SAR Evaluation Report

DUT Information	
Manufacturer	Wöhler Messgeräte Kehrgeräte GmbH
Model Name	802.11 b/g/n Module inside portable host with HMN: VIS 500
FCC ID	2ANWR-WMOD200
IC Number	23256-WMOD200
DUT Type	handheld device
Intended Use	☒ < 20 cm to human body (portable device) ☐ > 20 cm to human body (mobile/fixed device) ☐ - ☐ next to the ear ☐ body-worn ☐ limb-worn ☒ hand-held ☐ front-of-face ☒ body supported ☐ clothing-integrated
Prepared by	
Testing Laboratory	IMST GmbH, Test Center Carl-Friedrich-Gauß-Str. 2 – 4 47475 Kamp-Lintfort Germany
Laboratory Accreditation	The Test Center facility 'Dosimetric Test Lab' within IMST GmbH is accredited by the German National 'Deutsche Akkreditierungsstelle GmbH (DAkkS)' for testing according to the scope as listed in the accreditation certificate: D-PL-12139-01-01. The German Bundesnetzagentur (BNetzA) recognizes IMST GmbH as CAB-EMC on the basis of the Council Decision of 22. June 1998 concerning the conclusion of the MRA between the European Community and the United States of America (1999/178/EC) in accordance with § 4 of the Recognition Ordinance of 11. January 2016. The recognition is valid until 20. July 2026 under the registration number: BNetzA-CAB-16/21-14/1.
Prepared for	
Applicant	Phoenix Testlab GmbH Koenigswinkel 10 32825 Blomberg Germany
Test Specification	
Applied Standard / Rule	FCC CFR 47 § 2.1093; IEC/IEEE 62209-1528; RSS-102 Issue 5
Exposure Category	☒ general public / uncontrolled exposure ☐ occupational / controlled exposure
Test Result	☒ PASS ☐ FAIL
Report Information	
Data Stored	6210722
Issue Date	March 14, 2022
Revision Date	
Revision Number*	
	***A new revision replaces all previous revisions and thus, become invalid herewith.**
Remarks	This report relates only to the item(s) evaluated. This report shall not be reproduced, except in its entirety, without the prior written approval of IMST GmbH. The results and statements contained in this report reflect the evaluation for the certain model described above. The manufacturer is responsible for ensuring that all production devices meet the intent of the requirements described in this report.

Table of Contents

1 Subject of Investigation and Test Results

The product 802.11 b/g/n Module inside portable host with HMN: VIS 500 is manufactured by Wöhler Messgeräte Kehrgeräte GmbH operating in IEEE 802.11 b/g/n (WLAN 2.4GHz) standard. The device has one integrated antenna.

The objective of the measurements performed by IMST is the dosimetric assessment of WLAN 2.4GHz on one device in the intended use positions.

1.1 Technical Data of DUT

Product Specifications		
Manufacturer	Wöhler Messgeräte Kehrgeräte GmbH	
Model Name	802.11 b/g/n Module inside portable host with HMN: VIS 500	
Operation Mode	IEEE 802.11 b/g/n (WLAN 2.4GHz)	
Frequency Range	2412 – 2462 MHz	
Maximum Duty Cycle	100 %	
Antenna Type	integrated (WLAN)	
Maximum Output Power	refer chapter 7.3	
Power Supply	internal LiPo battery DC 3.8V	
Available Accessories	-	
DUT Stage	☒ production unit	☐ identical prototype
Notes:		

