SAR Compliance Test Report

Date of Report	29/01/2024	**Client's Contact person:**	Adam Strandelin
Number of pages:	35	**Responsible Test engineer:**	Jesper Varis
Testing laboratory:	**Verkotan Oy** Elektroniikkatie 17 90590 Oulu Finland	**Client:**	**Epiroc Rock Drills AB** Sundspacken 6 97242 Luleå Sweden

Tested device	Mobilaris Companion WiFi
Related reports:	-
Testing has been carried out in accordance with:	**47CFR §2.1093** Radiofrequency Radiation Exposure Evaluation: Portable Devices **FCC published RF exposure KDB procedures** **RSS-102, Issue 5** Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
Documentation:	The test report must always be reproduced in full; reproduction of an excerpt only is subject to written approval of the testing laboratory
Test Results:	**The EUT complies with the requirements in respect of all parameters subject to the test**. The test results relate only to devices specified in this document

Date and signatures:

29.01.2024

Miia Nurkkala

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1. SUMMARY OF SAR TEST REPORT

1.1 Test Details

Equipment under Test (EUT):

Product:	Mobilaris Companion WiFi
Manufacturer:	Epiroc Rock Drills AB
Model:	Mobilaris Companion WiFi
Serial Number:	P0027, P0028, P0029, 000103
FCC ID:	2A93V-466F
ISED ID:	29959-466F
Hardware Version:	466F
DUT Number:	21514, 21515, 21516, 21307
Battery Type used in testing:	Integrated battery
State of the Sample	Production sample

Testing information:

Testing performed:	10.10.2022 – 14.10.2022, 29-30.3.2023
Notes:	-
Document history:	This report replaces test report FCC_ISED SAR Report_Mobilaris_ID6057_05042023. Section 3.1 and 3.2 WLAN power updates Section 4.1 equipment list updated Section 4.5.1 Tissue Simulant Verification table updated Section 7 maximum output power revised
Document ID:	FCC_ISED SAR Report_Mobilaris_ID6057_2512024.docx
Temperature °C	22±2 / Controlled
Humidity RH%	30±20 / Controlled
Measurement performed by:	Jesper Varis
FCC Test Firm Designation Number	FI0005
ISED Company Number	22218

1.2 Maximum Results

The maximum reported* SAR values for Body-worn configuration for transmitting systems are shown in a table below. The device conforms to the requirements of the standards when the maximum reported SAR value is less than or equal to the limit. The SAR limit specified in FCC 47 CFR part 2 (2.1093) and Health Canada's RF exposure guideline, Safety Code 6 for Body-worn SAR_{1g} is 1.6 W/kg.

1.2.1 Standalone SAR

System	Highest Reported* SAR_{1g}(W/kg) in Body-Worn Condition, 5 mm separation distance	Result
WLAN 2.4 GHz	**0.71**	**PASS**
Bluetooth LE	**0.016**	**PASS**

*Reported SAR Values are scaled to upper limit of power tolerance.

1.2.2 Simultaneous Transmission

Highest Simultaneous Transmission SAR	Highest Reported* SAR_{1g}(W/kg) in Body-Worn Condition, 5 mm separation distance	Result
WLAN 2.4 GHz + Bluetooth LE	**0.73**	**PASS**

1.2.3 Maximum Drift

Maximum Drift During Measurements	**0.66dB***

*Larger than 5% drifts included to scaling factors

1.2.4 Measurement Uncertainty

Expanded Uncertainty (k=2) 95 %	**±22.1 %**

2. DESCRIPTION OF THE DEVICE UNDER TEST (DUT)

The DUT is a mining tag intended to be used as a tracker with capability to report Bluetooth sensor data over a wireless interface to a back-end server.

Device Category	Portable
Exposure Environment	General population, uncontrolled

2.1 Supported Frequency Bands and Operational Modes

TX Frequency bands	**Modes of Operation**	**Transmitter Frequency Range (MHz)**
	2.4 GHz WLAN	2412-2462
	Bluetooth LE	2402 - 2480

2.2 Simultaneous Transmission

WLAN 2.4GHz and Bluetooth LE can be operated simultaneously.

3. OUTPUT POWER

3.1 Maximum specified conducted output power

From a Customer, including tune-up tolerance;

WLAN 2.4GHz	Max Output Power [dBm]
802.11b	15.4
802.11g	15
802.11n	14.9

Bluetooth LE	Max Output Power [dBm]
BLE	5

3.2 Tested conducted power

WLAN 2.4 GHz:

Standard	Transmission mode	Data rate [Mbps]	Output power [dBm]		
			CH 1 2412 MHz	CH 6 2437 MHz	CH 11 2462 MHz
802.11b	DSSS	1	14.31	14.25	13.97

Bluetooth LE:

Standard	Output power [dBm]		
	CH 37 2402 MHz	CH 17 2440 MHz	CH 39 2480 MHz
BLE	4.19	3.79	3.39

4. TEST EQUIPMENT

Dasy52 near field scanning system, manufactured by SPEAG was used for SAR testing. The test system consists of high precision robotics system (Staubli), robot controller, computer, near-field probe, probe alignment sensor, and a phantom containing the tissue equivalent material. The robot is a six-axis industrial robot performing precise movements to position the probe to the location of maximum electromagnetic field.

