TESTING
NVLAP LAB CODE 600354-0

FCC SAR Test Report

FCC ID: RWO-RZ090510

Project No.	:	2309C132
Equipment	:	Notebook PC
Brand Name	:	RAZER
Test Model	:	RZ09-0510
Series Model	:	N/A
Date of Receipt	:	Nov. 16, 2023
Date of Test	:	Dec. 15, 2023
Issued Date	:	Jan. 18, 2024
Report Version	:	R00
Test Sample	:	Engineering Sample No.: DG2023111635
Standard(s)	:	Please refer to page 2.
Applicant	:	Razer Inc.
Address	:	9 Pasteur, Suite 100, Irvine, CA92618, USA.
Manufacturer	:	Razer Inc.
Address	:	9 Pasteur, Suite 100, Irvine, CA92618, USA.

The above equipment has been tested and found compliance with the requirement of the relative standards by BTL Inc.

Prepared by : Justin Huang
Justin Huang

Approved by : Herbort Liu
Herbort Liu

Room 108, Building 2, No. 1, Yile Road, Songshan Lake Zone Dongguan City, Guangdong 523000 China.
Tel: +86-769-8318-3000 Web: www.newbtl.com Service mail: btl_qa@newbtl.com

Standard(s)	:	**ANSI C95.1 (1992)** IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields (3 kHz to 300 GHz)
		IEEE 1528:2013 Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques; FCC requirements for RF Exposure- Devices subject to SAR requirements
		FCC KDB 616217 D04 (October 23, 2015) SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers
		FCC KDB 447498 D04 (November 29, 2021) Interim RF Exposure Procedures and Equipment Authorization Policies for Mobile and Portable Devices
		FCC KDB 248227 D01 (October 23, 2015) SAR Guidance for IEEE 802.11 (Wi-Fi) Transmitters
		FCC KDB 865664 D01 (August 7, 2015) SAR MEASUREMENT REQUIREMENTS FOR 100 MHz TO 6 GHz
		FCC KDB 865664 D02 (October 23, 2015) RF Exposure Compliance Reporting and Documentation Considerations

Declaration

BTL represents to the client that testing is done in accordance with standard procedures as applicable and that test instruments used has been calibrated with standards traceable to international standard(s) and/or national standard(s).

BTL's reports apply only to the specific samples tested under conditions. It is manufacture's responsibility to ensure that additional production units of this model are manufactured with the identical electrical and mechanical components. **BTL** shall have no liability for any declarations, inferences or generalizations drawn by the client or others from **BTL** issued reports.

The report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the U.S. Government.

This report is the confidential property of the client. As a mutual protection to the clients, the public and ourselves, the test report shall not be reproduced, except in full, without our written approval.

BTL's laboratory quality assurance procedures are in compliance with the ISO/IEC 17025: 2017 requirements, and accredited by the conformity assessment authorities listed in this test report.

BTL is not responsible for the sampling stage, so the results only apply to the sample as received.

The information, data and test plan are provided by manufacturer which may affect the validity of results, so it is manufacturer's responsibility to ensure that the apparatus meets the essential requirements of applied standards and in all the possible configurations as representative of its intended use.

Limitation

For the use of the authority's logo is limited unless the Test Standard(s)/Scope(s)/Item(s) mentioned in this test report is (are) included in the conformity assessment authorities acceptance respective.
Please note that the measurement uncertainty is provided for informational purpose only and are not use in determining the Pass/Fail results.

Table of Contents Page

Table of Contents Page

REPORT ISSUED HISTORY

Report No.	Version	Description	Issued Date	Note
BTL-FCC SAR-2-2309C132	R00	Original Report.	Jan. 18, 2024	Valid

1. GENERAL INFORMATION

1.1 STATEMENT OF COMPLIANCE

Mode	Highest Reported Body SAR-1g (W/kg)
WLAN 5.9G	0.956

Note:
1) The device is in compliance with Specific Absorption Rate (SAR) for general population uncontrolled exposure limits according to the FCC rule §2.1093, the ANSI C95.1:1992/IEEE C95.1:1991, the NCRP Report Number 86 for uncontrolled environment, and had been tested in accordance with the measurement methods and procedures specified in IEEE Std 1528-2013.

1.2 LABORATORY ENVIRONMENT

Temperature	Min. = 20ºC, Max. = 24ºC
Relative humidity	Min. = 30%, Max. = 70%
Ground system resistance	< 0.5Ω
Ambient noise is checked and found very low and in compliance with requirement of standards. Reflection of surrounding objects is minimized and in compliance with requirement of standards.	

1.3 GENERAL DESCRIPTION OF EUT

<table>
<tr><td>Equipment</td><td colspan="6">Notebook PC</td></tr>
<tr><td>Brand Name</td><td colspan="6">RAZER</td></tr>
<tr><td>Test Model</td><td colspan="6">RZ09-0510</td></tr>
<tr><td>Series Model</td><td colspan="6">N/A</td></tr>
<tr><td>Model Difference(s)</td><td colspan="6">N/A</td></tr>
<tr><td>Hardware Version</td><td colspan="6">APF22002_MB</td></tr>
<tr><td>Firmware Version</td><td colspan="6">Windows 11</td></tr>
<tr><td>Module Card</td><td colspan="6">BE200NGW</td></tr>
<tr><td>Modulation</td><td colspan="6">WiFi(DSSS/OFDM/OFDMA), BT(GFSK/π/4-DQPSK/8-DPSK)</td></tr>
<tr><td rowspan="2">Operation Frequency Range(s)</td><td colspan="2">Band</td><td colspan="2">TX (MHz)</td><td colspan="2">RX (MHz)</td></tr>
<tr><td colspan="2">WLAN 5.9G</td><td colspan="4">5850~5895</td></tr>
<tr><td rowspan="14">Test Channels (low-mid-high)</td><td colspan="2">Band</td><td colspan="4">WLAN 5.9G</td></tr>
<tr><td colspan="2">802.11a</td><td colspan="4">169-173-177</td></tr>
<tr><td colspan="2">802.11n HT20</td><td colspan="4">169-173-177</td></tr>
<tr><td colspan="2">802.11ax HE20</td><td colspan="4">169-173-177</td></tr>
<tr><td colspan="2">802.11be EHT20</td><td colspan="4">169-173-177</td></tr>
<tr><td colspan="2">802.11n HT40</td><td colspan="4">167-175</td></tr>
<tr><td colspan="2">802.11ax HE40</td><td colspan="4">167-175</td></tr>
<tr><td colspan="2">802.11be EHT40</td><td colspan="4">167-175</td></tr>
<tr><td colspan="2">802.11ac VHT80</td><td colspan="4">171</td></tr>
<tr><td colspan="2">802.11ax HE80</td><td colspan="4">171</td></tr>
<tr><td colspan="2">802.11be EHT80</td><td colspan="4">171</td></tr>
<tr><td colspan="2">802.11ac VHT160</td><td colspan="4">163</td></tr>
<tr><td colspan="2">802.11ax HE160</td><td colspan="4">163</td></tr>
<tr><td colspan="2">802.11be EHT160</td><td colspan="4">163</td></tr>
<tr><td rowspan="3">Antenna Information</td><td>Ant.</td><td>Manufacturer</td><td>Ant. Part number</td><td>Type</td><td>Band</td><td>Gain (dBi)</td></tr>
<tr><td>Main Ant</td><td>Amphenol Taiwan Corporation</td><td>BY510A-15-001-C</td><td>PIFA</td><td>WLAN 5.9G</td><td>1.60</td></tr>
<tr><td>Aux Ant</td><td>Amphenol Taiwan Corporation</td><td>BY510A-15-001-C</td><td>PIFA</td><td>WLAN 5.9G</td><td>3.14</td></tr>
<tr><td colspan="7">Other Information</td></tr>
<tr><td rowspan="3">Battery Information</td><td colspan="2">Model Name</td><td colspan="4">RC30-0483</td></tr>
<tr><td colspan="2">Power Rating</td><td colspan="4">DC 15.4V 6182mAh 95.2Wh</td></tr>
<tr><td colspan="2">Manufacturer</td><td colspan="4">BYD</td></tr>
</table>