1.2 Antenna Configuration

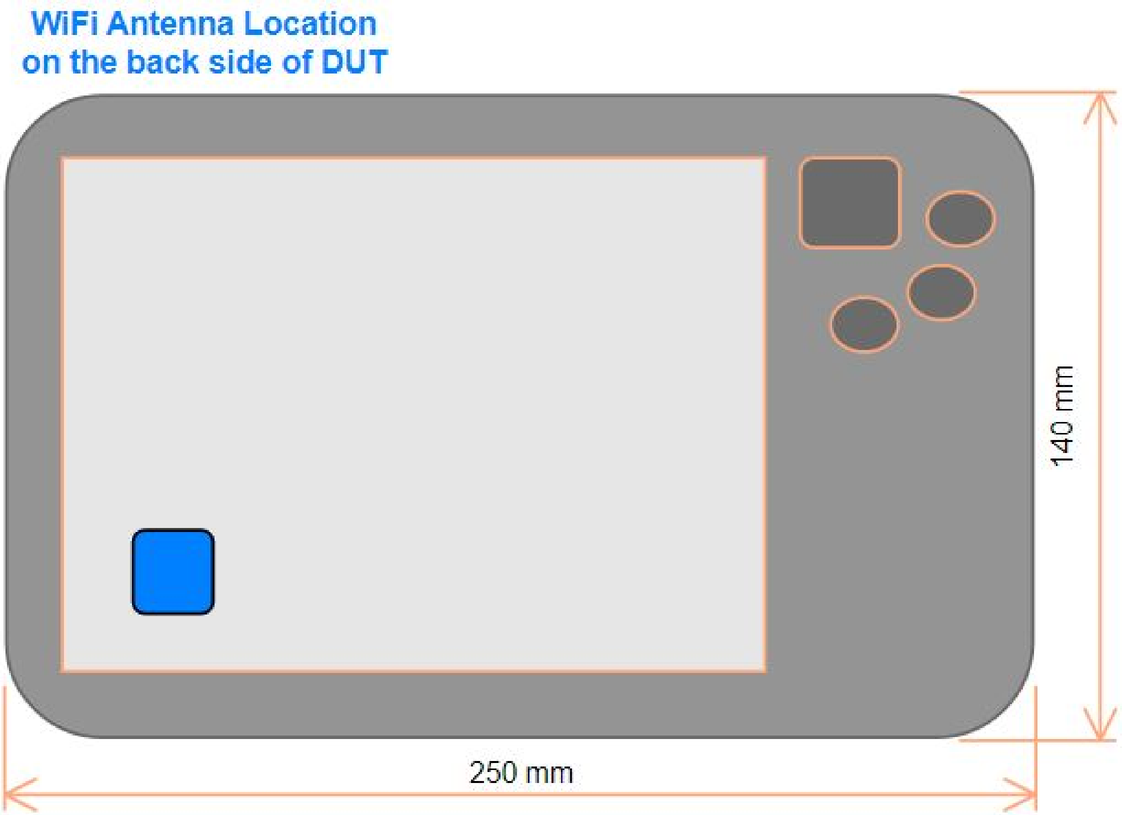

Fig. 1: Sketch of DUT and antenna location – antenna positioned on the back side of DUT.

1.3 Test Specification / Normative References

The tests documented in this report have been performed according to the standards and rules described below.

Test Specifications			
	Test Standard / Rule	**Description**	**Issue Date**
☒	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 (4 MHz to 10 GHz)	October, 2020
☐	FCC CFR 47 § 2.1091	Code of Federal Regulations; Title 47. Radiofrequency radiation exposure evaluation: **Mobile Devices.**	October 01, 2010
☒	FCC CFR 47 § 2.1093	Code of Federal Regulations; Title 47. Radiofrequency radiation exposure evaluation: **Portable Devices.**	October 01, 2010
☒	RSS-102, Issue 5	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)	March, 2015
Measurement Methodology KDB			
☒	KDB 865664 D01 v01r04	SAR measurement 100 MHz to 6 GHz	August 07, 2015
☒	KDB 865664 D02 v01r01	Exposure Reporting	October 23, 2015
Product KDB			
☒	KDB 447498 D01 v06	General RF Exposure Guidance	October 23, 2015
☒	KDB 648474 D04 v01r03	Handset SAR	October 23, 2015
Technology KDB			
☒	KDB 248227 D01 v02r02	802.11 Wi-Fi SAR	October 23, 2015

1.4 Attestation of Test Results

Highest Reported SAR1g [W/kg]				
Exposure Configuration		**Equipment Class** **DTS (IEEE 802.11)**	**Limit SAR_{1g}**	**Verdict**
Standalone TX	Body	0.371	1.6	PASS
Highest Reported SAR10g [W/kg]				
Exposure Configuration		**Equipment Class** **DTS (IEEE 802.11)**	**Limit SAR_{10g}**	**Verdict**
Standalone TX	Extremity	0.203	4.0	PASS
Notes: To establish a connection at a specific channel and with maximum output power, engineering test software has been used. All measured SAR results and configurations are shown in chapter 7.3 on page 16.				

2 Quality Assurance

The responsible test engineer states that all the measurements and evaluations have been performed under the guidelines of the valid quality assurance plan according to EN ISO IEC 17025-2017.

Prepared by: .... Reviewed by: ....

Alexander Rahn
Test Engineer

Jens Lerner
Quality Assurance

3 Exposure Criteria and Limits

3.1 SAR Limits

Human Exposure Limits				
Condition	**Uncontrolled Environment** (General Population)		**Controlled Environment** (Occupational)	
	SAR Limit [W/kg]	**Mass Avg.**	**SAR Limit [W/kg]**	**Mass Avg.**
SAR averaged over the whole body mass	0.08	whole body	0.4	whole body
Peak spatially-averaged SAR for the head, neck & trunk	1.6	1g of tissue*	8.0	1g of tissue*
Peak spatially-averaged SAR in the limbs	4.0	10g of tissue*	20.0	10g of tissue*
Note: *Defined as a tissue volume in the shape of a cube				

Table 1: SAR limits specified in IEEE Standard C95.1-2005 and Health Canada's Safety Code 6.

In this report the comparison between the exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

3.2 Exposure Categories

General Public / Uncontrolled Exposure
General population comprises individuals of all ages and of varying health status, and may include particularly susceptible groups or individuals. In many cases, members of the public are unaware of their exposure to electromagnetic fields. Moreover, individual members of the public cannot reasonably be expected to take precautions to minimize or avoid exposure.
Occupational / Controlled Exposure
The occupationally exposed population consists of adults who are generally exposed under known conditions and are trained to be aware of potential risk and to take appropriate precautions.

Table 2: RF exposure categories.

3.3 Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength *E* inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E^2}{\rho} = c \left. \frac{\partial T}{\partial t} \right|_{t \to 0+} \quad . \tag{1}$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity *c* of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric *E* and magnetic field strength *H* and power density *S*, derived from the SAR limits. The limits for *E*, *H* and *S* have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

4 The Measurement System

DASY is an abbreviation of „Dosimetric Assessment System“ and describes a system that is able to determine the SAR distribution inside a phantom of a human being according to different standards. The DASY4 system consists of the following items as shown in Fig: 2. Additionally, Fig: 3 shows the equipment, similar to the installations in other laboratories.