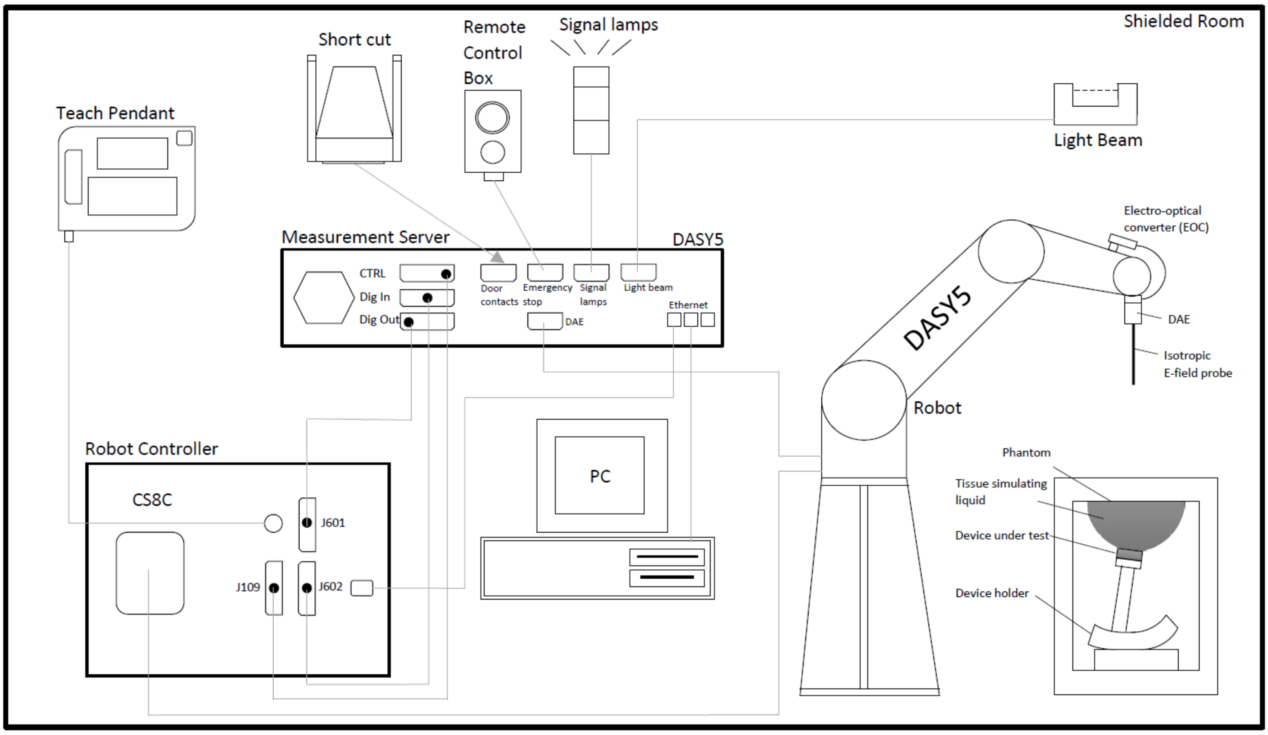


Figure 1 Schematic Laboratory Picture

4.1 Test Equipment List

Main used test system components are listed below. For full equipment list and calibration intervals, please contact the testing laboratory.

Test Equipment	Model	Serial Number	Calibration Date
DAE	DAE4	705	04.2022
Probe	EX3DV4	3892	04.2022
Probe	EX3DV4	7447	02.2023
Dipole	D2450V2	729	07.2022
DASY5 Software	52.8.8.1258	-	NA
Signal Generator	Agilent E4438C	MY42082527	NA
Amplifier	AR 10S1G4A	320421	NA
Power Sensor	R&S NRP-Z11	100265	12.2021
Power Sensor	Anritsu MA24105A	2102058	11.2021
Power Sensor	Anritsu MA24105A	2102058	11.2022
Thermometer	Rotronic, Hygropalm3	21458349	11/2022
tissue simulant	HBBL600-10000V6	191029-1	N/A
Triple Modular Phantom	QD000 P51 CA	1128/2	N/A

4.1.1 Isotropic E-field Probe Type EX3DV4

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	Calibration certificate in Appendix D
Frequency	10 MHz to >6 GHz (dosimetry); 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: ± 0.2 dB
Dimensions	Overall length: 330 mm Tip length: 10 mm Body diameter: 12 mm
Application	General dosimetry up to 6 GHz Compliance tests of mobile phones Fast automatic scanning in arbitrary phantoms

4.2 Phantom

The Triple Modular Phantom consists of three identical modules that can be installed and removed separately without emptying the liquid. It is used for compliance testing of small wireless devices in body-worn configurations. The shell thickness of the bottom plate is 2±0.2mm. The dimensions are 308x192x182mm and filling volume is 9.2 liters giving a filling height of 155mm.

