DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

Test report No:
NIE: 77793RAN.002

Test report
IEEE Std 1528™-2013

(*) Identification of item tested	Telematic control unit with wireless technologies, used in automotive industry
(*) Trademark	VW AG
(*) Model and /or type reference tested	TKCMOD12N00
(*) Derived model not tested	TKCMOD12E00, TKCMOD11000, TKCMOD12C00, TKCMOD12J00, TKCMOD12R00, TKCMOD12T00 and TKCMOD13C00
(*) Other identification of the product	FCC ID: T8G-CONMOD IC: 6434A-CONMOD
(*) Features	GSM, UMTS, LTE, 5G, GNSS, Wi-Fi, BTLE, BT EDR HW version: H25 SW version: X638
Manufacturer	HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH Becker-Goering-Str. 16 76307, Karlsbad, GERMANY
Test method requested, standard	1. IEEE Std 1528™-2013. 2. FCC 47 CFR Part 2.1093.
Summary	Considering the results of the performed test, the item under test is IN COMPLIANCE with FCC 47CFR Part 2.1093 exposure limits. The maximum 1g volume averaged SAR found during this test have been 0.170 W/kg, for 802.11 a/n/ac MIMO U-NII-3 mode. The maximum 1g volume averaged SAR for multiband transmission found during this test has been 1.439 W/kg, for GPRS 2 slots + BTLE + BT EDR + 802.11 a/n/ac SISO U-NII-3 + 802.11 a/n/ac MIMO U-NII-3 mode.
Approved by (name / position & signature)	Manuel García Antennas Lab Technical Responsible 74862741H MANUEL GARCÍA (C:A29507456) 74862741H MANUEL GARCÍA (C:A29507456) 2024.07.23 13:34:18 +02'00'

Date of issue	2024-07-23
Report template No	FAN44_00 (*) “Data provided by the client”

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Competences and guarantees

DEKRA Testing and Certification S.A.U. is a testing laboratory accredited by the National Accreditation Body (ENAC -Entidad Nacional de Acreditación), to perform the tests indicated in the Certificate No. 51/LE 147.

DEKRA Testing and Certification is a FCC-recognized accredited testing laboratory with appropriate scope of accreditation that include testing performed in this test report.

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The results presented in this Test Report apply only to the particular item under test established in this document.

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1. This report is only referred to the item that has undergone the test.
2. This report does not constitute or imply on its own an approval of the product by the Certification Bodies or competent Authorities.
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4. This test report cannot be used partially or in full for publicity and/or promotional purposes without previous written permission of DEKRA Testing and Certification S.A.U. and the Accreditation Bodies.

Uncertainty

Uncertainty (factor k=2) was calculated according to the following documents:

1. DEKRA Testing and Certification S.A.U. internal document PODT000.
2. FCC OET KDB 865664 D01 - SAR Measurement Requirements for 100 MHz to 6 GHz v01r04 (August 2015).

Data provided by the client

The following data has been provided by the client:

1. Information relating to the description of the sample ("Identification of the item tested", "Trademark", "Model and/or type reference tested", "Derived model not tested", "Other identification of the product", "Features" and "Test sample description").

2. Maximum output power and testing distance information.

HARMAN AUTOMOTIVE DIVISION
HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH
BECKER-GOERING-STRASSE 16
76307 KARLSBAD, GERMANY

Declaration of similarity

To whom it may concern,

We, **Harman Becker Automotive Systems GmbH**, located in **Becker-Goering-Str. 16; 76307 Karlsbad, Germany**

Hereby declare that the following units: TKCMOD12E00, TKCMOD12N00, TKCMOD11000, TKCMOD12C00, TKCMOD12J00, TKCMOD12R00, TKCMOD12T00 and TKCMOD13C00

have integrated the same BT/Wifi chipset.

The different naming comes from country specific, features enabled or network access device type.

Targeted countries	Product Name	Type	NAD-HW	GNSS	Bluetooth WLAN	NAD Services	CV2X
Rest of the world (offline variant)	TKCMOD11000	V046	EU	x	x		
EU + some other countries	TKCMOD12E00	V037, V042, V043, V044, V049	EU	x	x	x	
Canada/Mexico/USA	TKCMOD12N00	V038, V039, V047	NA	x	x	x	
China (without CV2X)	TKCMOD12C00	V105	CN	x	x	x	
Japan	TKCMOD12J00	V045	RW	x	x	x	
Armenia/Belarus/Kazakhstan/Russia/Uzbekistan	TKCMOD12R00	V048	EU	x	x	x	
Turkey	TKCMOD12T00	V040	EU	x	x	x	
China (with CV2X)	TKCMOD13C00	V106	CN	x	x	x	x

This declaration is intended to be included in the test reports where applies

Regards

HARMAN AUTOMOTIVE DIVISION
Harman Becker Automotive Systems GmbH
Becker-Göring-Straße 16
76307 Karlsbad, Germany

i.V.

i.V.

By: Andrei-Daniel CALIN
Title: Regulatory Product Compliance Expert
Company: Harman Becker
Telephone: +40 799 305 814
e-mail: andreidaniel.calin@harman.com

By: Iulian-George Stoica
Title: Regulatory Product Compliance Expert
Company: Harman Becker
Telephone: +40799 306 699
e-mail: iulian.stoica@harman.com

3. Derived model not tested. These models have been declared by the supplier of the sample as being the same as the model under test.

DEKRA Testing and Certification S.A.U. declines any responsibility with respect to the information provided by the client and that may affect the validity of results. The laboratory is not responsible for such information and it is not covered by accreditation.

Usage of samples

Samples undergoing test have been selected by: the client

Samples are composed of the following elements:

Sample	Control Nº	Description	Model	Serial Nº	Date of reception
S/01	77793B_4.1	Module	TKCMOD12N00	V04769R081900014	2024-05-16
S/01	77617B_103.1	Antenna Audi	8MA.035.225.C	--	2024-02-20

1. Sample S/01 has undergone the test(s) specified in subclause “Test method requested”: SAR evaluation for Wi-Fi mode.

Test sample description

Description of product ..... :	Telematic control unit with wireless technologies, used in automotive industry		
Software version..... :	X638		
Hardware version ..... :	H25		
Mounting position ..... :	[ ]	Table top equipment	
	[ ]	Wall/Ceiling mounted equipment	
	[ ]	Floor standing equipment	
	[ ]	Hand-held equipment	
	[X]	Other: Automotive telematics control unit	
Accessories (not part of the test item)..... :	Description	Type	Manufacturer