- Fully compliant with all current measurement standards as stated in Fig. 4
- High precision robot with controller
- Measurement server (for surveillance of the robot operation and signal filtering)
- Data acquisition electronics DAE (for signal amplification and filtering)
- Field probes calibrated for use in liquids
- Electro-optical converter EOC (conversion from the optical into a digital signal)
- Light beam (improving of the absolute probe positioning accuracy)
- Two SAM phantoms filled with tissue simulating liquid
- DASY4 software
- SEMCAD

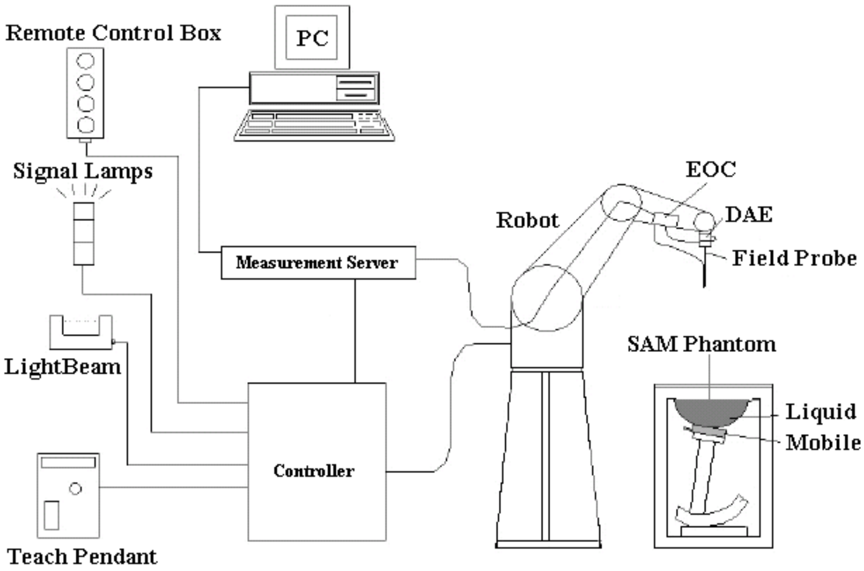

Fig. 2: The DASY4 measurement system.

Fig. 3: The measurement set-up with a DASY system and phantoms containing tissue simulating liquid.

The DUT operating at the maximum power level is placed by a non-metallic device holder (delivered from Schmid & Partner) in the above described positions at a shell phantom of a human being. The distribution of the electric field strength *E* is measured in the tissue simulating liquid within the shell phantom. For this miniaturised field probes with high sensitivity and low field disturbance are used. Afterwards the corresponding SAR values are calculated with the known electrical conductivity σ and the mass density ρ of the tissue in the SEMCAD FDTD software. The software is able to determine the averaged SAR values (averaging region 1 g or 10 g) for compliance testing.

The measurements are done by two scans: first a coarse scan determines the region of the maximum SAR, afterwards the averaged SAR is measured in a second scan within the shape of a cube.

4.1 Phantoms

TWIN SAM PHANTOM V4.0	
	Specific Anthropomorphic Mannequin delivered by Schmid & Partner Engineering AG. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. The details and the Certificate of conformity can be found in Fig. 5 on page 29.
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

ELI PHANTOM V4.0	
	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. The details and the Certificate of conformity can be found in Fig. 11 on page 30.
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 liters

4.2 E-Field-Probes

For the measurements the Dosimetric E-Field Probes ET3DV6R or EX3DV4 with following specifications are used. They are manufactured and calibrated in accordance with FCC and IEC/IEEE 62209-1528 recommendations annually by Schmid & Partner Engineering AG.

ET3DV6R	
Construction	Symmetrical design with triangular core Built-in optical fiber for surface detection system (ET3DV6 only) Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Dimensions	Overall length: 337 mm (Tip: 16 mm) Tip diameter: 6.8 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.7 mm
Frequency	10 MHz to 2.3 GHz Linearity: ± 0.2 dB (30 MHz to 2.3 GHz)
Directivity	Axial isotropy: ± 0.2 dB in TSL (rotation around probe axis) Spherical isotropy: ± 0.4 dB in TSL (rotation normal to probe axis)
Dynamic Range	5 µW/g to > 100 mW/g; Linearity: ± 0.2 dB
Calibration Range	450 MHz / 750 MHz / 835 MHz / 1750 MHz / 1900 MHz

EX3DV4	
Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
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
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	Axial isotropy: ± 0.3 dB in TSL (rotation around probe axis) Spherical isotropy: ± 0.5 dB in TSL (rotation normal to probe axis)
Dynamic Range	10 µW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 µW/g)
Calibration Range	2450 MHz / 2600 MHz / 5250 MHz / 5600 MHz / 5800 MHz

5 Measurement Procedure

5.1 General Requirement

The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity. All tests have been conducted according the latest version of all relevant KDBs.