4.3 Tissue Simulants

Recommended values for the dielectric parameters of the tissue simulants are given in IEEE 1528 and FCC published RF Exposure KDB Procedures. The dielectric parameters of the used tissue simulants were within ±10% of the recommended values. A liquid compensation algorithm was used in DASY5 with which measured peak average SAR values were corrected for the deviation of used liquid. Depth of the tissue simulant was at least 15.0 cm from the inner surface of the flat phantom. Tissue simulant consists of:

Head 600 – 6000 MHz tissue simulant liquid Ingredients
Deionized Water, oil, salt, emulsifiers

4.4 System Validation Status

Frequency [MHz]	Dipole Type / SN	Probe Type / SN	Calibrated Signal Type	DAE Unit / SN	Dielectric Constant ε	Conductivity, σ [S/m]	Validation Done
							Head tissue simulant
2450	D2450V2 - SN: 758	EX3DV4 - SN: 3892	CW	DAE 4 / 705	39.13	1.70	04.2022
2450	D2450V2 - SN: 758	EX3DV4 - SN: 7447	CW	DAE 4 / 1332	41.26	1.71	03.2023

4.5 System Check

Date	Tissue Type	Tissue Temp. [°C]	Frequency [MHz]	Input Power	Measured SAR_{1g} [W/kg]	1 W Target SAR_{1g} [W/kg]	1 W Normalized SAR_{1g} [W/kg]	Deviation (%)	Plot #
11.10.2022	WB Head	22	2450	250	12.6	52.3	50.4	-3.63	1
13.10.2022	WB Head	22	2450	250	12.5	52.3	50	-4.40	2
29.3.2023	WB Head	22	2450	250	11.8	52.3	47.2	-9.75	3

4.5.1 Tissue Simulant Verification

				Target		Measured		Deviation	
Date	Tissue Type	Tissue Temp. [°C]	Frequency [MHz]	Dielectric Constant [ε]	Conductivity, σ [S/m]	Dielectric Constant [ε]	Conductivity, σ [S/m]	ε (%)	σ (%)
11.10.2022*	WB Head	22	2412	39.27	1.77	38.24	1.68	-2.6	-4.7
11.10.2022*	WB Head	22	2437	39.22	1.79	38.19	1.70	-2.6	-5.0
11.10.2022*	WB Head	22	2450	39.2	1.8	38.17	1.71	-2.6	-5.0
11.10.2022*	WB Head	22	2462	39.18	1.81	38.16	1.72	-2.6	-5.4
12.10.2022**	WB Head	22	2402	39.29	1.76	39.25	1.69	-0.1	-3.8
12.10.2022**	WB Head	22	2440	39.22	1.79	39.18	1.72	-0.1	-4.2
12.10.2022**	WB Head	22	2450	39.2	1.8	39.16	1.72	-0.1	-4.3
12.10.2022**	WB Head	22	2480	39.16	1.83	39.11	1.74	-0.1	-5.0
29.3.2023	WB Head	22	2412	39.27	1.77	39.66	1.63	1.1	-7.6
29.3.2023	WB Head	22	2437	39.22	1.79	39.62	1.65	1.0	-8.0
29.3.2023	WB Head	22	2450	39.2	1.8	39.61	1.65	1.0	-8.1

* Dielectric parameters measured on 11.10.2022 at 14.03 PM were used SAR measurements done on 11 -12.10.2022.

**Dielectric parameters measured on 12.10.2022 at 16.03PM were used in the system check and SAR measurements done on 13.10.2022.

5. TEST PROCEDURE

Testing was carried out in accordance with FCC KDB Publications 447498 D01, 248227 D01 and Industry Canada RSS-102.

For WLAN and Bluetooth transmission, a control software was used to set the DUT to transmit at maximum power and maximum duty cycle. The maximum duty cycle used in WLAN 2.4GHz SAR testing was 100% and 83.3% in Bluetooth.

The WLAN transmission modes for testing were selected according to power, largest channel bandwidth configuration, lowest order modulation and lowest data rate. 2.4GHz WLAN was tested with 802.11b standard with data rate of 1Mbps.

5.1 Spot Check Measurements

The DUT was fully tested in October 2022. After the testing customer made changes on the DUT's HW, where a mosfet resistor and a high-power LED were patched on the board. The effect of these changes on SAR results were examined by remeasuring SAR of the worst-case configuration already measured.

5.2 Test Positions

5.2.1 Body-Worn Configuration, 5 mm separation

The device was placed on the device holder and lifted towards the phantom until the distance between the phantom and the device was 5mm. Testing was done on all the six sides of the DUT. Photos of the test positions are presented in appendix A.