Identification of the client

HARMAN BECKER AUTOMOTIVE SYSTEMS GMBH
Becker-Goering-Str. 16
76307, Karlsbad, GERMANY

Testing period and place

Test Location	DEKRA Testing and Certification S.A.U.
Date (start)	2024-05-22
Date (finish)	2024-06-13

Document history

Report number	Date	Description
77793RAN.002	2024-07-23	First release

Environmental conditions

Date	Max. Temp. ºC	Min. Temp. ºC	Max. Hum. %	Min. Hum. %	Limit
From 2024-05-22 to 2024-06-13	24.52	21.02	64.49	37.85	18-25 ºC, 30-70%

Remarks and comments

1. Maximum SAR values for the DUT were measured in DEKRA Testing and Certification, S.A.U. test report num. 67003RAN.009. Now, the DUT has been updated via software to support U-NII-3 MIMO mode, therefore, in this test report, SAR has been measured in the maximum averaged output power worst-case between SISO and MIMO mode and the simultaneous transmission evaluation has been updated accordingly to these new capabilities.
2. Zoom scan and/or power drifts measurements have not been able to be performed by the measurement system due to very low SAR values close to or under the noise level.
3. Only the plots of the highest SAR for each test position and mode/band are included in appendix C.
4. The tests have been performed by the technical personnel: Ismael Gamarro.
5. The instrumentation utilized to perform the tests covered in this test report is listed in the following table:

DEKRA Control Number	Equipment	S/N
02402	20 dB Attenuator, WEINSCHEL model 75A-20-11	902
04859	DAK software, SPEAG model DAK V1.10.325.10	-
04835	DC POWER SUPPLY 30V/5A 150W	MY58500043
08876	Data acquisition device, SPEAG model DAE4	1690
09448	Dielectric probe kit, SPEAG model DAK-3.5	1329
04170	Digital thermometer, LKM Electronics model DTM3000-SpezialL	2989
03524	Dipole Validation Kit 5 GHz	1071.
09513	Dosimetric E-field Probe, SPEAG model EX3DV4	7766
04393	Dual Power meter, Agilent model E4419B	MY45103349
03630	Dual directional coupler, NARDA model 4227-16	02953
08902	Electro-optical converter, SPEAG model EOCip-60	1154
09450	Head Tissue Equivalent Liquid for 3500-5800 MHz, SPEAG model HBBL3500-5800V5	-
08895	Measurement server, SPEAG model DASY6 SE UMS 028 CA	1602
03424	Mounting Device for Hand-held devices, SPEAG model SD000 HD1 HA	-
09168	Oval flat phantom, SPEAG model ELI4 V8.0	2158
02216	Power Divider, PICOSECOND PULSE LABS model 5333-104	236310 1504
04164	Power Sensor 50 MHz-18GHz, R&S model NRP-Z81	100527
03485	Power amplifier, MITEQ model AMF-4D-00400600-50-30P	1456425
04391	Power sensor, Agilent model E9300A	SG41491203
04392	Power sensor, Agilent model E9300A	SG41491189
08894	Robot controller, Stäubli model CS8C	F15/5Z0NB1/C/01
08867	Robot, Stäubli model TX60L	F15/5Z0NB1/A
08898	SAR measurement software, SPEAG model cDASY6	-
03346	Signal RF Generator, R&S model SMU200A	102234
03453	Temperature and humidity probe, Pico Technology model HUMIDIPROBE	UAL02/077
04482	Vector Network Analyzer, Agilent Technologies model N9923A FieldFox	US49470126

6. References

The tests documented in this report were performed in accordance with FCC 47 CFR § 2.1093 and the following FCC Published RF exposure KDB procedures:

- FCC OET KDB 447498 D01 General RF Exposure Guidance v06 (October 2015).
- FCC OET KDB 865664 D01 - SAR Measurement Requirements for 100 MHz to 6 GHz v01r04 (August 2015).
- FCC OET KDB 865664 D02 RF Exposure Reporting v01r02 (October 2015).
- FCC OET KDB 248227 D01 802.11 Wi-Fi SAR v02r02 (October 2015).

Testing verdicts

Not applicable :	N/A
Pass :	P
Fail :	F
Not measured :	N/M

Summary

FCC 47CFR Part 2.1093	VERDICT			
	N/A	P	F	N/M
802.11a/n/ac MIMO		P		

Appendix A: Test configuration

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1. GENERAL INTRODUCTION

1.1. Application Standard

The Federal Communications Commission (FCC) sets the limits for General Population/Uncontrolled exposure to radio frequency electromagnetic fields for transmitting devices designed to be used within 20 centimetres of the body of the user under FCC 47 CFR Part 2.1093 - "Radiofrequency radiation exposure evaluation: portable devices", paragraph (d)(2).

1.2. General requirements

The SAR measurement has been performed continuing the following considerations and environment conditions:

The ambient temperature shall be in the range of 18ºC to 25ºC and the variation shall not exceed +/-2ºC during the test.

The ambient humidity shall be in the range of and 30% - 70%.

The device battery shall be fully charged before each measurement.

1.3. Measurement system requirements

The measurement system used for SAR tests fulfills the procedural and technical requirements described at the reference standards used.

1.4. Phantom requirements

The phantom model for body measurements is an elliptical open-top container with a flat bottom, with the following shape and dimensions:

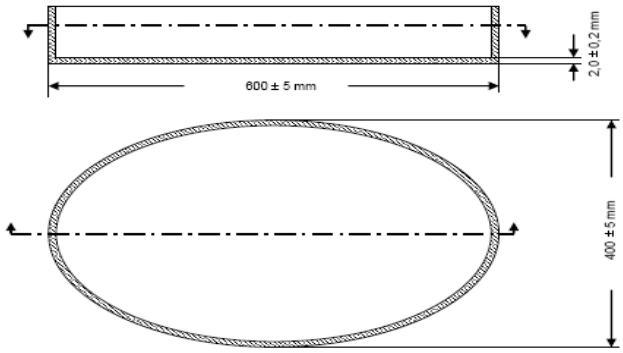


Figure 1: Proportions and shape of Phantom shell

1.5. Measurement Liquids requirements

The liquids used to simulate the human tissues, must fulfill the requirements of the dielectric properties required. These target dielectric properties are indicated into FCC OET KDB 865664 D01 Appendix A.