5.2 Test Position of DUT operating next to the Human Body

Body-worn operating configurations are tested with available accessories applied on the device and positioned against a flat phantom in a normal use configuration. Per FCC KDB 648474, Body-worn accessory exposure is typically related to voice mode operations when handsets are carried in body-worn accessories. The body-worn accessory procedures in KDB 447498 should be used to test for body-worn accessory SAR compliance, without a headset connected to it. This enables the test results for such configuration to be compatible with that required for hotspot mode when the body worn accessory test separation distance is greater than or equal to that required for hotspot mode, when applicable. When the reported SAR for body worn accessory, measured without 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 that body worn accessory with a headset attached to the handset.

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body.

For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested.

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. Nevertheless, all accessories that contain metallic components must be tested for compliance additionally.

5.2.1 Test to be Performed

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel resp. that channel with the highest output power for each test configuration is < 0.4 W/kg, testing at the high and low channels is optional.

5.3 Measurement Procedure

The following steps are used for each test position:

- Establish a call with the maximum output power with a base station simulator. The connection between the mobile phone and the base station simulator is established via air interface.
- Measurement of the local E-field value at a fixed location (P1). This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with resolution settings for area scan and zoom scan according IEC/IEEE 6209-1528 as shown in Table *3*.
- The used extrapolation and interpolation routines are all based on the modified Quadratic Shepard´s method [DASY4].
- Repetition of the E-field measurement at the fixed location (P1) and repetition of the whole procedure if the two results differ by more than ± 0.21dB.

Area Scan		
Parameter	**f ≤ 3 GHz**	**3 GHz < f ≤ 10 GHz**
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	½·δ·ln(2) ± 0.5 mm
Maximum spacing between adjacent measured points in mm	20, or half of the corresponding zoom scan length, whichever is smaller	60/f, or half of the corresponding zoom scan length, whichever is smaller
Maximum angle between the probe axis and the phantom surface	5° ± 1° (flat phantom) 30° ± 1°(other phantoms)	5° ± 1° (flat phantom) 20° ± 1°(other phantoms)
Zoom Scan		
Maximum distance between the closest measured points and the phantom surface	5 mm	½·δ ln(2) [a]
Maximum angle between the probe axis and the phantom surface	5° ± 1° (flat phantom) 30° ± 1°(other phantoms)	5° ± 1° (flat phantom) 20° ± 1°(other phantoms)
Maximum spacing between measured points in the x- and y-directions (Δx and Δy)	8 mm	24/f [b]
Uniform grid: ΔZ_1 Maximum spacing between measured points in the direction normal to the phantom shell	5 mm	10/(f − 1)
Minimum edge length of the zoom scan volume in the x- and y-directions (L_z in O.8.3.2)	30 mm	22 mm
Minimum edge length of the zoom scan volume in the direction normal to the phantom shell (L_h in O.8.3.2 in mm)	30 mm	22 mm
Note:	[a] δ is the penetration depth for a plane-wave incident normally on a planar half-space. [b] This is the maximum spacing allowed, which might not work for all circumstance	

Table 3: Parameters for SAR scan procedures.

5.4 Additional Information for IEEE 802.11 (WiFi) Transmitters

According to KDB 248227 D01, for both DSSS and OFDM wireless modes an initial test position must be established for each applicable exposure configuration using either:

- Design implementation defined by the manufacturer, or
- Investigative results by the test lab based on:
  - o Exclusions based on the distance from the antenna to the surface, or
  - o Highest measured SAR from the area-scan-only measurements on all applicable test positions at the Initial Test Configuration, if found to require SAR tests.

Then, the initial test position procedure defines the required complete SAR scan measurements on each exposure configuration as following:

- When the reported SAR of the initial test position is ≤ 0.4 W/kg, further SAR measurements is not required for the remaining test positions in that configuration as well as 802.11 transmission mode combinations within the frequency or aggregated band.
- When the reported SAR of the initial test position is > 0.4 W/kg, further SAR measurements is required in the initial test position or next closest/smallest test separation distance based on manufacturer justification, on the following highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions are tested.
- When the reported SAR for all initial and subsequent test positions is > 0.8 W/kg, further SAR measurements is required on these positions on the subsequent next highest measured output power channels, until the reported SAR is ≤ 1.2 W/kg or all required channels have been tested.

For OFDM transmission configurations in 2.4 GHz and 5 GHz bands, it is important to determine SAR Initial Test Configuration for each stand alone and aggregated frequency band according to the maximum output power and tune-up tolerance specified for production units. The procedure is as following:

- Highest output power channel is chosen; if there are channels with same maximum output power then the closest to the mid-band frequency is preferred. If there are more than one channel with same maximum output power and same distance to the mid-band frequency, then the channel with the higher frequency is preferred.
- When SAR measurement is required for a subsequent test configuration and the channel bandwidth is smaller than that in the initial test configuration, all channels in the subsequent test configuration that overlap with the larger bandwidth channel tested in the initial test configuration should be used to determine the highest maximum output power channel in the subsequent test configuration.

Along with the initial test position reduction guidelines, the following procedures are also applied to SAR measurement requirements when multiple OFDM configurations are supported:

- When the reported SAR of the initial test configuration with the highest output power channel is > 0.8 W/kg, further SAR measurements is required for next highest output power channel in the initial test configuration, until the reported SAR is ≤ 1.2 W/kg or all required channels have been tested.
- When the reported SAR of the subsequent test configuration with the highest output power channel is > 1.2 W/kg, further SAR measurements is required for next highest output power channel in this test configuration, until the reported SAR is ≤ 1.2 W/kg or all required channels have been tested.
- When the reported SAR of the subsequent test configuration is > 1.2 W/kg, further SAR measurements for the following subsequent test configurations are required.