Note: The antenna gain is provided by the manufacturer.

1.4 MAIN TEST INSTRUMENTS

Item	Equipment	Manufacturer	Model	Serial No.	Cal. Date	Cal. Interval
1	Data Acquisition Electronics	Speag	DAE4	1717	Apr. 10, 2023	1 Year
2	E-field Probe	Speag	EX3DV4	7544	Feb. 16, 2023	1 Year
3	System Validation Dipole	Speag	D5GHzV2	1160	May 27, 2021	3 Years
4	ELI Phantom	Speag	ELI Phantom V5.0	1222	N/A	N/A
5	Power Amplifier	Talent Microwave	TLPA1G18G-40-33-HS	220330003	Feb. 11, 2023	1 Year
6	DC Source metter	Iteck	IT6154	006104126768201001	Jul. 08, 2023	1 Year
7	Vector Network Analyzer	Agilent	E5071C	MY46102965	Feb. 11, 2023	1 Year
8	Signal Generator	Keysight	N5173B	MY59101420	Feb. 11, 2023	1 Year
9	Smart Power Sensor	R&S	NRP-Z21	102209	May 25, 2023	1 Year
10	3.5mm Economy Calibration Kit	Agilent	85052D	MY43252246	Nov. 10, 2023	1 Year
11	Dielectric Assessment Kit	Speag	DAK-3.5	1226	Jan. 24, 2022	3 Years
12	Coupler	Woken	0110A05601O-10	COM5BNW1A2	Feb. 11, 2023	1 Year
13	Digital Themometer	TES	TES-1310	210706071	Nov. 03, 2023	1 Year

Note:
1. “N/A” denotes no model name, serial No. or calibration specified.
2.
1) Per KDB865664 D01 requirements for dipole calibration, the test laboratory has adopted three-year extended calibration interval. Each measured dipole is expected to evaluate with the following criteria at least on annual interval in Appendix C.
  a) There is no physical damage on the dipole;
  b) System check with specific dipole is within 10% of calibrated value;
  c) The most recent return-loss result, measured at least annually, deviates by no more than 20% from the previous measurement;
  d) The most recent measurement of the real or imaginary parts of the impedance, measured at least annually is within 5Ω from the previous measurement.
2) Network analyzer probe calibration against air, distilled water and a short block performed before measuring liquid parameters.

2. RF EMISSIONS MEASUREMENT

2.1 TEST FACILITY

The test facilities used to collect the test data in this report is SAR room at the location of Room 108, Building 2, No. 1, Yile Road, Songshan Lake Zone, Dongguan City, Guangdong 523000.
BTL's Registration Number for FCC: 568794
BTL's Designation Number for FCC: CN5041

2.2 MEASUREMENT UNCERTAINTY

Note: Per KDB865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval. The equivalent ratio (1.5/1.6) is applied to extremity and occupational exposure conditions.

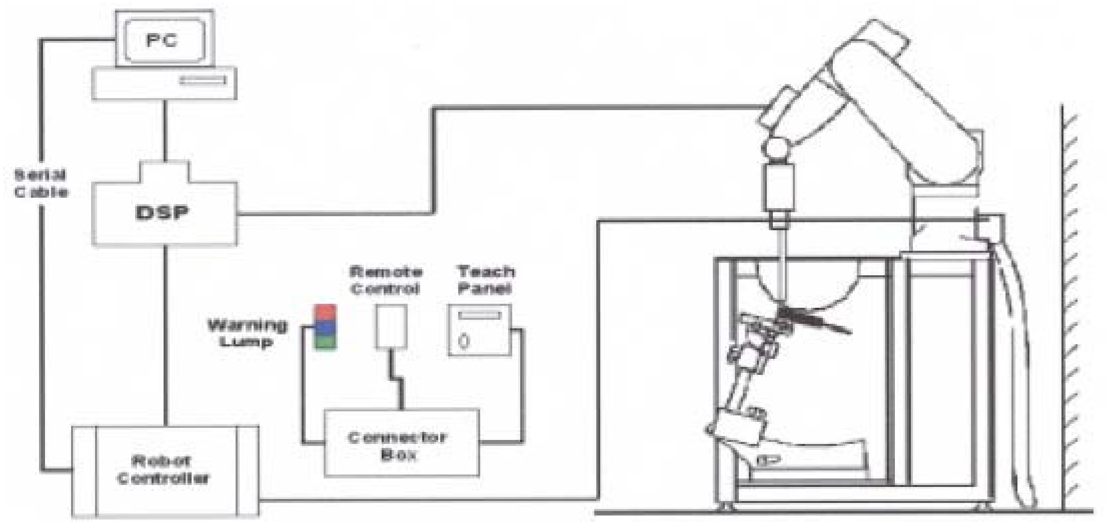
3. SAR MEASUREMENTS SYSTEM CONFIGURATION

3.1 SAR MEASUREMENT SET-UP

The DASY5 system for performing compliance tests consists of the following items:

1. A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
2. A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
3. A data acquisition electronic (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. A unit to operate the optical surface detector which is connected to the EOC.
5. The Electro-Optical Coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the DASY5 measurement server.
6. TheDASY5 measurement server, which performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation. A computer operating Windows.
7. DASY5 software and SEMCAD data evaluation software.
8. Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
9. The generic twin phantom enabling the testing of left-hand and right-hand usage.
10. The device holder for handheld mobile phones.
11. Tissue simulating liquid mixed according to the given recipes.
12. System validation dipoles allowing to validate the proper functioning of the system.