Frequency (MHz)	ε_r	σ (S/m)
750	41.94	0.89
835	41.5	0.90
900	41.5	0.97
1750	40.07	1.37
1800	40.0	1.40
1900	40.0	1.40
2000	40.0	1.40
2300	39.46	1.67
2450	39.2	1.80
2600	39.0	1.96
3300	38.14	2.71
3500	37.90	2.91
3700	37.70	3.12
3900	37.51	3.33
4200	37.16	3.63
5200	36.0	4.66
5500	35.65	4.97
5800	35.3	5.27

Table 1: Liquid material requirements

To minimize the effect of reflections on peak spatial-average SAR values, from the upper surface of the tissue equivalent liquid, the depth of the liquid should be at least 15 cm.

Dielectric porperties values of the Tissue Simulant Liquids used for SAR measurements are included in Appendix B, Section 3, of this document.

2. MEASUREMENT SYSTEM

2.1. Measurement System

The DASY6 system for performing compliance tests consists of the following items:

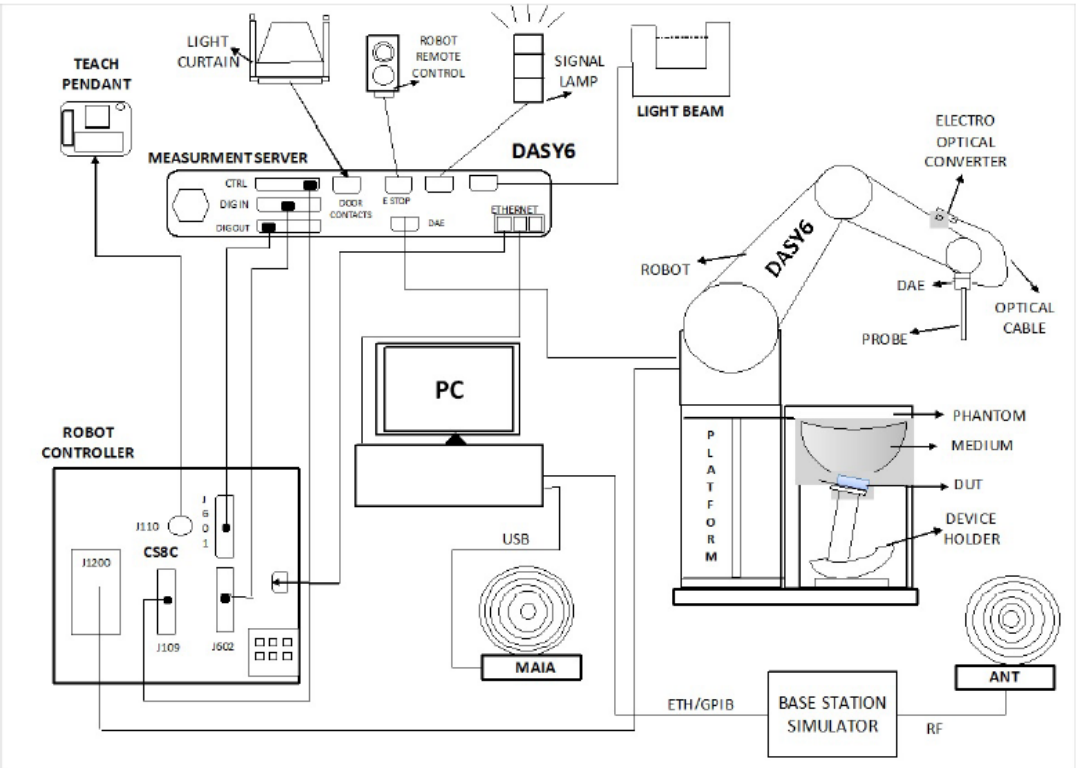
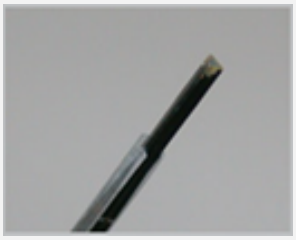


Figure 2: SAR Measurement system

- A standard high precision 6-axis robot (Stäubli TX=RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- An isotropic field probe optimized and calibrated for the targeted measurement.
- 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.
- 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.
- 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.
- The Light Beam used is for probe alignment. This improves the (absolute) accuracy of the probe positioning.
- A computer running the DASY software.
- Remote control and teach pendant as well as additional circuitry for robot safety such as warning lamps, etc.
- The phantom, the device holder and other accessories according to the targeted measurement.

	Model	EX3DV4
	**Construction**	Symmetrical design with triangular core. Built-in shielding against static charges. PEEK enclosure material (resistant to organic solvents, e.g., DGBE).
	Frequency	10 MHz to > 6 GHz; Linearity: ± 0.2 dB (30 MHz to 6 GHz)
	Directivity	± 0.3 dB in TSL (rotation around probe axis) ± 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)
	Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1.0 mm

	Model	DAE4
	**Construction**	Signal amplifier, multiplexer, A/D converter, and control logic. Serial optical link communication with DASY4/5 embedded system (fully remote controlled). Two-step probe touch detector for mechanical surface detection and emergency robot stop.
	Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV)
	Input Offset Voltage	< 5 µV (with auto zero)
	Input Resistance	200 MOhm
	Input Blas Current	< 50 fA

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

Model	Mounting Device for Hand-Held Transmitters
Construction	In combination with the Twin SAM V5.0/V5.0c or ELI Phantoms, the Mounting Device for Hand-Held Transmitters enables rotation of the mounted transmitter device to specified spherical coordinates. At the heads, the rotation axis is at the ear opening. Transmitter devices can be easily and accurately positioned according to IEC 62209-1, IEEE 1528, FCC, or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).
Material	Polyoxymethylene (POM)

Model	System Validations Kits 450 MHz – 6 GHz
Construction	Symmetrical dipole with I/4 balun. Enables measurement of feedpoint impedance with NWA. Matched for use near flat phantoms filled with tissue simulating solutions.
Frequency	450 MHz to 5800 MHz
Return Loss	20 dB at specified validation position

Dimensions (length and overall height in mm)

Product	Dipole length	Overall height
D450V3	290.0	330.0
D750V3	179.0	330.0
D900V2	148.5	340.0
D1800V2	72.5	300.0
D2000V2	65.0	300.0
D2300V2	56.3	290.0
D2450V2	52.0	290.0
D2600V2	49.2	290.0
D3300V2	38.0	285.0
D3500V2	37.0	285.0
D3700V2	34.7	285.0
D3900V2	32.0	280.0
D4200V2	30.1	280.0
D4600V2	27.0	280.0
D4900V2	25.0	280.0
D5GHzV2	20.6	300.0

2.2. Device Holder

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source in 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. An accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions, in which the devices must be measured, are defined by the standards.

The DASY device holder is designed to cope with different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation centre for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder has been made out 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.