6 System Verification and Test Conditions

6.1 Date of Testing

Date of Testing				
Band	Test Position	Frequency [MHz]	Date of System Check	Date of SAR Measurement
WiFi 2.4 GHz	Body / Extremity	2450	August 31, 2021	August 31, 2021

Table 4: Date of testing.

6.2 Environment Conditions

Environment Conditions		
Ambient Temperature[°C]	Liquid Temperature [°C]	Humidity [%]
22.0 ± 2	22.0 ± 2	40.0 ± 10
Notes: To comply with the required noise level (less than 12 mW/kg) periodically measurements without a DUT were conducted.		

Table 5: Environment Conditions.

6.3 Tissue Simulating Liquid Recipes

Tissue Simulating Liquid								
Frequency Range		Water	Tween 20	Tween 80	Salt	Preventol	DGME	Triton X/100
[MHz]		[%]	[%]	[%]	[%]	[%]	[%]	[%]
Head Tissue								
☐	450	50.8	47.5	-	1.6	0.1	-	-
☐	700 - 1000	52.8	46.0	-	1.1	0.1	-	-
☐	1600 - 1800	55.4	44.1	-	0.4	0.1	-	-
☐	1850 - 1980	55.2	44.5	-	0.2	0.1	-	-
☒	2000 - 2700	55.7	45.2	-	-	0.1	-	-
☐	5000 - 6000	65.5	-	-	-	-	17.25	17.25
Body Tissue								
☐	450	71.0	28.0	-	0.9	0.1	-	-
☐	700 - 1000	71.2	28.0	-	0.7	0.1	-	-
☐	1600 - 1800	71.4	28.0	-	0.5	0.1	-	-
☐	1850 - 1980	71.5	28.0	-	0.4	0.1	-	-
☐	2000 - 2700	71.6	28.0	-	0.3	0.1	-	-
☐	5000 - 6000	79.9	-	20.0	-	0.1	-	-

Table 6: Recipes of the tissue simulating liquid.

6.4 Tissue Simulating Liquid Parameters

For the measurement of the following parameters the Speag DAK-3.5 dielectric probe kit is used, representing the open-ended coaxial probe measurement procedure.

Recommended values for the dielectric parameters of the tissue simulating liquids are given in IEEE 1528 and FCC published RF Exposure KDB Procedures. All tests were carried out using liquids with dielectric parameters within +/- 5% of the recommended values. The dielectric properties of the tissue simulating liquid have been measured within 24 h before SAR testing. The depth of the tissue simulant was at least 15.0 cm for all system check and device tests, measured from the ear reference point in case of the SAM phantom and from the inner surface of the flat phantom.

Tissue Simulating Liquids Parameters									
Ambient Temperature(C) : 22.0 ± 2				Liquid Temperature(C) : 22.0 ± 2			Humidity(%) : 40.0 ± 5		
Band	Date	Frequency	Channel	Permittivity			Conductivity		
				Measured	Target	Delta	Measured	Target	Delta
		[MHz]		ε'	ε'	+/- 5 [%]	σ [S/m]	σ [S/m]	+/- 5 [%]
WiFi 2450 MHz	August 31, 2021	*2450*	*System Check*	40.0	39.2	2.0	1.84	1.80	2.4
		2412	*1*	40.1	39.3	2.1	1.79	1.76	1.6
		2437	6	40.0	39.2	2.0	1.83	1.79	2.2
		2462	11	39.9	39.2	1.9	1.86	1.81	2.7
Notes:									

Table 7: Parameters of the head tissue simulating liquid.

6.5 Simplified Performance Checking

The simplified performance check was realized using the dipole validation kit. The input power of the dipole antenna was 250 mW (CW) and it was placed under the flat part of the SAM phantom. The target and measured results are listed in the table 8 and shown in Appendix C - System Verification Plots.

The target values were adopted from the calibration certificates found also in the appendix.

System Check Results										
Frequency [MHz]	Dipole #SN	Measured				Target		Delta		Date
		with 250 mW		scaled to 1 W		normalized to 1 W		+/- 10 [%]		
		1g	10g	1g	10g	1g	10g	1g	10g	
2450	D2450V2 #709	13.90	6.43	55.60	25.72	53.50	25.00	3.93	2.88	August 31, 2021
Notes:										

Table 8: Dipole target and measured results.

7 SAR Measurement Conditions and Results

7.1 SAR Measurement Conditions

Test Conditions				
Band	**TX Range [MHz]**	**Used Channels**	**Crest Factor**	**Phantom**
WLAN 2.4 GHz	2412.0 – 2462.0	1, 6, 11	1	SAM Twin Phantom V4.0
Notes:				

Table 9: Used channels and crest factors during the test.

7.2 Tune-Up Information

Tune-Up Output Power			
Band	**Frequency [MHz]**	**CH**	**Max. Tune-Up Limit [dBm]**
WLAN 2.4	2412 - 2462	1 - 11	16.5
Notes:			

Table 10: Maximum transmitting output power values declared by the manufacturer.