3.1.1 TEST SETUP LAYOUT



3.2 DASY5 E-FIELD PROBE SYSTEM

The SAR measurements were conducted with the dosimetric probe EX3DV4 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation.

3.2.1 PROBE SPECIFICATION

EX3DV4

Construction	Symmetrical design with triangular core Interleaved sensors Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	ISO/IEC 17025 calibration service available
Frequency	10 MHz to 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
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:± 0.2dB
Dimensions	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Distance from probe tip to dipole centers: 1.0 mm

E-field Probe

3.2.2 E-FIELD PROBE CALIBRATION

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

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 1 GHz, and in a wave guide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees.

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent thermostat-based temperature probe is used in conjunction with the E-field probe.

$$\mathbf{SAR} = \mathbf{C}\frac{\Delta T}{\Delta t}$$

Where: Δt=Exposure time (30 seconds),

C =Heat capacity of tissue (brain or muscle),

ΔT=Temperature increase due to RF exposure.

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

Where: σ= Simulated Tissue Conductivity,

ρ=Tissue density (kg/m3).

3.2.3 OTHER TEST EQUIPMENT

3.2.3.1. Device Holder for Transmitters

Construction: Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices (e.g., laptops, cameras, etc.) It is light weight and fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin SAM, ELI and SAM v6.0 Phantoms.
Material: POM, Acrylic glass, Foam

3.2.3.2 Phantom

Model	ELI Phantom	
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.	
Shell Thickness	2±0.1 mm	
Filling Volume	Approx. 30 liters	
Dimensions	Length: 600 mm; Width: 190mm Height: adjustable feet	
Aailable	Special	

3.2.4 SCANNING PROCEDURE

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

The “reference” and “drift” measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure. The indicated drift is mainly the variation of the DUT’s output power and should vary max. ± 5 %.

The “surface check” measurement tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ± 0.1mm). To prevent wrong results tests are only executed when the liquid is free of air bubbles. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within ± 30°.)

- Area Scan

The “area scan” measures the SAR above the DUT or verification dipole on a parallel plane to the surface. It is used to locate the approximate location of the peak SAR with 2D spline interpolation. The robot performs a stepped movement along one grid axis while the local electrical field strength is measured by the probe. The probe is touching the surface of the SAM during acquisition of measurement values. The standard scan uses large grid spacing for faster measurement. Standard grid spacing for head measurements is 15 mm in x- and y- dimension (≤2GHz)，12 mm inx- and y- dimension (2-4 GHz) and 10mm in x- and y- dimension (4-6GHz). If a finer resolution is needed, the grid spacing can be reduced. Grid spacing and orientation have no influence on the SAR result. For special applications where the standard scan method does not find the peak SAR within the grid, e.g. mobile phones with flip cover, the grid can be adapted in orientation.

- Zoom Scan

A “zoom scan” measures the field in a volume around the 2D peak SAR value acquired in the previous “coarse” scan. This is a fine grid with maximum scan spatial resolution: Δx_{zoom}, Δy_{zoom}≤ 2GHz -≤8mm, 2-4GHz -≤ 5 mm and 4-6 GHz-≤ 4mm; Δz_{zoom}≤ 3GHz -≤ 5 mm, 3-4 GHz-≤ 4mm and 4-6GHz-≤ 2mm where the robot additionally moves the probe along the z-axis away from the bottom of the Phantom. DASY is also able to perform repeated zoom scans if more than 1 peak is found during area scan. In this document, the evaluated peak 1g and 10g averaged SAR values are shown in the 2D-graphics in Appendix B. Test results relevant for the specified standard (see chapter 1.4.) are shown in table form in chapter 7.2.

A Z-axis scan measures the total SAR value at the x-and y-position of the maximum SAR value found during the cube scan. The probe is moved away in z-direction from the bottom of the SAM phantom in 2 mm steps. This measurement shows the continuity of the liquid and can - depending in the field strength – also show the liquid depth.

The following table summarizes the area scan and zoom scan resolutions per FCC KDB 865664D01:

Frequency	Maximun Area Scan resolution (Δx_{area}, Δy_{area})	Maximun Zoom Scan spatial resolution (Δx_{Zoom}, Δy_{Zoom})	Maximun Zoom Scan spatial resolution			Minimum zoom scan volume (x,y,z)
			Uniform Grid	Graded Grad		
			$\Delta z_{Zoom}(n)$	$\Delta z_{Zoom}(1)$*	$\Delta z_{Zoom}(n>1)$*	
≤2GHz	≤15mm	≤8mm	≤5mm	≤4mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥30mm
2-3GHz	≤12mm	≤5mm	≤5mm	≤4mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥30mm
3-4GHz	≤12mm	≤5mm	≤4mm	≤3mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥28mm
4-5GHz	≤10mm	≤4mm	≤3mm	≤2.5mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥25mm
5-6GHz	≤10mm	≤4mm	≤2mm	≤2mm	≤1.5*$\Delta z_{Zoom}(n-1)$	≥22mm

3.2.5 SPATIAL PEAK SAR EVALUATION

The spatial peak SAR - value for 1 and 10 g is evaluated after the Cube measurements have been done. The basis of the evaluation are the SAR values measured at the points of the fine cube grid consisting of 5 x 5 x 7 points (with 8mm horizontal resolution) or 7 x 7 x 7 points (with 5mm horizontal resolution) or 8 x 8 x 7 points (with 4mm horizontal resolution). The algorithm that finds the maximal averaged volume is separated into three different stages.