2.3. Test Positions of device relative to body

The device is a Telematics control unit with wireless technologies, used in automotive, equipped with one modem, OEM. This unit was designed for automotive usage and contains the following features: GSM, UMTS, LTE, 5G, GNSS, Wifi (a, b, g, n, ac), Bluetooth Low Energy (BTLE) and Bluetooth EDR.

The equipment supports several antennas that can be used for transmission. It supports different configurations in which different antennas can be used for different purposes and transmit simultaneously:

Antenna	Tx - Bands	Position on vehicle	Installation distance (mm)
Shark fin antenna “LTE1” (Main cellular antenna)	GSM 900/1800 WCDMA I/III/V/VIII LTE 1/3/5/7/8/20/28/38/40 5G n1/n28/n77/n78	Car roof	> 19.375mm
Shark fin antenna “LTE2” (Backup/e-call cellular antenna)	GSM 900/1800 WCDMA I/III/V/VIII		
Shark fin antenna “BTLE”	Bluetooth LE		
Bumper “LTE3” (Additional Backup/e-call cellular antenna)	GSM 900/1800 WCDMA I/III/V/VIII	Rear bumper	> 20cm
Internal backup antenna	GSM 900/1800 WCDMA I/III/V/VIII	Trunk	> 20cm
“BT_WLAN1”	WLAN 2.4GHz SISO	Rear mirror bracket	> 20cm
“BT_WLAN2”	Bluetooth EDR 2.4GHz WLAN 5GHz SISO/MIMO	C/D pilar/frame window backside	> 10mm
“BT_WLAN3”	WLAN 5GHz MIMO	C/D pilar/frame window backside	> 10mm

Table 2: Antenna specifications and location.

Only three antennas will be installed close to car passangers at a distance minor to 20 cm, these antennas will be named as “LTE1/LTE2/BTLE” (which are inside the external shark fin antenna)” and two of the WLAN antennas named as “BT_WLAN2” and “BT_WLAN3” antennas, which will be installed into the “C/D pilar/frame window backside” of the car with the following minimum declared installation distances.

“LTE1/LTE2/BTLE” antennas were tested in DEKRA Testing and Certification, S.A.U. test report num. 67003RAN.009.

For the" BT_WLAN2" antenna, conducted output power measurements have been performed in the antenna port for SISO and MIMO modes. SISO mode was found as the worst-case configuration, therefore, maximum SAR values between both modes are stated in DEKRA Testing and Certification, S.A.U. test report 67003RAN.009.

SAR measurements for the "BT_WLAN3" antenna were performed at a conservative 0 mm testing distance for both antenna faces.

The rest of supported antennas, which will be installed more than 20 cm away from any nearby passenger, will be assessed according to EN IEC 62311:2020 into DEKRA Testing and Certification, S.A.U. test report num. 67003RAN.010.

2.4. Test to be performed

Test shall be performed for each test position previously described, using the channel producing the highest rated output power.

Additionally, the other applicable test frequency channels must be measured for the test configuration providing the highest SAR for each applicable transmitting band.

2.5. Description of interpolation/extrapolation scheme

The local SAR inside the Phantom is measured using small dipole sensing elements inside a probe element. The probe tip must not be in contact with the Phantoms surface in order to minimise measurement errors, but the highest local SAR is obtained from measurements at a certain distances from the shell trough extrapolation. The accurate assessment of the maximum SAR averaged over 10 gr. requires a very fine resolution in the three dimensional scanned data array. Since the measurements have to be performed over a limited time, the measured data have to be interpolated to provide an array of sufficient resolution.

The interpolation of 2D area scan is used after the initial area scan, at a fixed distance from the Phantom shell wall. The initial scan data is collected with approx. 15 mm spatial resolution and this interpolation is used to find the location of the local maximum for positioning the subsequent 3D scanning within a 1mm resolution.

For the 3D scan, data is collected on a spatially regular 3D grid having 5 mm steps in both directions. After the data collection by the SAR probe, the data are extrapolated in the depth direction to assign values to points in the 3D array closer to the shell wall. A notional extrapolation value is also assigned to the first point outside the shell wall so that subsequent interpolation schemes will be applicable right up to the shell wall boundary.

2.6. Determination of the largest peak spatial-average SAR

To determine the maximum value of the peak spatial-average SAR of a DUT, all device positions, configurations and operational modes should be tested for each frequency band.

The averaging volume shall be chosen as 1gr. of contiguous tissue. The cubic volumes, over which the SAR measurements are averaged after extrapolation and interpolation, are chosen in order to include the highest values of local SAR.

The maximum SAR level for the DUT will be the maximum level obtained of the performed measurements indicated in the previous points.

2.7. System Check

Prior to the SAR measurements, system verification is done to verify the system accuracy. As IEEE 1528-2013, Annex paragraph 8.2.1 "System Check - Purpose" specifies, a complete SAR evaluation is done using a half-wavelength dipole as source with the frequency of the mid-band channel of the operating band, or within 10% of this channel, whichever is greater.

The measured 1 gr. and 10 gr. SAR should be within 10% of the expected target values specified in the calibration certificate of the dipole, for the specific tissue and frequency used.

3. UNCERTAINTY

According to FCC OET KDB 865664 D01, if the highest measured 1-g SAR is < 1.5 W/kg, SAR measurement uncertainty analysis is not required to be included into SAR report, but it has been included for ISO 17025 accreditation.