7.3 Measured Output Power

7.3.1 WLAN 2.4 GHz Output Power

<table>
<tr><th colspan="11">Max. Averaged Output Power (RMS) [dBm]</th></tr>
<tr><th rowspan="2">2.4 GHz Range</th><th rowspan="3">Frequency [MHz]</th><th rowspan="3">CH</th><th colspan="8">SW PWL 16</th></tr>
<tr><th colspan="8">Data Rate [Mbit/s]</th></tr>
<tr><th>Mode</th><th colspan="2">1</th><th colspan="2">2</th><th colspan="2">5.5</th><th colspan="2">11</th></tr>
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<tr><td>2437</td><td>6</td><td colspan="2">15.0</td><td colspan="2">-</td><td colspan="2">-</td><td colspan="2">-</td></tr>
<tr><td>2462</td><td>11</td><td colspan="2">15.1</td><td colspan="2">14.1</td><td colspan="2">13.8</td><td colspan="2">13.8</td></tr>
<tr><th rowspan="3">Mode</th><th rowspan="3">Frequency [MHz]</th><th rowspan="3">CH</th><th colspan="8">SW PWL 19</th></tr>
<tr><th colspan="8">Data Rate [Mbit/s]</th></tr>
<tr><th>6.0</th><th>9</th><th>12</th><th>18</th><th>24</th><th>36</th><th>48</th><th>54</th></tr>
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<tr><th colspan="8">MCS Index No.</th></tr>
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HT20</td><td>2412</td><td>1</td><td>13.6</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2437</td><td>6</td><td>13.9</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2462</td><td>11</td><td>14.0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="11">Notes:</td></tr>
</table>

Table 11: Conducted output power values for WLAN 2.4 GHz.

7.4 Standalone SAR Test Exclusion according to KDB 447498

SAR test exclusion is determined for the DUT according to KDB 447498 D01 with 1g SAR exclusion thresholds for 100 MHz to 6GHz at test separation distances ≤ 50 mm determined by:

*[(max power of channel. incl. tune-up tolerance. mW) / (min test separation distance. mm)] * [√f(GHz)]*

≤ 3.0 for 1g SAR and ≤ 7.5 for 10g extremity SAR, where

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

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

Standalone SAR Test Exclusion Consideration for Body (FCC)												
Mode	Freq.	Distance	Output Power		Maximum Duty Cycle	Output Power (RMS)		Threshold Comparison Value	Exclusion Threshold SAR 1g	SAR Testing Exclusion	Estimated SAR Values	SAR Testing Required
	[MHz]	[mm]	[dBm]	[mW]	[%]	[dBm]	[mW]					
WLAN	2450	5	16.50	44.67	100.0	16.50	44.67	14.0	≤ 3.0	NO	measured	YES
Notes:												

Table 12: SAR test exclusion for the applicable transmitter according to KDB 447498.

Standalone SAR Test Exclusion Consideration for Extremity (FCC)												
Mode	Freq.	Distance	Output Power		Maximum Duty Cycle	Output Power (RMS)		Threshold Comparison Value	Exclusion Threshold SAR 10g	SAR Testing Exclusion	Estimated SAR Values	SAR Testing Required
	[MHz]	[mm]	[dBm]	[mW]	[%]	[dBm]	[mW]					
WLAN	2450	5	16.50	44.67	100.0	16.50	44.67	14.0	≤ 7.5	NO	measured	YES
Notes:												

Table 13: SAR test exclusion for the applicable transmitter according to KDB 447498.

When the standalone SAR test exclusion applies to an antenna that transmits simultaneously with other antennas the standalone SAR must be estimated according to KDB 447498 in order to determine simultaneous transmission SAR test exclusion:

- *(max. power of channel. including tune-up tolerance. mW)/(min. test separation distance. mm)]·[√f(GHz)/x] W/kg for test separation distances ≤ 50 mm;*

where x = 7.5 for 1-g SAR and x = 18.75 for 10-g SAR

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

- *0.4 W/kg for 1g SAR and 1.0 W/kg for 10g SAR. when the test separation distance is > 50 mm*

7.5 SAR Test Exclusion Consideration according to RSS-102

Standalone SAR Test Exclusion Consideration (ISED)													
Mode	Freq.	Distance	Output Power		Maximum Duty Cycle	Output Power (RMS)		Exemption Limit for SAR 1g [mW]		SAR Testing Exclusion		SAR Testing Required	
	[MHz]	[mm]	[dBm]	[mW]	[%]	[dBm]	[mW]	Body	Extr.	Body	Extr.	Body	Extr.
WLAN	2450	5	16.50	44.67	100.0	16.50	44.67	4.0	10.0	NO	NO	YES	YES
Notes: B – Body, Extr. - Extremity													

Table 14: SAR test exclusion for the applicable transmitter according to RSS-102, section 2.5.1.

7.6 SAR Measurement Results

SAR assessment was conducted in the worst case configuration with output power values according to the tables in Chapter 7.3. According to KDB 447498 D01, the reported SAR is the measured SAR value adjusted for maximum tune-up tolerance limit shown in Chapter 7.2.

Reported SAR is calculated by the following formulas:

- Scaling factor tune up limit = tune-up limit power (mW) / RF power (mW)
- Scaling factor max. duty cycle = max. possible duty cycle / used duty cycle for SAR measurement
- Reported SAR = measured SAR * scaling factor tune up limit * scaling factor max. duty cycle

The plots with the highest measured SAR values are shown in Appendix B - SAR Distribution Plots.