- The data between the dipole center of the probe and the surface of the phantom are extrapolated. This data cannot be measured since the center of the dipole is 2.7 mm away from the tip of the probe and the distance between the surface and the lowest measuring point is about 1 mm (see probe calibration sheet). The extrapolated data from a cube measurement can be visualized by selecting “Graph Evaluated”.
- The maximum interpolated value is searched with a straight-forward algorithm. Around this maximum the SAR - values averaged over the spatial volumes (1g or 10 g) are computed using the 3d-spline interpolation algorithm. If the volume cannot be evaluated (i.e., if a part of the grid was cut off by the boundary of the measurement area) the evaluation will be started on the corners of the bottom plane of the cube.
- All neighboring volumes are evaluated until no neighboring volume with a higher average value is found.

Extrapolation

The extrapolation is based on a least square algorithm [W. Gander, Computer mathematic, p.168-180]. Through the points in the first 3 cm along the z-axis, polynomials of order four are calculated. These polynomials are then used to evaluate the points between the surface and the probe tip. The points, calculated from the surface, have a distance of 1 mm from each other.

Interpolation

The interpolation of the points is done with a 3d-Spline. The 3d-Spline is composed of three one-dimensional splines with the "Not a knot"-condition [W. Gander, Computer mathematic, p.141-150] (x, y and z -direction) [Numerical Recipes in C, Second Edition, p.123ff].

Volume Averaging

At First the size of the cube is calculated. Then the volume is integrated with the trapezoidal algorithm. 8000 points (20x20x20) are interpolated to calculate the average.

Advanced Extrapolation

DASY5 uses the advanced extrapolation option which is able to compensate boundary effects on E-field probes.

3.2.6 DATA STORAGE AND EVALUATION

3.2.6.1 Data Storage

The DASY5 software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for the data evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension “DAE”. The software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be re-evaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [mW/g], [mW/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show meaningless results, e.g., a SAR output in a lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

3.2.7 DATA EVALUATION BY SEMCAD

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

Probe parameters:	Sensitivity	Normi, a_{i0}, a_{i1}, a_{i2}
	Conversion factor	$ConvF_i$
	Diode compression point	Dcp_i
Device parameters:	Frequency	f
	Crest factor	cf
Media parameters:	Conductivity	
	Density	

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY5 components. In the direct measuring mode of the multi meter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics.

If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot cf / dcp_i$$

With	V_i = compensated signal of channel i	(i = x, y, z)
	U_i = input signal of channel i	(i = x, y, z)
	cf = crest factor of exciting field	(DASY parameter)
	dcp_i = diode compression point	(DASY parameter)

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

E-field probes: $E_i = (V_i \ / \ Norm_i \cdot ConvF \ )^{1/2}$

H-field probes: $H_i = (V_i \ )^{1/2} \cdot (a_{i0} + a_{i1} f + a_{i2} f^2 \ ) / f$

With V_i = compensated signal of channel i (i = x, y, z)

$Norm_i$ = sensor sensitivity of channel i (i = x, y, z)

$[mV/(V/m)^2]$ for E-field Probes

ConvF = sensitivity enhancement in solution

aij = sensor sensitivity factors for H-field probes

f = carrier frequency [GHz]

E_i = electric field strength of channel i in V/m

H_i = magnetic field strength of channel i in A/m

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

$$E_{tot} = (E_X^2 + E_Y^2 + E_Z^2)^{1/2}$$

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

$$SAR = (E_{tot})^2 \cdot \sigma / (\rho \cdot 1000)$$

With SAR = local specific absorption rate in mW/g

E_{tot} = total field strength in V/m

= conductivity in [mho/m] or [Siemens/m]

= equivalent tissue density in g/cm^3

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid. The power flow density is calculated assuming the excitation field to be a free space field.

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

With P_{pwe} = equivalent power density of a plane wave in mW/cm^2

E_{tot} = total field strength in V/m

H_{tot} = total magnetic field strength in A/m

4. SYSTEM VERIFICATION PROCEDURE

4.1 TISSUE VERIFICATION

The simulating liquids should be checked at the beginning of a series of SAR measurements to determine of the dielectic parameter are within the tolerances of the specified target values. The measured conductivity and relative permittivity should be within ± 5% of the target values.

The following materials are used for producing the tissue-equivalent materials.

Tissue Type	Bactericide	DGBE	HEC	NaCl	Sucrose	Triton X-100	Water	Diethylene Glycol Mono-hexylether
Head 5G	-	-	-	-	-	17.2	65.5	17.3

Salt: 99+% Pure Sodium Chloride; Sugar: 98+% Pure Sucrose; Water: De-ionized, 16M + resistivity
HEC: Hydroxyethyl Cellulose; DGBE: 99+% Di(ethylene glycol) butyl ether,[2-(2-butoxyethoxy)ethanol]
Triton X-100(ultra pure): Polyethylene glycol mono [4-(1,1,3,3-tetramethylbutyl)phenyl]ether

Tissue Verification									
Tissue Type	Frequency (MHz)	Liquid Temp. (℃)	Conductivity (σ)	Permittivity (εr)	Targeted Conductivity (σ)	Targeted Permittivity (εr)	Deviation Conductivity (σ) (%)	Deviation Permittivity (εr) (%)	Date
Head	5800	22.5	5.346	34.129	5.27	35.3	1.44	-3.32	Dec. 15, 2023

Note:
1)The dielectric parameters of the tissue-equivalent liquid should be measured under similar ambient conditions and within 2 °C of the conditions expected during the SAR evaluation to satisfy protocol requirements.
2)KDB 865664 was ensured to be applied for probe calibration frequencies greater than or equal to 50MHz of the EUT frequencies.
3)The above measured tissue parameters were used in the DASY software to perform interpolation via the DASY software to determine actual dielectric parameters at the test frequencies. The SAR test plots may slightly differ from the table above since the DASY rounds to three significant digits.