5.3 Scan Procedures

First, area scans were used for determination of the field distribution. Next, a zoom scan was performed around the highest E-field value to determine the averaged SAR value. Drift was determined by measuring the same point at the start of the area scan and again at the end of the zoom scan.

5.4 SAR Averaging Methods

The maximum SAR value was averaged over a cube of tissue using interpolation and extrapolation.

The interpolation, extrapolation and maximum search routines within Dasy52 are all based on the modified Quadratic Shepard's method (Robert J. Renka," Multivariate Interpolation of Large Sets of Scattered Data", University of North Texas ACM Transactions on Mathematical Software, vol. 14, no. 2, June 1988, pp. 139-148).

The interpolation scheme combines a least-square fitted function method with a weighted average method. A trivariate 3-D / bivariate 2-D quadratic function is computed for each measurement point and fitted to neighboring points by a least-square method. For the zoom scan, inverse distance weighting is incorporated to fit distant points more accurately. The interpolating function is finally calculated as a weighted average of the quadratics.

In the zoom scan, the interpolation function is used to extrapolate the Peak SAR from the deepest measurement points to the inner surface of the phantom.

6. MEASUREMENT UNCERTAINTY

DASY5 Uncertainty Budget
According to IEC/IEEE 62209-1528
(Frequency band: 300MHz - 3GHz range)

Symbol	Error Description	Uncert. value	Prob. Dist.	Div.	(c_i) 1g	(c_i) 10g	Std. Unc. (1g)	Std. Unc. (10g)
Measurement System Errors								
CF	Probe Calibration	±12.0%	N	√2	1	1	±6.0%	±6.0%
CFdrift	Probe Calibration Drift	±1.7%	R	√3	1	1	±1.0%	±1.0%
LIN	Probe Linearity	±4.7%	R	√3	1	1	±2.7%	±2.7%
BBS	Broadband Signal	±3.0%	R	√3	1	1	±1.7%	±1.7%
ISO	Probe Isotropy	±7.6%	R	3	1	1	±4.4%	±4.4%
DAE	Data Acquisition	±0.3%	N	1	1	1	±0.3%	±0.3%
AMB	RF Ambient	±1.8%	N	1	1	1	±1.8%	±1.8%
Δsys	Probe Positioning	±3.9%	N	1	0.14	0.14	±0.5%	±0.5%
DAT	Data Processing	±1.2%	N	1	1	1	±1.2%	±1.2%
Phantom and Device Errors								
LIQ(σ)	Conductivity (meas.)[DAK]	±2.5%	N	√1	0.78	0.71	±2.0%	±1.8%
LIQ(T_σ)	Conductivity (temp.)[BB]	±3.3%	R	√3	0.78	0.71	±1.5%	±1.4%
EPS	Phantom Permittivity	±14.0%	R	3	0	0	±0%	±0%
DIS	Distance DUT - TSL	±2.0%	N	1	2	2	±4.0%	±4.0%
Dxyz	Device Positioning (±0.5mm)	±1.0%	N	1	1	1	±1.0%	±1.0%
H	Device Holder	±3.6%	N	√1	1	1	±3.6%	±3.6%
MOD	DUT Modulation[m]	±2.4%	R	√3	1	1	±1.4%	±1.4%
TAS	Time-average SAR	±2.6%	R	3	1	1	±1.5%	±1.5%
RFdrift	DUT drift	±2.5%	N	1	1	1	±2.5%	±2.5%
VAL	Val Antenna Unc.[val]	±0.0%	N	1	1	1	±0%	±0%
RF_{in}	Unc. Input Power[val]	±0.0%	N	1	1	1	±0%	±0%
Correction to the SAR results								
C(ε, σ)	Deviation to Target	±1.9%	N	√1	1	0.84	±1.9%	±1.6%
C(R)	SAR scaling[p]	±0%	R	3	1	1	±0%	±0%
u(ΔSAR)	Combined Uncertainty						±11.0%	±10.9%
U	**Expanded Uncertainty**						±22.1%	±21.9%

7. TEST RESULTS

7.1 SAR Results for Body-Worn Condition with 5mm separation

WLAN 2.4:

Mode	Data Rate [Mbps]	Channel	Frequency [MHz]	Maximum Power [dBm]	Conducted Power [dBm]	Test Position	Measured SAR_{1g} [W/kg]	Power Drift [dB]	Duty Cycle [%]	Scaling Factor	Reported SAR_{1g} [W/kg]	Plot #
802.11b	1	1	2412	15.4	14.31	Front	0.51	0.13	100	1.29	0.66	
802.11b	1	1	2412	15.4	14.31	Back	0.39	0.01	100	1.29	0.50	
802.11b	1	1	2412	15.4	14.31	Left	0.14	-0.11	100	1.29	0.18	
802.11b	1	1	2412	15.4	14.31	Right	0.01	0.17	100	1.29	0.02	
802.11b	1	1	2412	15.4	14.31	Top	0.35	-0.02	100	1.29	0.45	
802.11b	1	1	2412	15.4	14.31	Bottom	0.01	0.08	100	1.29	0.02	
802.11b	1	6	2437	15.4	14.25	Front	0.55	-0.16	100	1.30	0.71	4
802.11b	1	11	2462	15.4	13.97	Front	0.48	-0.19	100	1.39	0.67	