Uncertainty for 3 GHz – 6 GHz

ERROR SOURCES (source of uncertainty)	Uncertainty value (%)	Prob. Dist.	Div.	*ci (1g)*	*ci (10g)*	*Standard uncertainty (1g) (%)*	*Standard uncertainty (10g) (%)*
Measurement Equipment							
Probe Calibration	13.10%	N	2	1	1	6.55%	6.55%
Probe calibration drift	1.70%	R	√3	1	1	0.98%	0.98%
Axial Isotropy	4.70%	R	√3	0.7	0.7	1.90%	1.90%
Hemisfericall Isotropy	9.60%	R	√3	0.7	0.7	3.88%	3.88%
Boundary effect	2.00%	R	√3	1	1	1.15%	1.15%
Linearity	4.70%	R	√3	1	1	2.71%	2.71%
System Detection limits	0.25%	R	√3	1	1	0.14%	0.14%
Probe modulation response	4.80%	N	1	1	1	4.80%	4.80%
Readout electronics	0.30%	N	1	1	1	0.30%	0.30%
Response time	1.01%	R	√3	1	1	0.58%	0.58%
Integration time	2.60%	R	√3	1	1	1.50%	1.50%
RF Ambient noise	3.00%	R	√3	1	1	1.73%	1.73%
RF Ambient reflections	3.00%	R	√3	1	1	1.73%	1.73%
Probe positioner mech. restrictions	0.40%	R	√3	1	1	0.23%	0.23%
Probe positioning with respect to phantom shell	6.70%	R	√3	1	1	3.87%	3.87%
Max. SAR Eval.	4.00%	R	√3	1	1	2.31%	2.31%
Test Sample Related							
Device holder uncertainty	3.60%	N	1	1	1	3.60%	3.60%
Test sample positioning	2.90%	N	1	1	1	2.90%	2.90%
Drift of output power	2.50%	N	1	1	1	2.50%	2.50%
System Validation source (dipole)							
Deviation of experimental dipole from numerical dipole	0.00%	N	1	0	0	0.00%	0.00%
Input power and SAR drift measurement	2.00%	R	√3	1	1	1.15%	1.15%
Dipole axis to liquid distance	3.40%	R	√3	1	1	1.96%	1.96%
Phantom and Setup							
Phantom uncertainty (shape and thickness tolerances)	6.60%	R	√3	1	1	3.81%	3.81%
Algorithm for correcting SAR for deviations in permittivity and conductivity	1.90%	N	1	1	0.84	1.90%	1.60%
Liquid conductivity (meas.)	3.57%	N	1	0.78	0.71	2.79%	2.54%
Liquid permittivity (meas.)	3.57%	N	1	0.26	0.26	0.93%	0.93%
Liquid conductivity – temperature uncertainty	3.36%	R	√3	0.78	0.71	1.51%	1.38%
Liquid permittivity – temperature uncertainty	0.40%	R	√3	0.23	0.26	0.05%	0.06%
Combined standard uncertainty (Validation antenna)	$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					10.81%	10.68%
Expanded uncertainty (confidence interval of 95%)	*ue =2.00 uc*					**21.62%**	**21.36%**
Combined standard uncertainty (DUT)	$u_c = \sqrt{\sum_{i=1}^{m} c_i^2 \cdot u_i^2}$					13.42%	13.31%
Expanded uncertainty (confidence interval of 95%)	*ue =2.00 uc*					**26.83%**	**26.62%**

Table 3: Uncertainty Assessment for 3 GHz – 6GHz.

4. SAR LIMIT

Having a worst-case measurement, the SAR limit is valid for general population/uncontrolled exposure.

The SAR values have to be averaged over a mass of 1 gr. (SAR 1 gr.) with the shape of a cube and averaged over a mass of 10 gr (Extremity SAR 10 gr). These levels could not exceed the values indicated in the application Standard:

Standard	Exposure	SAR	SAR Limit (W/kg)
FCC 47 CFR Part 1.1310, Paragraph (c)	General population/Uncontrolled	SAR 1-g.	1.6
FCC 47 CFR Part 1.1310, Paragraph (c)	General population/Uncontrolled Extremity	SAR 10-g.	4.0

Table 4: SAR limit

5. DEVICE UNDER TEST

5.1. Dimensions

Element	Length x Width x Height (mm)
TCU	260.0 x 130.0 x 25.0
Shark fin antenna	220.0 x 85.0 x 70.0
BT_WLAN 2 antenna	110.0 x 20.0 x 15.0
BT_WLAN 3 antenna	110.0 x 20.0 x 15.0

Table 5: DUT dimensions

5.2. Wireless Technology

Wireless Technology	Frequency Bands	Modes	Duty Cycle used for SAR testing
GSM	900/1800	- Voice (GMSK) - GPRS (GMSK, Multi-slot class 33) - EGPRS (8PSK, Multi-slot class 33)	- GMSK: 12.5 % - GPRS/EGPRS 1 slot: 12.5 % - GPRS/EGPRS 2 slot: 25.0 % - GPRS/EGPRS 3 slot: 37.5 % - GPRS/EGPRS 4 slot: 50.0 %
WCDMA	I/III/V/VIII	- UMTS Rel. 99 - HSDPA (Rel. 5) - HSPA (Rel. 6) - HSPA+ (Rel. 7)	- 100 %
LTE	1/3/5/7/8/20/28/38/40	- FDD and TDD Bands - CA Downlink - CA Uplink Intra-Band - CA Uplink Inter-Band - QPSK and 16-QAM (Rel. 9)	- FDD: 100 % - TDD: 62.9 %
5G	n1/n28/n77/n78	- FDD and TDD Bands - SA mode - NSA-EN-DC mode	- FDD: 100 % - TDD: 50 %
WLAN	5 GHz	- 802.11 a/n/ac (20MHz & 40MHz) - 802.11 ac (80MHz)	- 802.11a/n/ac (20MHz): 80 % - 802.11a/n/ac (40 MHz): 65 % - 802.11ac (80 MHz): 45 %
Bluetooth	2.4 GHz	- Bluetooth	SAR Low-Power Exclusion compliant

Table 6: Supported modes

The supported transmitting technology for each antenna is:

Antenna	Wireless Technology	Frequency Bands	Modes
LTE1 (Shark fin antenna)	GSM	900/1800	- Voice (GMSK) - GPRS (GMSK, Multi-slot class 33) - EGPRS (8PSK, Multi-slot class 33)
	WCDMA	I/III/V/VIII	- UMTS Rel. 99 - HSDPA (Rel. 5) - HSPA (Rel. 6) - HSPA+ (Rel. 7)
	LTE	1/3/5/7/8/20/28/38/40	- FDD and TDD Bands - CA Downlink - CA Uplink Intra-Band - CA Uplink Inter-Band - QPSK and 16-QAM (Rel. 9)
	5G	n1/n28/n77/n78	- FDD and TDD Bands - SA mode - NSA-EN-DC mode
LTE2 (Shark fin antenna)	GSM	900/1800	- Voice (GMSK) - GPRS (GMSK, Multi-slot class 33) - EGPRS (8PSK, Multi-slot class 33)
	WCDMA	I/III/V/VIII	- UMTS Rel. 99 - HSDPA (Rel. 5) - HSPA (Rel. 6) - HSPA+ (Rel. 7)
BTLE (Shark fin antenna)	Bluetooth	2.4GHz	- BTLE
BT_WLAN 2	Bluetooth	2.4GHz	- BT_EDR
	WLAN	UNII-3 SISO / MIMO	- 802.11a/n/ac (20MHz & 40MHz) - 802.11 ac(80MHz)
BT_WLAN 3	WLAN	UNII-3 MIMO	- 802.11a/n/ac (20MHz & 40MHz) - 802.11 ac(80MHz)