4.2 SYSTEM CHECK

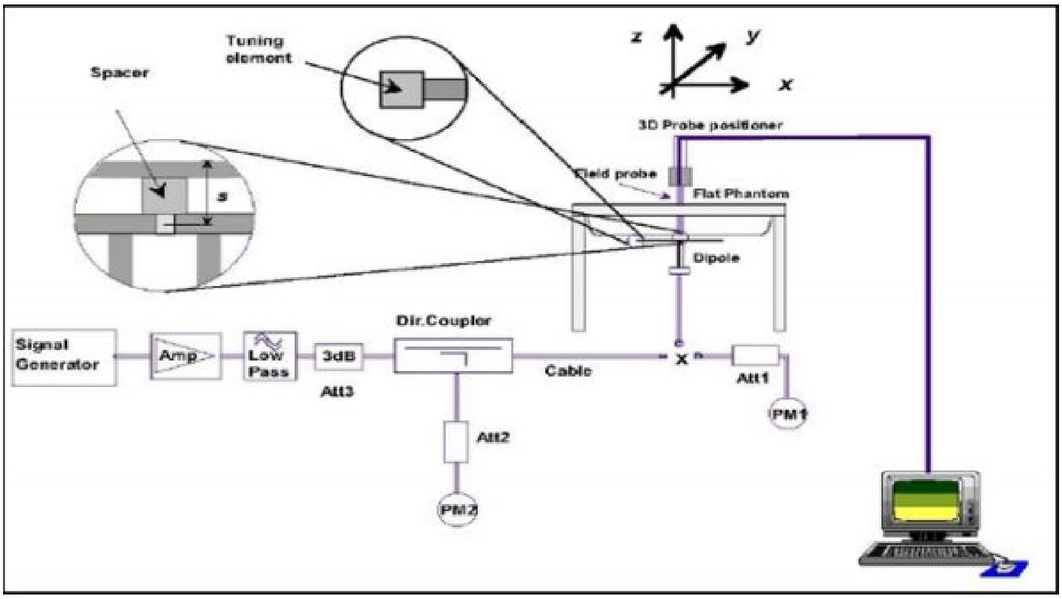
The system check is performed for verifying the accuracy of the complete measurement system and performance of the software. The system check is performed with tissue equivalent material according to IEEE P1528 (described above). The following table shows system check results for all frequency bands and tissue liquids used during the tests.

System Check	Date	Frequency (MHz)	Targeted SAR 1g (W/kg)	Measured SAR 1g (W/kg)	normalized SAR 1g (W/kg)	Deviation (%)	Dipole S/N
Head	Dec. 15, 2023	5800	78.60	7.84	78.40	-0.25	1160

4.3 SYSTEM CHECK PROCEDURE

The system check is performed by using a system check dipole which is positioned parallel to the planar part of the SAM phantom at the reference point. The distance of the dipole to the SAM phantom is determined by a plexiglass spacer. The dipole is connected to the signal source consisting of signal generator and amplifier via a directional coupler, N-connector cable and adaption to SMA. It is fed with a power of 250mW (below 3GHz) or 100mW (3-6GHz). To adjust this power a power meter is used.
The power sensor is connected to the cable before the system check to measure the power at this point and do adjustments at the signal generator. At the outputs of the directional coupler both return loss as well as forward power are controlled during the system check to make sure that emitted power at the dipole is kept constant. This can also be checked by the power drift measurement after the test.

System check results have to be equal or near the values determined during dipole calibration (target SAR in table above) with the relevant liquids and test system (±10 %).



5. SAR MEASUREMENT VARIABILITY AND UNCERTAINTY

5.1 SAR MEASUREMENT VARIABILITY

Per KDB865664 D01 SAR measurement 100 MHz to 6 GHz, 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. The additional measurements are repeated after the completion of all measurements requiring the same head or body tissue-equivalent medium in a frequency band. The test device should be returned to ambient conditions (normal room temperature) with the battery fully charged before it is re-mounted on the device holder for the repeated measurement(s) to minimize any unexpected variations in the repeated results.

1) Repeated measurement is not required when the original highest measured SAR is < 0.80 W/kg; steps 2) through 4) do not apply.
2) When the original highest measured SAR is ≥ 0.80 W/kg, repeat that measurement once.
3) Perform a second repeated measurement only if the ratio of largest to smallest SAR for the original and first repeated measurements is > 1.20 or when the original or repeated measurement is ≥ 1.45 W/kg (~ 10% from the 1-g SAR limit).
4) Perform a third repeated measurement only if the original, first or second repeated measurement is ≥ 1.5 W/kg and the ratio of largest to smallest SAR for the original, first and second repeated measurements is > 1.20.

The same procedures should be adapted for measurements according to extremity and occupational exposure limits by applying a factor of 2.5 for extremity exposure and a factor of 5 for occupational exposure to the corresponding SAR thresholds.

The detailed repeated measurement results are shown in Section 7.2.

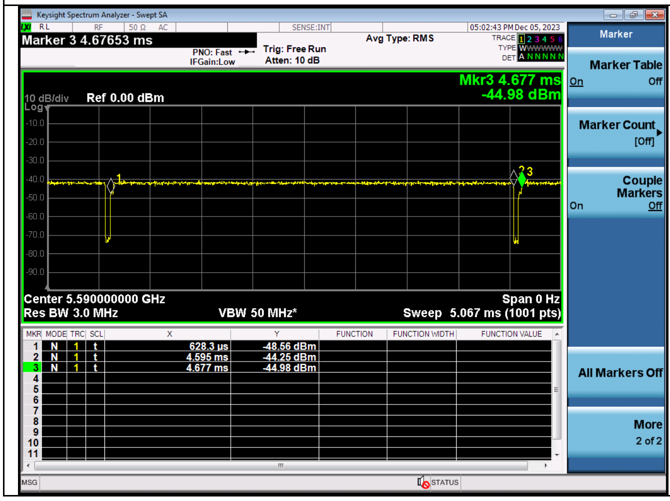
6. OPERATIONAL CONDITIONS DURING TEST

6.1 SAR TEST CONFIGURATION

6.1.1 WIFI TEST CONFIGURATION

For WLAN SAR testing, WLAN engineering testing software installed on the DUT can provide continuous transmitting RF signal.

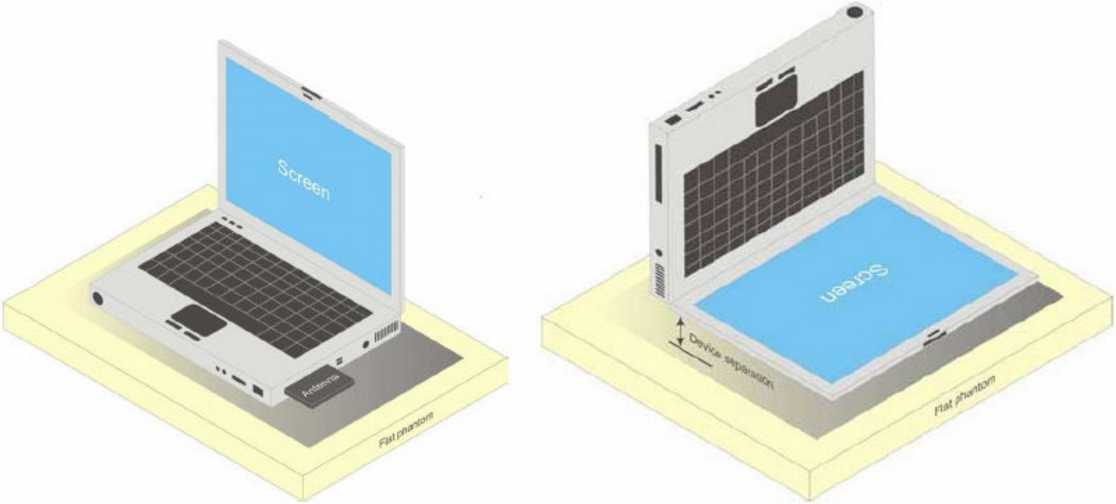
For WiFi SAR testing, a communication link is set up with the test mode software for WiFi mode test. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. The test procedures in KDB 248227 D01 are applied.