Bluetooth:

Mode	Channel	Frequency [MHz]	Maximum Power [dBm]	Conducted Power [dBm]	Test Position	Measured SAR_{1g} [W/kg]	Power Drift* [dB]	Duty Cycle [%]	Scaling Factor	Reported SAR_{1g} [W/kg]	Plot #
BLE	37	2402	5	4.19	Front	0.014	-0.03	83.3	1.21	0.016	5
BLE	37	2402	5	4.19	Back	0.008	0.53	83.3	1.36	0.012	
BLE	37	2402	5	4.19	Left	0.0008	0.66	83.3	1.40	0.001	
BLE	37	2402	5	4.19	Right	0.012	0.11	83.3	1.21	0.014	
BLE	37	2402	5	4.19	Top	0.011	-0.22	83.3	1.27	0.014	
BLE	37	2402	5	4.19	Bottom	0.000004	-0.17	83.3	1.21	0.000005	
BLE	17	2440	5	3.79	Front	0.012	-0.08	83.3	1.32	0.016	
BLE	39	2480	5	3.39	Front	0.010	-0.19	83.3	1.45	0.015	

*Larger than 5% drifts included to scaling factors

7.2 Spot Check Measurements

One version of the DUT was fully tested above. Another version, where a mosfet resistor and a high-power LED were patched on the board, was examined by remeasuring SAR in the worst-case configuration.

The spot check measurement showed no significant chance in SAR values.

Mode	Data Rate [Mbps]	Channel	Frequency [MHz]	Maximum Power [dBm]	Conducted Power [dBm]	Test Position	Original DUT Measured SAR_{10g} [W/kg]	DUT with changes on the board Measured SAR_{10g} [W/kg]
802.11b	1	1	2412	15.4	14.31	Top	0.35	0.31
802.11b	1	1	2412	15.4	14.31	Back	0.39	0.31
802.11b	1	6	2437	15.4	14.25	Front	0.55	0.58

7.3 Simultaneous Transmission

Simultaneous transmission analysis for maximum WLAN 2.4GHz SAR and maximum Bluetooth SAR is in a table below. Direct summation of SAR results was performed.

Exposure Condition	Body SAR_{1g} [W/kg]					
Test Position	Front	Back	Left	Right	Top	Bottom
WLAN 2.4GHz	0.71	0.50	0.18	0.02	0.45	0.02
Bluetooth LE	0.016	0.012	0.001	0.014	0.014	0.000005
SAR Summation	0.73	0.51	0.18	0.03	0.46	0.02

7.4 IEC 62209-2 AMD1:2019

According to IEC 62209-2 AMD1:2019, the zoom scan complies if the peak spatial-average SAR is below 0.1 W/kg, or if the following criteria is met:

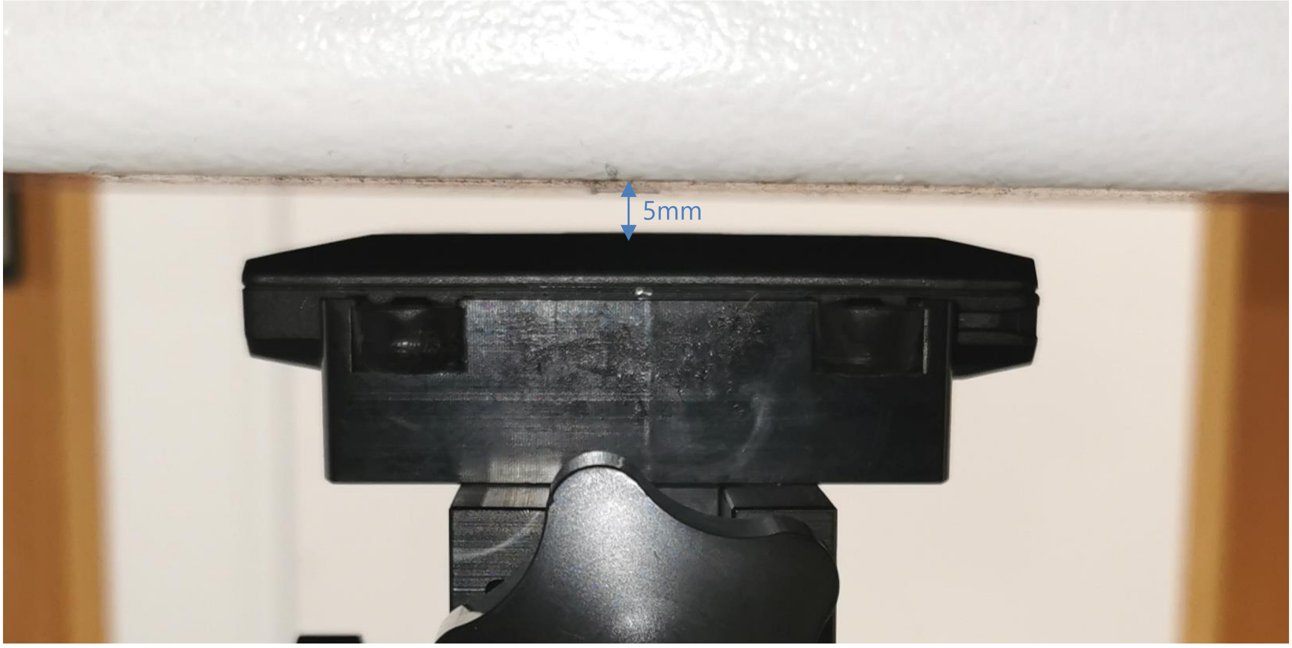
1. The smallest horizontal distance from the local SAR peaks to all points 3 dB below the SAR peak is larger than the horizontal grid step.