7.6.1 SAR Measurement Results

SAR Measurement Results in Body Exposure

Band	Mode IEEE 802.11	Freq. [MHz]	CH	Pos.	Gap [mm]	Pic. No.	Measured SAR1g [W/kg]	Power Drift [dB]	Power [dBm]		Tune-Up SF	Reported SAR1g [W/kg]	Plot No.	Note No.
									Meas.	Limit				
2.4 GHz	b 1mbps	2437	6	Front	0	4	0.019	0.151	15.0	16.5	1.413	0.021	-	-
		2437	6	Rear	0	5	0.203	0.070	15.0	16.5	1.413	0.287	-	-
		2437	6	Left	0	6	0.034	0.181	15.0	16.5	1.413	0.048	-	-
		2437	6	Right	0	7	0.020	-0.190	15.0	16.5	1.413	0.028	-	-
		2437	6	Top	0	8	0.009	-0.149	15.0	16.5	1.413	0.013	-	-
		2437	6	Bottom	0	9	0.008	-0.030	15.0	16.5	1.413	0.011	-	-
		2412	1	Rear	0	5	0.154	-0.204	14.8	16.5	1.479	0.228	-	-
		2462	11		0		0.269	-0.196	15.1	16.5	1.380	**0.371**	1	-

Notes:

Table 15: SAR measurement results in body-worn exposure configuration.

SAR Measurement Results in Extremity Exposure

Band	Mode IEEE 802.11	Freq. [MHz]	CH	Pos.	Gap [mm]	Pic. No.	Measured SAR10g [W/kg]	Power Drift [dB]	Power [dBm]		Tune-Up SF	Reported SAR10g [W/kg]	Plot No.	Note No.
									Meas.	Limit				
2.4 GHz	b 1mbps	2437	6	Front	0	4	0.015	0.151	15.0	16.5	1.413	0.021	-	
		2437	6	Rear	0	5	0.114	0.070	15.0	16.5	1.413	0.161	-	-
		2437	6	Left	0	6	0.025	0.181	15.0	16.5	1.413	0.035	-	-
		2437	6	Right	0	7	0.019	-0.190	15.0	16.5	1.413	0.027	-	-
		2437	6	Top	0	8	0.006	-0.149	15.0	16.5	1.413	0.008	-	-
		2437	6	Bottom	0	9	0.004	-0.030	15.0	16.5	1.413	0.006	-	-
		2412	1	Rear	0	5	0.088	-0.204	14.8	16.5	1.479	0.130	-	-
		2462	11		0		0.147	-0.196	15.1	16.5	1.380	**0.203**	1	-

Notes:

Table 16: SAR measurement results in extremity exposure configuration.

To control the output power stability during the SAR test the used DASY4 system calculates the power drift by measuring the e-field at the same location at the beginning and at the end of the measurement for each test position. These drift values can be found in the above tables labeled as: (Power Drift [dB]). This ensures that the power drift during one measurement is within 5%.

8 Administrative Measurement Data

8.1 Calibration of Test Equipment

Test Equipment Overview					
Test Equipment	**Manufacturer**	**Model**	**Serial Number**	**Last Calibration**	**Next Calibration**
DASY System Components					
☒ Software Versions DASY4	SPEAG	V4.7	N/A	N/A	N/A
☒ Software Versions SEMCAD	SPEAG	V1.8	N/A	N/A	N/A
☐ Dosimetric E-Field Probe	SPEAG	ET3DV6R	1579	02/2020	02/2022
☐ Dosimetric E-Field Probe	SPEAG	ET3DV6R	1669	03/2021	03/2023
☒ Dosimetric E-Field Probe	SPEAG	EX3DV4	3536	08/2020	08/2022
☐ Dosimetric E-Field Probe	SPEAG	EX3DV4	3860	10/2019	10/2021
☐ Data Acquisition Electronics	SPEAG	DAE 3	335	03/2021	03/2022
☒ Data Acquisition Electronics	SPEAG	DAE 4	631	08/2020	08/2021
☐ Phantom	SPEAG	SAM	1059	N/A	N/A
☐ Phantom	SPEAG	SAM	1176	N/A	N/A
☐ Phantom	SPEAG	SAM	1340	N/A	N/A
☒ Phantom	SPEAG	SAM	1341	N/A	N/A
☐ Phantom	SPEAG	ELI4	1004	N/A	N/A
Dipoles					
☐ System Validation Dipole	SPEAG	D450V2	1014	03/2021	03/2024
☐ System Validation Dipole	SPEAG	D835V2	470	03/2021	03/2024
☐ System Validation Dipole	SPEAG	D1640V2	311	09/2018	09/2021
☐ System Validation Dipole	SPEAG	D1750V2	1005	03/2021	03/2024
☐ System Validation Dipole	SPEAG	D1900V2	535	03/2021	03/2024
☒ System Validation Dipole	SPEAG	D2450V2	709	11/2018	11/2021
☐ System Validation Dipole	SPEAG	D2600V2	1019	11/2018	11/2021
☐ System Validation Dipole	SPEAG	D5GHzV2	1028	04/2020	04/2023
Material Measurement					
☒ Network Analyzer	Agilent	E5071C	MY46103220	08/2019	08/2021
☒ Dielectric Probe Kit	SPEAG	DAK-3.5	1234	02/2020	02/2022
☒ Thermometer	LKMelectronic	DTM3000	3511	02/2020	02/2022
Power Meters and Sensors					
☒ Power Meter	Anritsu	ML2487A	6K00002319	07/2020	07/2022
☒ Power Sensor	Anritsu	MA2472A	990365	07/2020	07/2022
☒ Power Meter	Anritsu	ML2488A	6K00002078	07/2020	07/2022
☒ Power Sensor	Anritsu	MA2472A	002122	07/2020	07/2022
☒ Spectrum Analyzer	Rohde & Schwarz	FSP7	100433	01/2021	01/2023
RF Sources					
☒ Network Analyzer	Agilent	E5071C	MY46103220	08/2019	08/2021
☐ RF Generator	Rohde & Schwarz	SM300	100142	N/A	N/A
Amplifiers					
☐ Amplifier 10 MHz – 4200 MHz	Mini Circuits	ZHL-42-42W	D080504-1	N/A	N/A
☒ Amplifier 2 GHz – 6 GHz	Ciao Wireless	CA26-451	37452	N/A	N/A
Radio Tester					
☐ Radio Communication Tester	Anritsu	MT8815B	6200576536	06/2020	06/2022
☐ Radio Communication Tester	Anritsu	MT8820C	6200918336	05/2020	05/2022
Notes: Used test equipment for measurement is checked above.					