Duty Cycle
WiFi 5G
97.97%


6.2 TEST POSITION

6.2.1 NOTEBOOK MODE

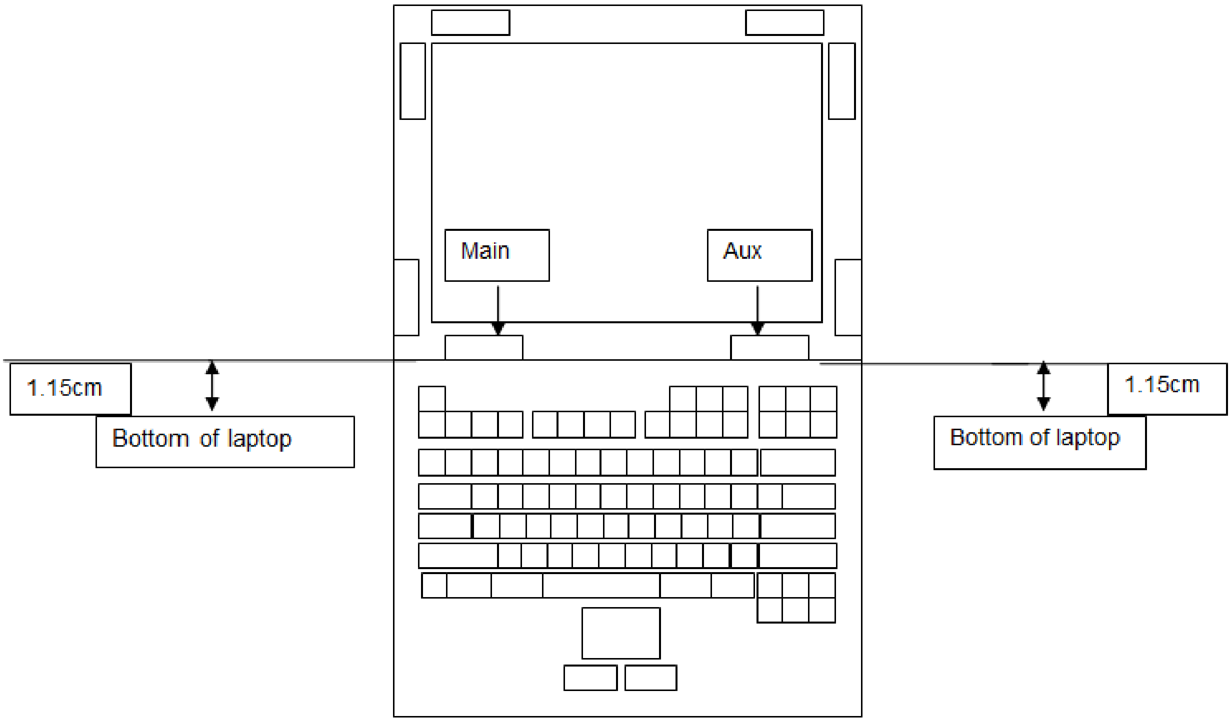
This DUT was tested in 2 different positions. They are back of keyboard and back of screen as illustrated below:



a) Portable computer with back of keyboard and back of screen.

When antennas are incorporated in the keyboard section of a laptop computer, SAR is required for the bottom surface of the keyboard. Provided tablet use conditions are not supported by the laptop computer, SAR tests for bystander exposure from the edges of the keyboard and display screen of laptop computers are generally not required. However, when edge testing is necessary, the similar concerns for simultaneous transmission on adjacent or multiple edges described for tablets near the end of 4.3 also apply.
When the modular approach is applied, transmitters and modules must be tested initially without using a representative host for incorporation in the display and/or keyboard of qualified laptop computers for standalone use according to the following minimum test separation distance and antenna installation requirements. The separation distance required for incorporation in qualified hosts is described in KDB Publication 447498 D04; item e) of 4.1 and item a) of 5.2.2 etc.
a) ≤ 25 mm between the antenna and user for incorporation in laptop display screens15
b) ≤ 5 mm between the antenna and user; only when incorporation in the keyboard compartment is required by the hosts, for bottom surface and edge exposure conditions
c) the antennas used by the host must have been tested for equipment approval or qualify for SAR test exclusion
d) the antenna polarization, physical orientation, rotation and installation configurations used by the host must have been tested for compliance for the required display and/or keyboard installation conditions and test separation distance(s) or qualify for SAR test exclusion
e) when the SAR Test Exclusion Threshold in KDB Publication 447498 D04 applies, a minimum test separation distance of 25 mm is required to determine test exclusion for the display, and 5 mm for the keyboard compartment.

The location of the antenna for notebook mode is as below:



The SAR measurement positions of each band are as below:

Antenna	Back of Keyboard	Back of Screen
Main Ant	Yes	Yes
Aux Ant	Yes	Yes

Note: According to the antenna location shown as above, particular DUT edges were not required to be evaluated for SAR if the antenna-to-edge distance is greater than 50mm.