2. Ratio of SAR at the second measured point (M2) to the SAR at the closest measured point (M1) at the x-y location of the measured maximum is at least 30%.

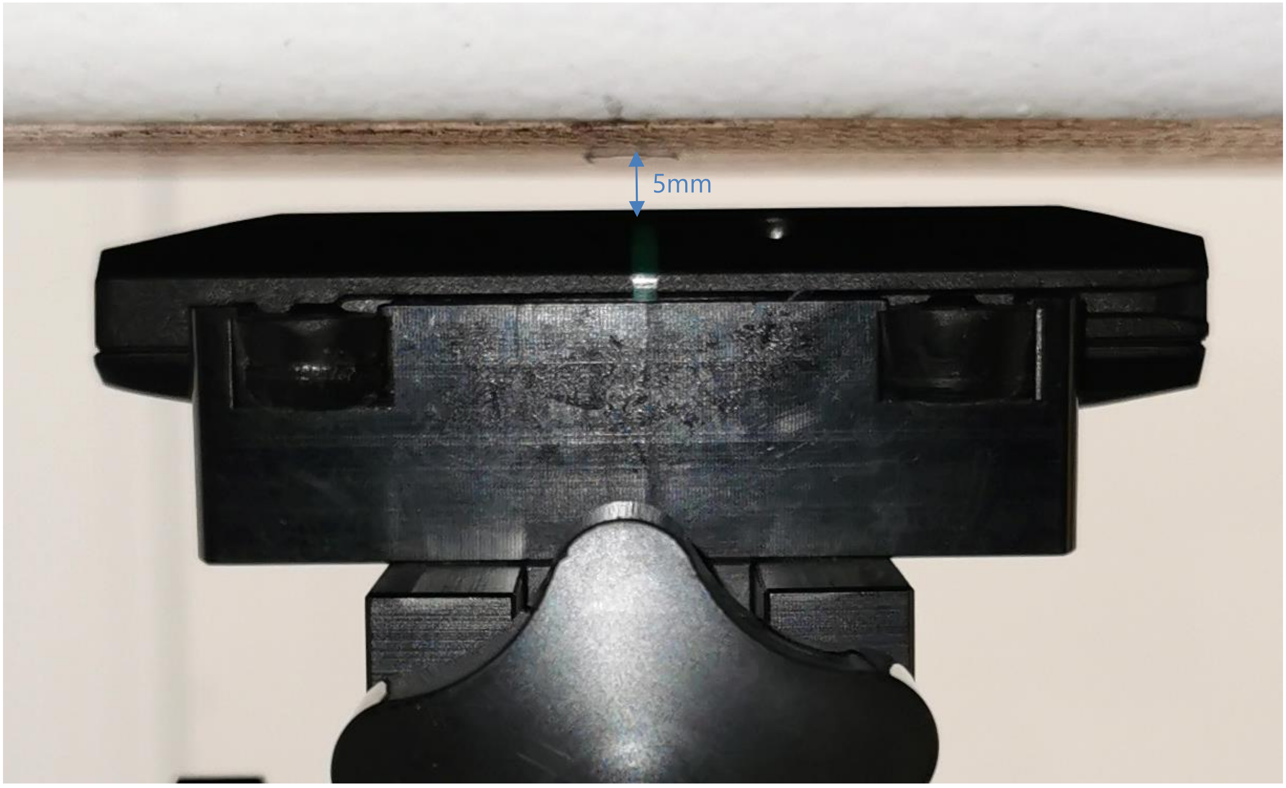
Zoom scan compliance according to IEC 62209-2 AMD1:2019 is automatically verified by DASY5 software and all zoom scans in this test report do pass the criteria. The smallest horizontal distance and Ratio between measurement points M2 and M1 of the highest SAR results is available in Appendix C.

