SPEAG	Dielectric Probe Kit	DAKS-3.5	1101	May. 23, 2022	1 year
HILA	Digital Thermometer	TM-906A	1500033	Oct. 29, 2021	1 year
Agilent	Power Sensor	8481H	3318A20779	May. 26, 2022	1 year
Agilent	Power Meter	EDM Series E4418B	GB40206143	May. 26, 2022	1 year
Agilent	Power Sensor	N1921A	MY45241957	Dec. 06, 2021	1 year
Agilent	Power Meter	N1911A	MY45101619	Dec. 06, 2021	1 year
Agilent	Signal Generator	E8257D	MY44320425	Feb. 15, 2022	1 year
Agilent	Spectrum Analyzer	E4446A	MY46180578	Sep. 11, 2021	1 year
Mini-Circuits	Dual Directional Coupler	ZCDC20-5R263-S+	E69806	NCR	
Mini-Circuits	Power Amplifier	EMC014225P	980292	NCR	
Mini-Circuits	Power Amplifier	EMC2830P	980293	NCR	
EMCI	Power Amplifier	EMC0618-P	980833	NCR	
EMCI	Power Amplifier	EMC2830-P	980880	NCR	
Attenuator	INMET	18AH-03	S180301	NCR	
Attenuator	INMET	18AH-10	S181001	NCR	
Attenuator	INMET	18AH-20	S182001	NCR	

Testing Engineer: Gary Chao

8. Measurement Procedure

8.1 SAR Measurement Procedure

The measurement procedures are as follows:

1. The DUT is installed engineering testing software that provides continuous transmitting signal.
2. Measure output power through RF cable and power meter
3. Set scan area, grid size and other setting on the DASY software
4. Find out the largest SAR result on these testing positions of each band
5. Measure SAR results for other channels in worst SAR testing position if the SAR of highest power channel is larger than 0.8 W/kg

According to the test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

1. Power reference measurement
2. Area scan
3. Zoom scan
4. Power drift measurement

8.1.1 Area & Zoom Scan Procedures

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan measures points and step size follow as below. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution.

The measure settings are referred to KDB 865664 D01v01r04 :

<table>
<tr><th colspan="3"></th><th>≤ 3 GHz</th><th>> 3 GHz</th></tr>
<tr><td colspan="3">Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface</td><td>5 mm ± 1 mm</td><td>½·δ·ln(2) mm ± 0.5 mm</td></tr>
<tr><td colspan="3">Maximum probe angle from probe axis to phantom surface normal at the measurement location</td><td>30° ± 1°</td><td>20° ± 1°</td></tr>
<tr><td colspan="3" rowspan="2">Maximum area scan spatial resolution: Δx_{Area}, Δy_{Area}</td><td>≤ 2 GHz: ≤ 15 mm
2 – 3 GHz: ≤ 12 mm</td><td>3 – 4 GHz: ≤ 12 mm
4 – 6 GHz: ≤ 10 mm</td></tr>
<tr><td colspan="2">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.</td></tr>
<tr><td colspan="3">Maximum zoom scan spatial resolution: Δx_{Area}, Δy_{Area}</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: $\Delta z_{Zoom}(n)$</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>$\Delta z_{Zoom}(1)$: between 1st 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>$\Delta z_{Zoom}(n>1)$: between subsequent points</td><td colspan="2">≤ $1.5 \cdot \Delta z_{Zoom}(n-1)$ 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>

8.1.2 Volume Scan Procedures

The volume scan is used for assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1 g aggregate SAR, the DUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software, SEMCAD postprocessor can combine and subsequently superpose these measurement data to calculating the multiband SAR.

8.1.3 Power Drift Monitoring

All SAR testing is under the DUT install full charged battery and transmit maximum output power. In DASY measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of DUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. The software will calculate the field difference in dB. If the power drifts more than 5 %, the SAR will be retested.

8.1.4 Spatial Peak SAR Evaluation

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1 g and 10 g, as well as for user-specific masses. The DASY software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1 g and 10 g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine (SEMCAD). The system always gives the maximum values for the 1 g and 10 g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

1. Extraction of the measured data (grid and values) from the Zoom Scan
2. Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
3. Generation of a high-resolution mesh within the measured volume
4. Interpolation of all measured values form the measurement grid to the high-resolution grid
5. Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
6. Calculation of the averaged SAR within masses of 1 g and 10 g