Table 7: Antenna supported transmitting modes

5.3. Simultaneous Transmission

Simultaneous transmission evaluation was performed according to FCC OET KDB 447498 D01 General RF Exposure Guidance v06 (October 2015). The detailed simultaneous transmission combination is:

RF Exposure Condition	Simultaneous transmission configurations
Head/Body	WWAN (LTE1/LT2) + Bluetooth LE (BTLE) + Bluetooth EDR (BT_WLAN2) + Wi-Fi 5GHz (BT_WLAN 2) + Wi-Fi 5GHz (BT_WLAN 3)

Table 8: DUT simultaneous transmission

5.4. Antenna Location

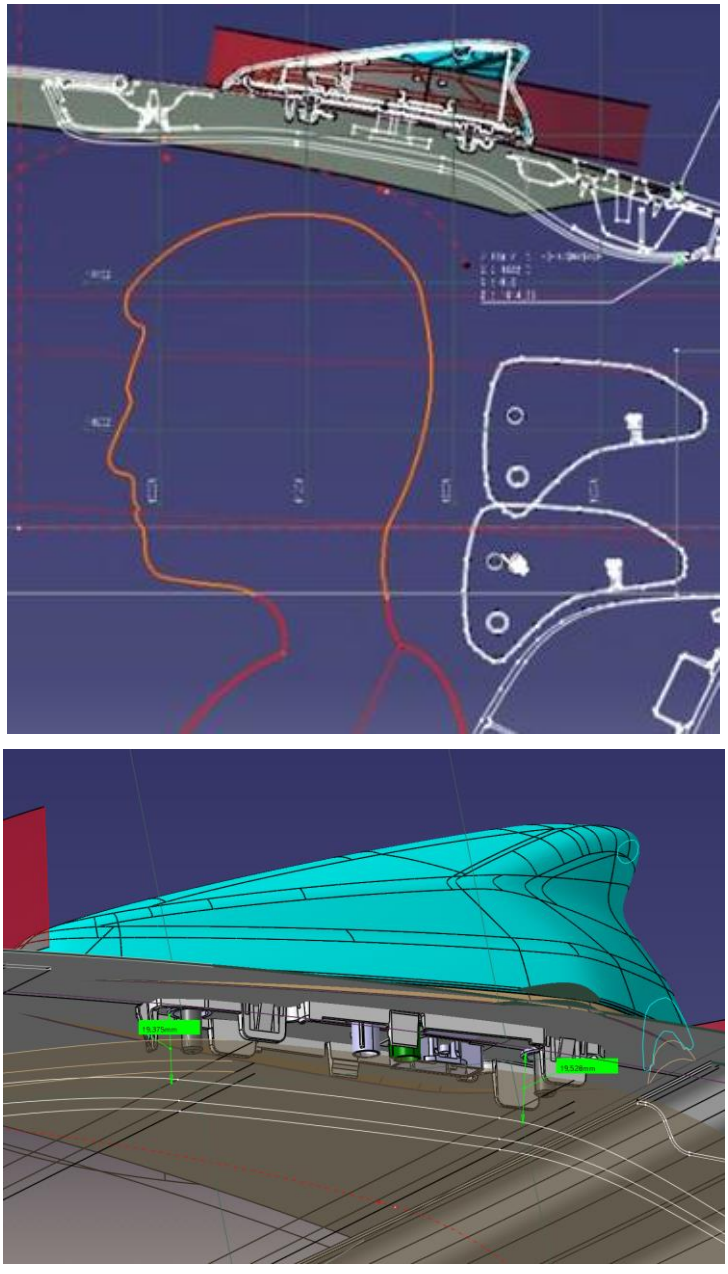


Figure 3: Shark fin (“LTE1”, “LTE2”, “BTLE”) antenna location.

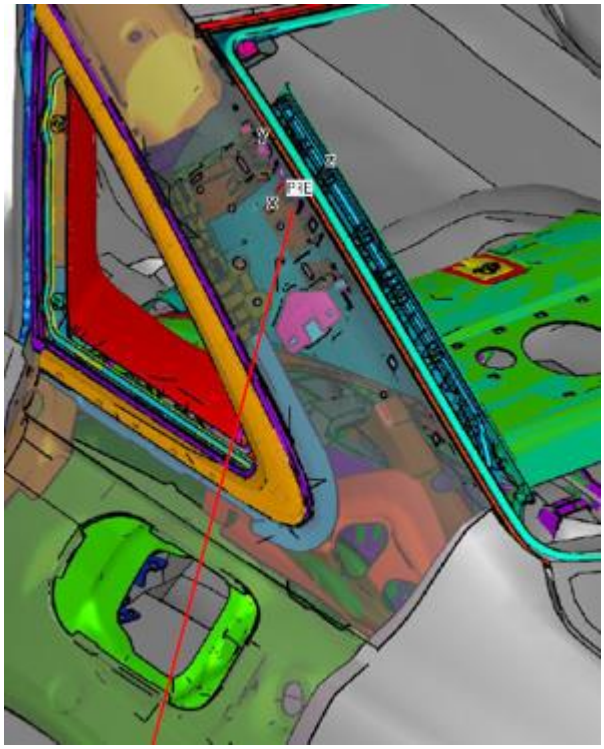


Figure 4: “BT_WLAN 2 / BT_WLAN 3” antenna location.

Appendix B: Test results

Index

1. TEST CONDITIONS

1.1. Power supply (V):

Vn = 13.2 V
Type of power supply = DC Voltage from power supply.

1.2. Temperature (ºC):

Tn = +20.00 to +25.00
The subscript n indicates normal test conditions.

1.3. DUT information and test-site configurations

For all supported modes, the back and front face of the DUT was place facing the flat phantom surface using 0 mm test separation distance for measurements for the “BT_WLAN3 antenna”.

1.4. Test signal, Output Power and Frequencies

For the 802.11a/n/ac modes, the device was put into operation by using a proprietary test mode with test commands supplied by the manufacturer, setting the maximum output power for each mode. The duty cycle was set to maximum (aprox. 100%).

In all operating bands and test positions, the measurements were performed using the channel producing the highest rated output power.

In each band, for those positions where the maximum averaged SAR was found, measurements were performed on the other applicable test frequency channels except those with applicable test reductions.

The maximum conducted time-averaged power of the device for each mode was measured with a power sensor R&S NRP-Z81.