APPENDIX A: PHOTOS OF THE DUT

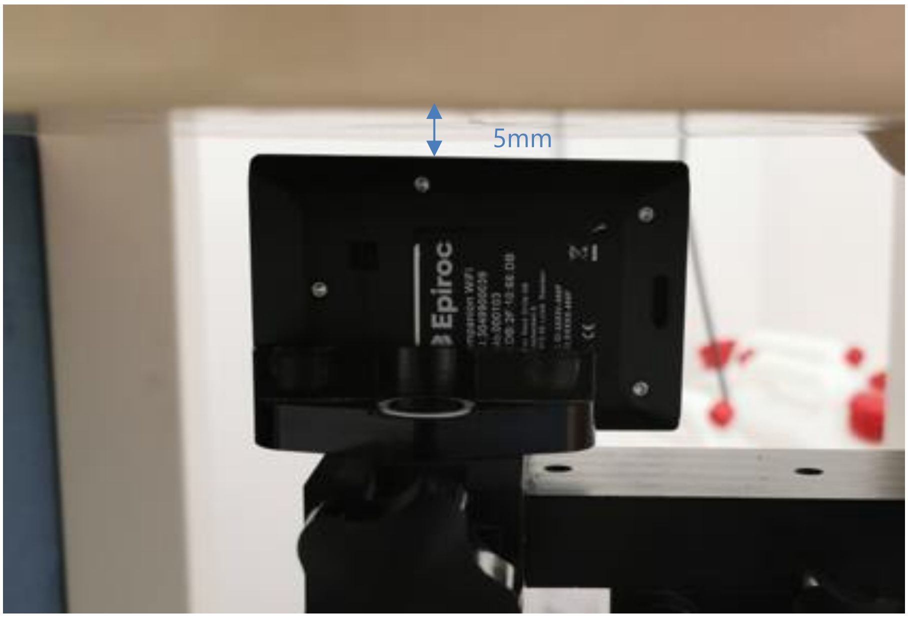
Size of the DUT is maximum 90 x 60 x 15 mm.



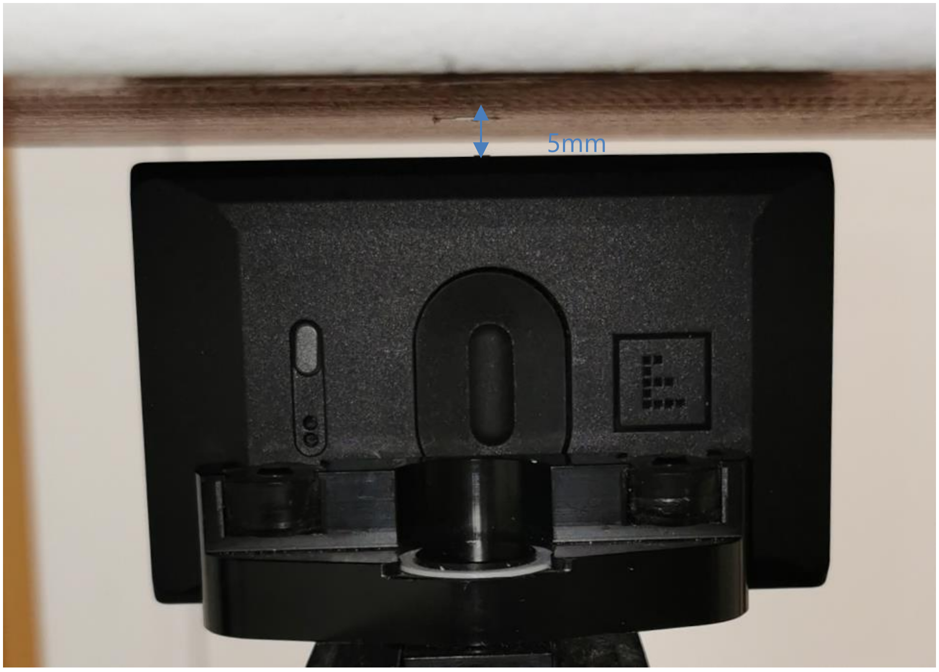
Front side of the device against the phantom, 5 mm separation distance