7. TEST RESULT

7.1 CONDUCTED POWER RESULTS

1. Conducted power measurements of WiFi 5.9G

Band	Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Max. Tune up	Average Power(dBm)
5.9G WIFI _1TX _Main Ant	802.11a	169	5845	6	19.00	No Require
		173	5865		19.00	
		177	5885		19.00	
	802.11n HT20	169	5845	HT0	19.00	
		173	5865		19.00	
		177	5885		19.00	
	802.11n HT40	167	5835	HT0	19.00	
		175	5875		19.00	
	802.11ac VHT80	171	5855	VHT0	19.00	
	802.11ac VHT160	163	5815	VHT0	19.00	
	802.11ax HE20	169	5845	HE0	19.00	
		173	5865		19.00	
		177	5885		18.50	
	802.11be EHT20	169	5845	EHT0	19.00	
		173	5865		19.00	
		177	5885		18.50	
	802.11ax HE40	167	5835	HE0	19.50	**18.91**
		175	5875		19.50	**19.34**
	802.11be EHT40	167	5835	EHT0	19.00	No Require
		175	5875		19.00	
	802.11ax HE80	171	5855	HE0	19.00	
	802.11be EHT80	171	5855	EHT0	19.00	
	802.11ax HE160	163	5815	HE0	18.50	
	802.11be EHT160	163	5815	EHT0	18.50	

Band	Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	Max. Tune up	Average Power(dBm)
5.9G WIFI _1TX _Aux Ant	802.11a	169	5845	6	16.00	No Require
		173	5865		16.00	
		177	5885		16.00	
	802.11n HT20	169	5845	HT0	16.00	
		173	5865		16.00	
		177	5885		16.00	
	802.11n HT40	167	5835	HT0	16.00	
		175	5875		16.00	
	802.11ac VHT80	171	5855	VHT0	16.00	
	802.11ac VHT160	163	5815	VHT0	16.00	
	802.11ax HE20	169	5845	HE0	16.00	
		173	5865		16.00	
		177	5885		16.00	
	802.11be EHT20	169	5845	EHT0	16.00	
		173	5865		16.00	
		177	5885		16.00	
	802.11ax HE40	167	5835	HE0	16.50	**15.79**
		175	5875		16.50	**16.02**
	802.11be EHT40	167	5835	EHT0	16.00	No Require
		175	5875		16.00	
	802.11ax HE80	171	5855	HE0	16.00	
	802.11be EHT80	171	5855	EHT0	16.00	
	802.11ax HE160	163	5815	HE0	16.00	
	802.11be EHT160	163	5815	EHT0	16.00	

Band	Mode	Channel	Frequency (MHz)	Data Rate (Mbps)	ANT Main Average Power (dBm)	ANT Aux Average Power (dBm)	Max. Tune up	Total Average Power (dBm)
5.9G WIFI _2TX _Main Ant + Aux Ant	802.11n HT20	169	5845	HT8	-	-	19.50	No Require
		173	5865		-	-	19.50	
		177	5885		-	-	19.50	
	802.11n HT40	167	5835	HT8	16.29	16.61	20.00	19.46
		175	5875		16.28	16.53	20.00	19.42
	802.11ac VHT80	171	5855	VHT8	16.10	16.71	20.00	19.43
	802.11ac VHT160	163	5815	VHT8	15.44	16.58	20.00	19.06
	802.11ax HE20	169	5845	HE8	-	-	19.50	No Require
		173	5865		-	-	19.50	
		177	5885		-	-	19.00	
	802.11be EHT20	169	5845	EHT8	-	-	19.50	
		173	5865		-	-	19.50	
		177	5885		-	-	19.00	
	802.11ax HE40	167	5835	HE8	16.78	16.73	20.00	19.77
		175	5875		16.59	16.17	20.00	19.40
	802.11be EHT40	167	5835	EHT8	15.76	16.86	20.00	19.36
		175	5875		16.69	16.22	20.00	19.47
	802.11ax HE80	171	5855	HE8	16.75	16.12	20.00	19.46
	802.11be EHT80	171	5855	EHT8	16.71	16.49	20.00	19.61
	802.11ax HE160	163	5815	HE8	-	-	19.50	No Require
	802.11be EHT160	163	5815	EHT8	-	-	19.50	

Note:
1) The Average conducted power of WiFi 5.9G is measured with RMS detector.
2) The tested channel results are marks in bold.

7.2 SAR TEST RESULTS

General Notes:
1) Per KDB447498 D04, all measurement SAR results are scaled to the maximum tune-up tolerance limit to demonstrate compliant.
2) Per KDB447498 D04, testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is: ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz. When the maximum output power variation across the required test channels is > ½ dB, instead of the middle channel, the highest output power channel must be used.
3) Per KDB865664 D01, for each frequency band, repeated SAR measurement is required only when the measured SAR is ≥ 0.8W/kg; if the deviation among the repeated measurement is ≤ 20%, and the measured SAR < 1.45W/kg, only one repeated measurement is required.
4) Per KDB941225 D06, the DUT Dimension is bigger than 9 cm x 5 cm, so 10mm is chosen as the test separation distance for Hotspot mode. When the antenna-to-edge distance is greater than 2.5cm, such position does not need to be tested.
5) Per KDB648474 D04, SAR is evaluated without a headset connected to the device. When the standalone reported body-worn SAR is ≤ 1.2 W/kg, no additional SAR evaluations using a headset are required.
6) Per KDB865664 D02, SAR plot is only required for the highest measured SAR in each exposure configuration, wireless mode and frequency band combination; Plots are also required when the measured SAR is > 1.5 W/kg, or > 7.0 W/kg for occupational exposure. The published RF exposure KDB procedures may require additional plots; for example, to support SAR to peak location separation ratio test exclusion and/or volume scan post-processing.

WLAN Notes:
1. For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all positions in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position. When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurement is not required for the other (remaining) test positions. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2. Justification for test configurations for WLAN per KDB Publication 248227 for 5GHZ WIFI single transmission chain operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed power. Other transmission modes were not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2W/kg. See Section 7.1 for more information.