9. Measurement Uncertainty

9.1 SAR Measurement Uncertainty

Measurement Uncertainty (0.3-6 GHz)								
Uncertainty Component	**Tol.**	**Prob. Dist.**	**Div.**	**Ci - 1g**	**Ci - 10g**	**ui - 1g (%)**	**ui - 10g (%)**	**vi**
Measurement System								
Probe calibration	12.0	N	2	1	1	6.0	6.0	∞
Probe Calibration Drift	1.7	R	1.732	1	1	1.0	1.0	∞
Data acquisition	0.3	N	1	1	1	0.3	0.3	∞
Probe Linearity	4.7	R	1.732	1	1	2.7	2.7	∞
Broadband Signal	3.0	R	1.732	1	1	1.7	1.7	∞
Probe Isotropy	7.6	R	1.732	1	1	4.4	4.4	∞
RF Ambient	1.8	N	1	1	1	1.8	1.8	∞
Probe Positioning	0.2	N	1	0.14	0.14	0.0	0.0	∞
Data Processing	1.2	N	1	1	1	1.2	1.2	∞
Phantom and Device Errors								
Conductivity (meas.)DAK	2.5	N	1	0.78	0.71	2.0	1.8	∞
Conductivity (temp.)	3.3	R	1.732	0.78	0.71	1.5	1.4	∞
Phantom Shell Permittivity	14	R	1.732	0	0	0.0	0.0	∞
Distance DUT - TSL	2	N	1	2	2	4.0	4.0	∞
Device Positioning	1	N	1	1	1	1.0	1.0	∞
Device Holder	3.6	N	1	1	1	3.6	3.6	∞
DUT Modulation	2.4	R	1.732	1	1	1.4	1.4	∞
Time-average SAR	1.7	R	1.732	1	1	1.0	1.0	∞
DUT Drift	2.5	N	1	1	1	2.5	2.5	∞
Correction to the SAR Results								
Deviation to Target	1.9	N	1	1	0.84	1.9	1.6	∞
SAR scaling	0.0	R	1.732	1	1	0.0	0.0	∞
Combined Standard Uncertainty					RSS	11.0	10.9	
Expanded Uncertainty (95% confidence interval)					k =2	21.9	21.7	

Measurement Uncertainty (3-6 GHz)								
Uncertainty Component	**Tol.**	**Prob. Dist.**	**Div.**	**Ci - 1g**	**Ci - 10g**	**ui - 1g (%)**	**ui - 10g (%)**	**vi**
Measurement System								
Probe Calibration	13.1	N	2	1	1	6.55	6.55	∞
Probe Calibration Drift	1.7	R	1.732	1	1	1.0	1.0	∞
Data Acquisition	0.3	N	1	1	1	0.3	0.3	∞
Probe Linearity	4.7	R	1.732	1	1	2.7	2.7	∞
Broadband Signal	2.6	R	1.732	1	1	1.5	1.5	∞
Probe Isotropy	7.6	R	1.732	1	1	4.4	4.4	∞
RF Ambient	1.8	N	1	1	1	1.8	1.8	∞
Probe Positioning	0.2	N	1	0.33	0.33	0.1	0.1	∞
Data Processing	2.3	N	1	1	1	2.3	2.3	∞
Phantom and Device Errors								
Conductivity (meas.)DAK	2.5	N	1	0.78	0.71	2.0	1.8	∞
Conductivity (temp.)	3.4	R	1.732	0.78	0.71	1.5	1.4	∞
Phantom Shell Permittivity	14	R	1.732	0.25	0.25	2.0	2.0	∞
Distance DUT - TSL	2	N	1	2	2	4.0	4.0	∞
Device Positioning	1	N	1	1	1	1.0	1.0	∞
Device Holder	3.6	N	1	1	1	3.6	3.6	∞
DUT Modulation	2.4	R	1.732	1	1	1.4	1.4	∞
Time-average SAR	1.7	R	1.732	1	1	1.0	1.0	∞
DUT Drift	2.5	N	1	1	1	2.5	2.5	∞
Correction to the SAR Results								
Deviation to Target	1.9	N	1	1	0.84	1.9	1.6	∞
SAR scaling	0.0	R	1.732	1	1	0.0	0.0	∞
Combined Standard Uncertainty					RSS	11.6	11.5	
Expanded Uncertainty (95% confidence interval)					k =2	23.2	23.0	

10. Measurement Evaluation

10.1 Positioning of the DUT in Relation to the Phantom

According to KDB 447498 D02:

Test all USB orientations with a device-to-phantom separation distance of 5 mm or less, according to KDB Publication 447498 D01 requirements. These test orientations are intended for the exposure conditions found in typical laptop/notebook/netbook or tablet computers with either horizontal or vertical USB connector configurations at various locations in the keyboard section of the computer. Current generation portable host computers should be used to establish the required SAR measurement separation distance. The same test separation distance must be used to test all frequency bands and modes in each USB orientation. The typical Horizontal-Up USB connection, found in the majority of host computers, must be tested using an appropriate host computer. A host computer with either Vertical-Front or Vertical-Back USB connection should be used to test one of the vertical USB orientations. If a suitable host computer is not available for testing the Horizontal-Down or the remaining Vertical USB orientation, a high quality USB cable, 12 inches or less, may be used for testing these other orientations. It must be documented that the USB cable does not influence the radiating characteristics and output power of the transmitter.