The target power alignments, including tune-up tolerance, for RF components declared by the manufacturer for each supported technology are:

Maximum Output Power (dBm)			
Band	**802.11a**	**802.11n20/n40**	**802.11ac40/ac80**
UNII-3 SISO	10.8	10.8	10.8
UNII-3 MIMO	7.8	7.8	7.8

2. CONDUCTED AVERAGE POWER MEASUREMENTS

2.1. WLAN

Module port	TX Configuration	WLAN Mode	Band	Bandwidth (MHz)	Channel	Frequency (MHz)	Data Rate	Average Output Power (dBm)
BT_WLAN 2	SISO	802.11a	U-NII-3	20.00	149.0	5745.00	6 Mbps	9.26
					157.0	5785.00	6 Mbps	9.31
					165.0	5825.00	6 Mbps	9.38
		802.11n		20.00	149.0	5745.00	HT0	9.15
					157.0	5785.00	HT0	9.07
					165.0	5825.00	HT0	9.08
		802.11ac		20.00	149.0	5745.00	VHT0	9.19
					157.0	5785.00	VHT0	9.15
					165.0	5825.00	VHT0	9.07
		802.11n		40.00	151.0	5755.00	HT0	9.25
					159.0	5795.00	HT0	9.06
		802.11ac		40.00	151.0	5755.00	VHT0	9.06
					159.0	5795.00	VHT0	9.11
		802.11ac		80.00	155.0	5775.00	HE80	9.03
BT_WLAN 2	MIMO	802.11a	U-NII-3	20.00	149.0	5745.00	6 Mbps	6.63
					157.0	5785.00	6 Mbps	6.50
					165.0	5825.00	6 Mbps	6.56
		802.11n		20.00	149.0	5745.00	HT0	5.60
					157.0	5785.00	HT0	5.54
					165.0	5825.00	HT0	5.66
		802.11ac		20.00	149.0	5660.00	VHT0	5.67
					157.0	5745.00	VHT0	5.56
					165.0	5825.00	VHT0	5.62
		802.11n		40.00	151.0	5755.00	HT0	6.53
					159.0	5795.00	HT0	6.48
		802.11ac		40.00	151.0	5755.00	VHT0	6.51
					159.0	5795.00	VHT0	6.54
		802.11ac		80.00	155.0	5775.00	HE80	6.59

Module port	TX Configuration	WLAN Mode	Band	Bandwidth (MHz)	Channel	Frequency (MHz)	Data Rate	Average Output Power (dBm)
BT_WLAN 3	MIMO	802.11a	U-NII-3	20.00	149.0	5745.00	6 Mbps	5.12
					157.0	5785.00	6 Mbps	5.28
					165.0	5825.00	6 Mbps	5.32
		802.11n		20.00	149.0	5745.00	HT0	4.20
					157.0	5785.00	HT0	4.52
					165.0	5825.00	HT0	4.30
		802.11ac		20.00	149.0	5745.00	VHT0	4.29
					157.0	5785.00	VHT0	4.45
					165.0	5825.00	VHT0	4.54
		802.11n		40.00	151.0	5755.00	HT0	4.55
					159.0	5795.00	HT0	4.39
		802.11ac		40.00	151.0	5755.00	VHT0	4.41
					159.0	5795.00	VHT0	4.39
		802.11ac		80.00	155.0	5775.00	HE80	4.35

3. TISSUE PARAMETERS MEASUREMENTS

requency (MHz)	Target Head Tissue		Measured Head Tissue		Deviation %		Measured Date
	Permittivity ε	Conductivity σ [S/m]	Permittivity ε	Conductivity σ [S/m]	Permittivity ε	Conductivity σ [S/m]	
5200	35.99	4.66	34.10	4.27	-5.23	-8.22	2024-06-12
5500	35.64	4.96	33.79	4.56	-5.21	-8.17	2024-06-12
5800	35.30	5.27	33.38	4.85	-5.44	-7.95	2024-06-12

Note: The dielectric properties have been measured by the contact probe method at 22° C.

DASY5 and DASY6 measurement systems have a SAR error compensation algorithm to automatically compensate the measured SAR results for deviations between the measured and required tissue dielectric parameters, so the tolerance for εr and σ may be relaxed to ± 10%.

- Composition / Information on ingredients

Head and Muscle Tissue Simulation Liquids HBBL3500-5800V5/MBBL3500-5800V5

H_2O	50 – 65 %
Mineral Oil	10 – 30 %
Emulsifiers	8 – 25 %
Additives and Salt	0 – 1.5%

4. SYSTEM CHECK MEASUREMENTS

Execution Date	Frequency (MHz)	Exposure Conditions	SAR over	Fast SAR (W/Kg)	SAR (W/Kg)	1 W Target SAR (W/Kg)	1 W Nor. SAR (W/Kg)	Drift (%)
2024-06-12	5800	Head	1-g	6.71	7.72	75.70	77.20	1.98
2024-06-12	5800	Head	10-g	2.05	2.21	22.16	22.10	-0.27

5. MEASUREMENT RESULTS FOR SAR (SPECIFIC ABSORPTION RATE)

5.1. Summary maximum results for body measurements.

Mode	Side / Position	Channel (Frequency)	Reported SAR 1-g (W/kg)	Limit SAR 1-g (W/kg)
802.11a	Front face 0 mm	CH 165 (5825 MHz)	0.170	1.6

5.2. Summary maximum simultaneous multi-band transmission

Transmission Mode	Band	Reported SAR 1-g (W/kg)	Σ SARi (W/kg)	Limit SAR 1-g (W/kg)	Verdict
GPRS 2 slots	850 MHz	1.097*	1.439	1.6	Pass
BTLE	2.4 GHz	0.02*			
BT EDR	2.4 GHz	0.05*			
802.11 a/n/ac SISO	U-NII-3	0.102*			
802.11 a/n/ac MIMO	U-NII-3	0.170			