Table 17: Calibration of test equipment.

8.2 Uncertainty Assessment

The following tables include the uncertainty budgets suggested by IEC/IEEE 62209-1528. The requirements for the validity and the certificate of conformity can be found in Appendix D – Certificates of Conformity.

Uncertainty Budget for SAR Measurements according to IEC/IEEE 62209-1528 (300 MHz - 6 GHz)

Error Sources	Uncertainty Value [± %]	Probability Distribution	Divisor	c_i	c_i	Standard Uncertainty [± %]		v_i^2 or v_{eff}
Measurement System				1g	10g	1g	10g	
Probe calibration	6.3	Normal (k=2)	1	1	1	6.3	6.3	∞
Probe linearity	0.3	Rectangular	√3	1	1	0.2	0.2	∞
Probe isotropy axial	0.3	Rectangular	√3	√0.5	√0.5	0.1	0.1	∞
Probe isotropy spherical	1.3	Rectangular	√3	√0.5	√0.5	0.5	0.5	∞
Boundary effects	1.0	Rectangular	√3	1	1	0.6	0.6	∞
System detection limit	1.0	Rectangular	√3	1	1	0.6	0.6	∞
Modulation response	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Readout electronics	0.3	Normal	1	1	1	0.3	0.3	∞
Response time	0.8	Rectangular	√3	1	1	0.5	0.5	∞
Integration time	1.4	Rectangular	√3	1	1	0.8	0.8	∞
RF ambient conditions - noise	3.0	Rectangular	√3	1	1	1.7	1.7	∞
RF ambient conditions - refl.	3.0	Rectangular	√3	1	1	1.7	1.7	∞
Probe positioner mech. tol.	0.4	Rectangular	√3	1	1	0.2	0.2	∞
Probe positioning	2.9	Rectangular	√3	1	1	1.7	1.7	∞
Data processing errors	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Phantom and set-up errors								
Measurement of phantom conductivity	5.0	Normal	1	1	1	5.0	5.0	∞
Liquid conductivity temp. unc.	2.9	Rectangular	√3	0.78	0.71	1.3	1.2	∞
Liquid permittivity temp. unc.	1.8	Rectangular	√3	0.23	0.26	0.2	0.3	∞
Phantom shell permittivity	4.0	Rectangular	√3	1	1	2.3	2.3	∞
Distance between DUT and medium	1.0	Normal	1	2	2	2.0	1.0	∞
Repeatability of positioning the DUT	2.9	Normal	1	1	1	2.9	2.9	145
Device holder uncertainty	3.6	Normal	1	1	1	3.6	3.6	5
Effect of operation mode	7.0	Rectangular	√3	1	1	4.0	4.0	∞
Time-average SAR	5.0	Rectangular	√3	1	1	2.9	2.9	∞
SAR drift measurement (< 0.2 dB)	4.7	Rectangular	√3	1	1	2.7	2.7	∞
Corrections to the SAR result								
Phantom deviation from target (ε′,σ)	1.2	Normal	1	1	0.8	1.2	1.0	∞
SAR scaling	2.0	Rectangular	√3	1	1	1.2	1.2	∞
Combined Standard Uncertainty						12.4	12.2	
Coverage Factor for 95%						kp=2		
Expanded Standard Uncertainty						**24.8**	**24.5**	
Notes: *Worst case probe calibration uncertainty has been applied for all available probes and frequencies.*								

Table 18: Uncertainty budget for SAR measurement.

9 Report History

Revision History				
Revision	**Description of Revision**	**Date**	**Revised Page**	**Revised By**
/	Initial Release	March 14, 2022	-	-

END OF THE SAR REPORT

Please refer to separated appendix file for the following data:

- Appendix A - Pictures
- Appendix B - SAR Distribution Plots
- Appendix C - System Verification Plots
- Appendix D – Certificates of Conformity
- Appendix E – Calibration Certificates for DAEs
- Appendix F – Calibration Certificates for E-Field Probes
- Appendix G – Calibration Certificates for Dipoles