USB dongles have a rather small footprint; therefore, the SAR scan resolutions should be smaller than those typically used for testing devices with larger form factors, to maintain acceptable uncertainty for the interpolation and extrapolation algorithms used in the 1-g SAR analysis. In addition, when USB cables are used to connect a dongle to the host for SAR testing, the dongle should be supported in several cm of foamed polystyrene (e.g., Styrofoam) to minimize any field perturbation effects due to test device holder used to position the dongle for SAR testing. Dongles with certain spacers, contours or tapering added to the housing should generally be tested according to the 5 mm test separation requirement required for simple dongles, which is based on overall host platform, device and user operating configurations and exposure conditions of a peripheral device as compared to individual use conditions.

USB dongle transmitters must show compliance at a test separation distance of 5 mm. When the SAR is ≥ 1.2 W/kg, applications for equipment certification require a KDB inquiry for equipment approval.2 Preliminary data submitted through KDB inquiries showing compliance at test distances greater than 5 mm are usually inapplicable and insufficient for the FCC to determine if potential exposure concerns may be eliminated to enable the device to satisfy compliance. The information must clearly demonstrate that the likelihood of non-compliance is remote. When the SAR is ≥ 1.2 W/kg, especially for SAR > 1.5 W/kg, certain caution statements, labels and other means to ensure compliance may be required.

10.2 SAR Testing with RF Transmitter

10.2.1 SAR Testing with WLAN

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 actualchannel frequencies.
For WLAN SAR testing, the DUT has installed WLAN engineering testing software which can provide continuous transmitting RF signal. And the RF signal utilized in SAR measurement has almost 100 % duty cycle and crest factor is 1.

- The cards was operated utilizing proprietary software (RTLBTAPP) and each channel was measured using a broadband power meter to determine the maximum average power.

<KDB 248227 D01 General requirements>

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the initial test position(s) by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The initial test position(s) is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the reported SAR for the initial test position is:

- ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions are tested.
  ※ For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
  ※ When it is unclear, all equivalent conditions must be tested.

- For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required test channels are considered.
  ※ The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.

- When the specified maximum output power is the same for both UNII 1 and UNII 2A, begin SAR measurements in UNII 2A with the channel with the highest measured output power. If the reported SAR for UNII 2A is ≤ 1.2 W/kg, SAR is not required for UNII 1; otherwise treat the remaining bands separately and test them independently for SAR.

- When the specified maximum output power is different between UNII 1 and UNII 2A, begin SAR with the band that has the higher specified maximum output. If the highest reported SAR for the band with the highest specified power is ≤ 1.2 W/kg, testing for the band with the lower specified output power is not required; otherwise test the remaining bands independently for SAR.

To determine the initial test position, Area Scans were performed to determine the position with the Maximum Value of SAR (measured). The position that produced the highest Maximum Value of SAR is considered as the worst case position; thus used as the initial test position.

- 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.
  These channel selection procedures apply to both the initial test configuration and subsequent test configuration(s) selection.

10.3 Conducted Power Measurements

Refer to Appendix A.

10.4 Antenna location

Refer to Appendix E.