*See remarks and comments 1

5.3. WLAN

Band	Antenna	TX Config	Exposure Condition	Mode	BW (MHz)	Position	Dist (mm)	Channel	Frequency (MHz)	Estimated SAR 1-g (W/kg)	SAR 1-g (W/kg)	Power Drift (%)	Scale factor	Report. SAR 1-g (W/kg)	Limit SAR 1-g (W/kg)	Verdict	Plot No.
U-NII-3	BT_WLAN 3	MIMO	Body	802.11a	20.00	Front Face	0	165.0	5825.00	0.044	0.048	-2.276*	3.532	0.170	1.600	P	1
				802.11a	20.00	Back Face	0	165.0	5825.00	0.002*	0.000*	0.000*	3.532	0.000*	1.600	P	
				802.11n	20.00	Front Face	0	157.0	5785.00	0.036	0.038	0.000*	4.246	0.161	1.600	P	
				802.11ac	20.00	Front Face	0	165.0	5825.00	0.035	0.038	0.000*	4.227	0.161	1.600	P	
				802.11n	40.00	Front Face	0	151.0	5755.00	0.037	0.039	0.000*	4.217	0.164	1.600	P	
				802.11ac	40.00	Front Face	0	151.0	5755.00	0.027	0.024	0.000*	4.315	0.104	1.600	P	
				802.11ac	80.00	Front Face	0	155.0	5775.00	0.021	0.023	0.000*	4.365	0.100	1.600	P	
				802.11a	20.00	Front Face	0	149.0	5745.00	0.040	0.045	1.391*	3.698	0.166	1.600	P	
				802.11a	20.00	Front Face	0	157.0	5785.00	0.048	0.046	0.000*	3.565	0.164	1.600	P	

*See remarks and comments 2

DEKRA Testing and Certification, S.A.U.
Parque Tecnológico de Andalucía,
c/ Severo Ochoa nº 2 · 29590 Campanillas · Málaga · España
C.I.F. A29 507 456

Appendix C: Measurement report

Plot Nº1

Device under Test Properties

Model, Manufacturer	Dimensions [mm]	IMEI	DUT Type
Device,	86.0 x 18.0 x 14.0		Phone

Exposure Conditions

Phantom Section, TSL	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor	TSL Conductivity [S/m]	TSL Permittivity
Flat, HSL	FRONT, 0.00	U-NII-3 Standalone	WLAN, 10062-CAD	5825.0, 165	5.1	4.88	33.4

Hardware Setup

Phantom	TSL, Measured Date	Probe, Calibration Date	DAE, Calibration Date
ELI V8.0 (20deg probe tilt) - 2158	HBBL 3500-5800V5 - 5800MHz - 2024-06-12 , --	EX3DV4 - SN7766, 2023-10-17	DAE4 Sn1690, 2023-10-20

Scan Setup

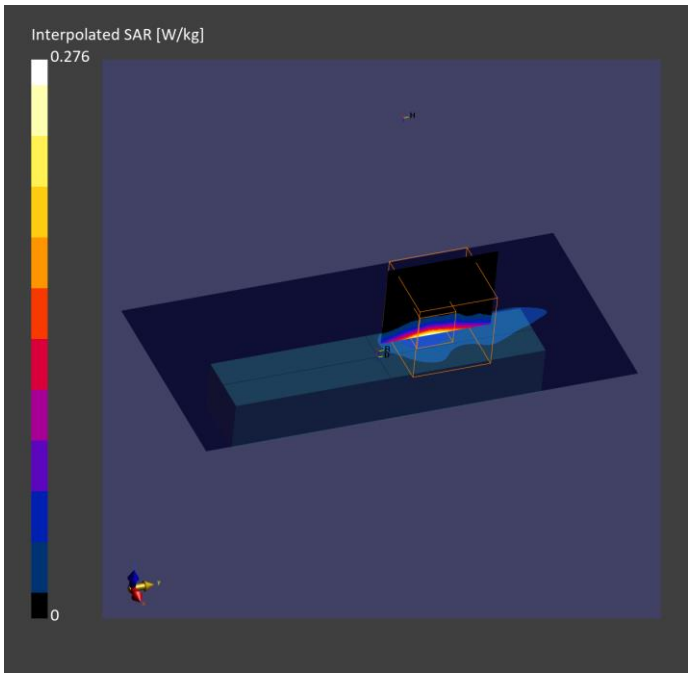
	Area Scan	Zoom Scan
Grid Extents [mm]	60.0 x 120.0	22.0 x 22.0 x 22.0
Grid Steps [mm]	10.0 x 10.0	3.4 x 3.4 x 1.4
Sensor Surface [mm]	3.0	1.4
Graded Grid	n/a	Yes
Grading Ratio	n/a	1.4
MAIA	Y	Y
Surface Detection	VMS + 6p	VMS + 6p
Scan Method	Measured	Measured

Measurement Results

	Area Scan	Zoom Scan
Date	2024-06-13, 08:14	2024-06-13, 08:30
psSAR1g [W/kg]	0.044	0.048
psSAR10g [W/kg]	0.014	0.013
Power Drift [dB]	-0.27	0.14
Power Scaling	Disabled	Disabled
Scaling Factor [dB]		
TSL Correction	Positive only	Positive only
M2/M1 [%]		55.4
Dist 3dB Peak [mm]		4.6

Warning(s) / Error(s)

Details	Area Scan	Zoom Scan
Warning(s)		
Error(s)		



Appendix D: System Validation Report

Validation results in 5800 MHz Band for Head TSL

Device under Test Properties

Model, Manufacturer	Dimensions [mm]	IMEI	DUT Type
Device,	n/a x n/a x n/a		Phone

Exposure Conditions

Phantom Section, TSL	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz], Channel Number	Conversion Factor	TSL Conductivity [S/m]	TSL Permittivity
Flat, HSL	,		CW, 0--	5800.0, 0	5.1	4.85	33.4

Hardware Setup

Phantom	TSL, Measured Date	Probe, Calibration Date	DAE, Calibration Date
ELI V8.0 (20deg probe tilt) - 2158	HBBL 3500-5800V5 - 5800MHz - 2024-06-12 , --	EX3DV4 - SN7766, 2023-10-17	DAE4 Sn1690, 2023-10-20

Scan Setup

	Area Scan	Zoom Scan
Grid Extents [mm]	40.0 x 80.0	22.0 x 22.0 x 22.0
Grid Steps [mm]	10.0 x 10.0	4.0 x 4.0 x 1.4
Sensor Surface [mm]	3.0	1.4
Graded Grid	n/a	Yes
Grading Ratio	n/a	1.4
MAIA	N/A	N/A
Surface Detection	VMS + 6p	VMS + 6p
Scan Method	Measured	Measured

Measurement Results

	Area Scan	Zoom Scan
Date	2024-06-12, 10:28	2024-06-12, 10:40
psSAR1g [W/kg]	6.71	7.72
psSAR10g [W/kg]	2.05	2.21
Power Drift [dB]	0.03	0.07
Power Scaling	Disabled	Disabled
Scaling Factor [dB]		
TSL Correction	Positive only	Positive only
M2/M1 [%]		60.3
Dist 3dB Peak [mm]		7.6

Warning(s) / Error(s)

Details	Area Scan	Zoom Scan
Warning(s)		
Error(s)