7.2.1 SAR MEASUREMENT RESULT

1. SAR test results of WiFi 5.9G

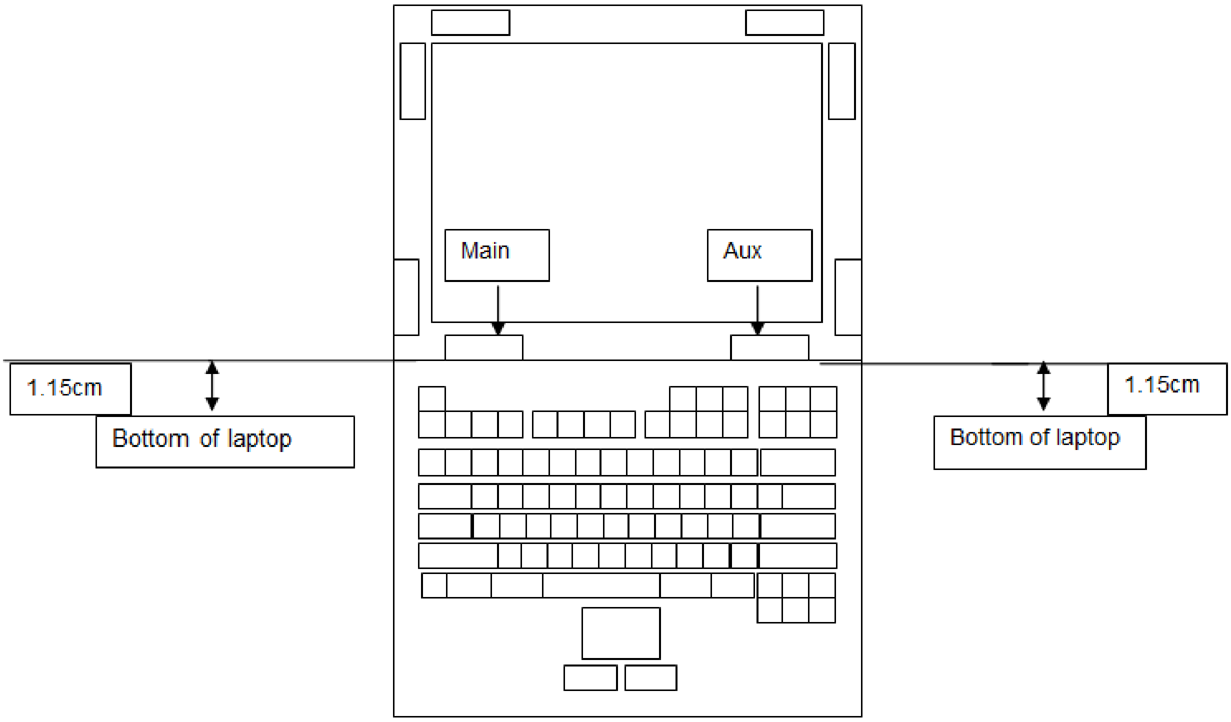
Test No.	Band	Channel	Test Position	Separation Distance (cm)	Ant	MB	Data Rate	Duty Cycle (%)	Maximum Tune-up (dBm)	Conducted Power (dBm)	Power Drift (dB)	SAR 1g (W/kg)	SAR 10g (W/kg)	Reported 1g SAR (W/kg)
W52	802.11ax HE40	167	Back of Screen	2.5	Main	MB1	HE0	97.97	19.50	18.91	0	0.101	0.044	0.118
W53	802.11ax HE40	167	Back of Keyboard	0	Main	MB1	HE0	97.97	19.50	18.91	0	0.545	0.204	0.637
W54	802.11ax HE40	175	Back of Keyboard	0	Main	MB1	HE0	97.97	19.50	19.34	0	0.642	0.220	0.680
W55	802.11ax HE40	175	Back of Keyboard	0	Main	MB2	HE0	97.97	19.50	19.34	0	**0.903**	**0.315**	**0.956**
W57	802.11ax HE40	167	Back of Screen	2.5	Aux	MB1	HE0	97.97	16.50	15.79	0	0.050	0.027	0.060
W58	802.11ax HE40	167	Back of Keyboard	0	Aux	MB1	HE0	97.97	16.50	15.79	0	0.408	0.145	0.490
W59	802.11ax HE40	175	Back of Keyboard	0	Aux	MB1	HE0	97.97	16.50	16.02	0	0.487	0.182	0.555
W60	802.11ax HE40	175	Back of Keyboard	0	Aux	MB2	HE0	97.97	16.50	16.02	-0.07	**0.501**	**0.181**	**0.571**

Note: The value with boldface is the maximum SAR Value of each test band.

7.3 MULTIPLE TRANSMITTER EVALUATION

The following tables list information which is relevant for the decision if a simultaneous transmit evaluation is necessary according to FCC KDB447498 D04 Interim General RF Exposure Guidance v01.

The location of the antennas inside the EUT is shown as below picture:



7.3.1 SIMULTANEOUS TRANSMISSION CONDITIONS

Per FCC KDB447498 D04, SAR compliance for simultaneous transmission must be considered when the maximum duration of overlapping transmissions, including network hand-offs, is greater than 30 seconds. This device contains multiple transmitters that may operate simultaneously, and therefore requires a simultaneous transmission analysis.

The Simultaneous Transmission Possibilities of this device are as below:

No.	Configuration	Body
1	WLAN 5.9G Main Ant + WLAN 5.9G Aux Ant	Yes
2	BT Main Ant + WLAN 5.9G Aux Ant	Yes

Note: Only the Main Ant supports BT function.

7.3.2 SAR UMMATION SCENARIO

About WIFI and Bluetooth transmit simultaneously

Band \ Position		Back of Screen (2.5cm)	Back of Keyboard (0cm)
Main Ant	WiFi 5.9G	0.118	0.956
	BT	0.000	0.032
Aux Ant	WiFi 5.9G	0.060	0.571
MAX $\sum SAR_{1g}$		0.178	1.527

Note:
1) The data of Bluetooth refer to report: BTL-FCC SAR-1-2309C132.
2) Thus $SAR_{MAX.total}$=1.527 W/kg < 1.6 W/kg, so Simultaneous SAR are not required for Main Ant and Aux Ant.

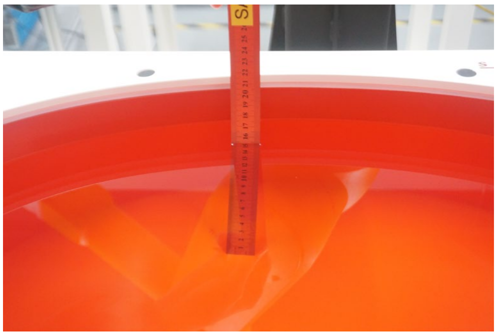
APPENDIX

1. TEST LAYOUT

Specific Absorption Rate Test Layout

Liquid depth in the flat Phantom (≥15cm depth)

HSL_4500MHz-6000MHz_Body_15.4cm



Appendix A. SAR Plots of System Verification

(Pls See BTL-FCC SAR-2-2309C132_Appendix A.)

Appendix B. SAR Plots of SAR Measurement

(Pls See BTL-FCC SAR-2-2309C132_Appendix B.)

Appendix C. Calibration Certificate

(Pls See BTL-FCC SAR-2-2309C132_Appendix C.)

Appendix D. Photographs of the Test Set-Up

(Pls See BTL-FCC SAR-2-2309C132_Appendix D.)

End of Test Report