10.5 Test Results

10.5.1 SAR Test Result

Index.	Band	Modulation	Channel	Frequency (MHz)	Test Position	Spacing (mm)	SAR_{1g} (W/kg)	Meas. Conducted Power (dBm)	Tune-up (dBm)	Duty Cycle (%)	Duty Cycle Scaling Factor	Reported SAR_{1g} (W/kg)
1	WLAN 2.4 GHz	802.11b	1	2412	Horizontal-UP	5	1.140	18.42	18.50	98.47	1.016	1.18
	WLAN 2.4 GHz	802.11b	6	2437	Horizontal-UP	5	1.090	18.33	18.50	98.47	1.016	1.15
	WLAN 2.4 GHz	802.11b	11	2462	Horizontal-UP	5	1.020	18.25	18.50	98.47	1.016	1.10
	WLAN 2.4 GHz	802.11b	1	2412	Horizontal-Down	5	1.090	18.42	18.50	98.47	1.016	1.13
	WLAN 2.4 GHz	802.11b	6	2437	Horizontal-Down	5	1.040	18.33	18.50	98.47	1.016	1.10
	WLAN 2.4 GHz	802.11b	11	2462	Horizontal-Down	5	0.982	18.25	18.50	98.47	1.016	1.06
	WLAN 2.4 GHz	802.11b	1	2412	Vertical-Front	5	0.661	18.42	18.50	98.47	1.016	0.68
	WLAN 2.4 GHz	802.11b	1	2412	Vertical-Back	5	0.963	18.42	18.50	98.47	1.016	1.00
	WLAN 2.4 GHz	802.11b	6	2437	Vertical-Back	5	0.924	18.33	18.50	98.47	1.016	0.98
	WLAN 2.4 GHz	802.11b	11	2462	Vertical-Back	5	0.868	18.25	18.50	98.47	1.016	0.93
	WLAN 2.4 GHz	802.11b	1	2412	Tip	5	0.349	18.42	18.50	98.47	1.016	0.36
	WLAN 5 GHz	802.11ac VHT80	42	5210	Horizontal-UP	5	0.074	14.32	15.00	86.53	1.156	0.10
	WLAN 5 GHz	802.11ac VHT80	42	5210	Horizontal-Down	5	0.064	14.32	15.00	86.53	1.156	0.09
	WLAN 5 GHz	802.11ac VHT80	42	5210	Vertical-Front	5	0.010	14.32	15.00	86.53	1.156	0.01
	WLAN 5 GHz	802.11ac VHT80	42	5210	Vertical-Back	5	0.087	14.32	15.00	86.53	1.156	0.12
2	WLAN 5 GHz	802.11ac VHT80	42	5210	Tip	5	0.101	14.32	15.00	86.53	1.156	0.14
	WLAN 5 GHz	802.11n HT40	38	5190	Tip	5	0.093	14.39	15.00	87.38	1.144	0.12
	WLAN 5 GHz	802.11ac VHT80	155	5775	Horizontal-UP	5	0.235	14.42	15.00	86.53	1.156	0.31
	WLAN 5 GHz	802.11ac VHT80	155	5775	Horizontal-Down	5	0.220	14.42	15.00	86.53	1.156	0.29
	WLAN 5 GHz	802.11ac VHT80	155	5775	Vertical-Front	5	0.010	14.42	15.00	86.53	1.156	0.01
	WLAN 5 GHz	802.11ac VHT80	155	5775	Vertical-Back	5	0.187	14.42	15.00	86.53	1.156	0.25
3	WLAN 5 GHz	802.11ac VHT80	155	5775	Tip	5	0.330	14.42	15.00	86.53	1.156	0.44
	WLAN 5 GHz	802.11n HT40	159	5795	Tip	5	0.322	14.40	15.00	87.38	1.144	0.42

10.6 Measurement Variability

According to KDB 865664 D01v01r04, SAR measurement variability must be 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.

The following procedures are applied to determine if repeated measurements are required:

1. The original highest measured Reported SAR 1-g is ≧ 0.80 W/kg, repeated that measurement once.
2. Perform a second repeated measurement the ratio of the largest to the smallest SAR for the original and first repeated measurements is <1.2 W/kg, or when the original or repeated measurement is ≧ 1.45 W/kg (~10% from the 1-g SAR limit).

Band	Modulation	Channel	Frequency (MHz)	Test Position	Spacing (mm)	Note	Original SAR_{1g} (W/kg)	First SAR_{1g} (W/kg)	First Ratio SAR_{1g}	Original SAR_{10g} (W/kg)	First SAR_{10g} (W/kg)	First Ratio SAR_{10g}
WLAN 2.4 GHz	802.11b	1	2412	Horizontal-UP	5	Index. #1_once	1.14	1.09	4.39%	0.543	0.521	4.05%

10.7 Requirements on the Uncertainty Evaluation

Decision Rule

■ Uncertainty is not included.

☐ Uncertainty is included.

The highest measured 1-g SAR is less than 1.5 W/kg and the highest measured 10-g SAR is less than 3.75 W/kg. Therefore, per KDB Publication 865664 D01, the extended measurement uncertainty analysis described in IEEE 1528-2013 and IEC/IEEE 62209-1528 is not required.

11. Conclusion

The SAR test values found for the device are below the maximum limit of 1.6 W/kg.

---- END ----