Back side of the device against the phantom, 5mm separation distance



Left side of the device against the phantom, 5mm separation distance



Right side of the device against the phantom, 5 mm separation distance

Top side of the device against the phantom, 5 mm separation distance

Bottom side of the device against the phantom, 5mm separation distance

APPENDIX B: SYSTEM CHECK SCANS

Plot 1

Date/Time: 11.10.22 14:42:01

Test Laboratory: Verkotan Oy

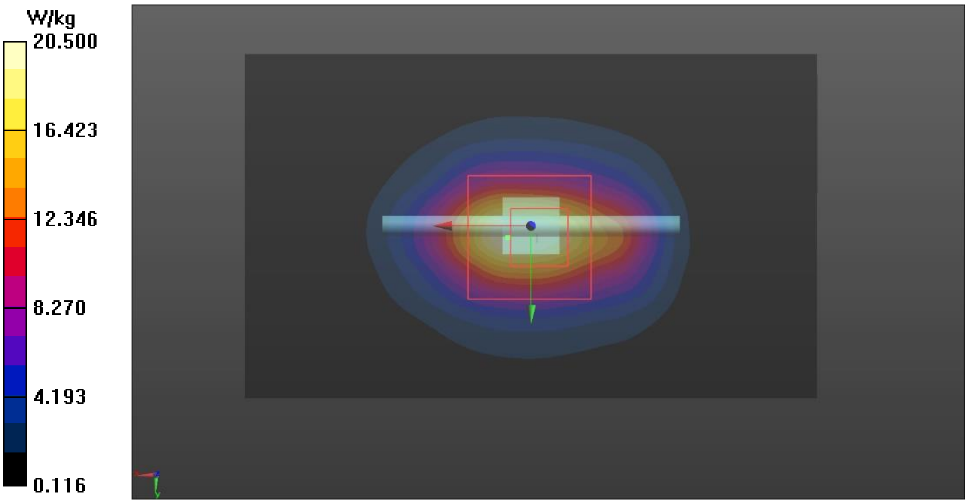
DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:729

Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;
Communication System PAR: 0 dB;
Medium parameters used (interpolated): f = 2450 MHz; σ = 1.709 S/m; ε_r = 38.175; ρ = 1000 kg/m^3
Phantom section: Center Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.66, 7.66, 7.66) @ 2450 MHz; Calibrated: 12.4.22
    - Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 31.0, -4.0
    - Electronics: DAE4 Sn705; Calibrated: 12.4.22
    - Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx;
    - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Configuration/system check 2450MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 90.86 V/m; Power Drift = -0.16 dB
Peak SAR (extrapolated) = 25.0 W/kg
SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.94 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 50.2%
Maximum value of SAR (measured) = 20.5 W/kg
Configuration/system check 2450MHz/Area Scan (101x61x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 20.4 W/kg



Plot 2

Date/Time: 13.10.22 08:33:18

Test Laboratory: Verkotan Oy

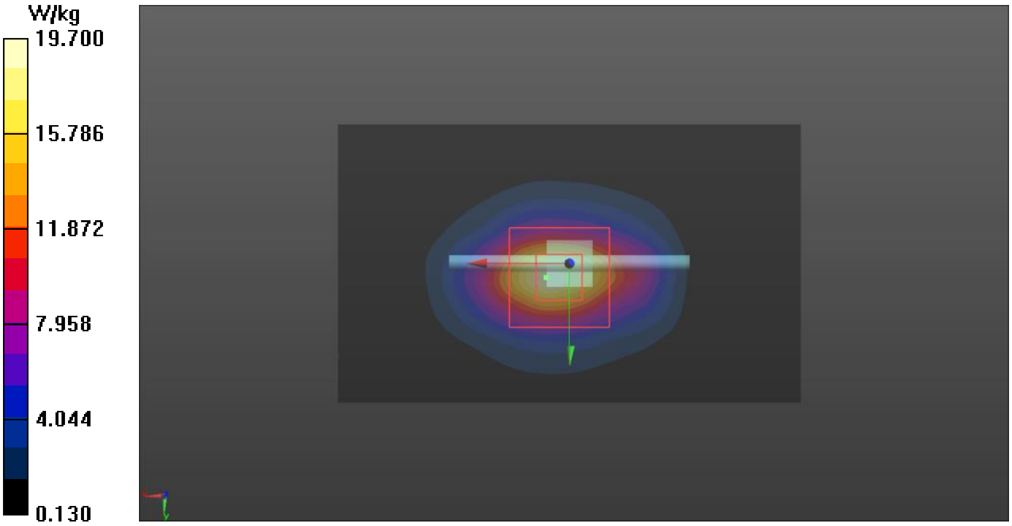
DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:729

Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;
Communication System PAR: 0 dB;
Medium parameters used (interpolated): f = 2450 MHz; σ = 1.722 S/m; ε_r = 39.159; ρ = 1000 kg/m^3
Phantom section: Center Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.66, 7.66, 7.66) @ 2450 MHz; Calibrated: 12.4.22
  - Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 31.0, -4.0
  - Electronics: DAE4 Sn705; Calibrated: 12.4.22
  - Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Configuration/system check 2450MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 88.18 V/m; Power Drift = -0.13 dB
Peak SAR (extrapolated) = 24.2 W/kg
SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.91 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 50.6%
Maximum value of SAR (measured) = 19.7 W/kg
Configuration/system check 2450MHz/Area Scan (101x61x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 21.3 W/kg



Plot 3

Date/Time: 29.3.23 14:54:25

Test Laboratory: Verkotan Oy

DUT: D2450V2 - SN729; Type: D2450V2; Serial: SN729

Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;
Communication System PAR: 0 dB;
Medium parameters used: f = 2450 MHz; σ = 1.654 S/m; ε_r = 39.61; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY Configuration:

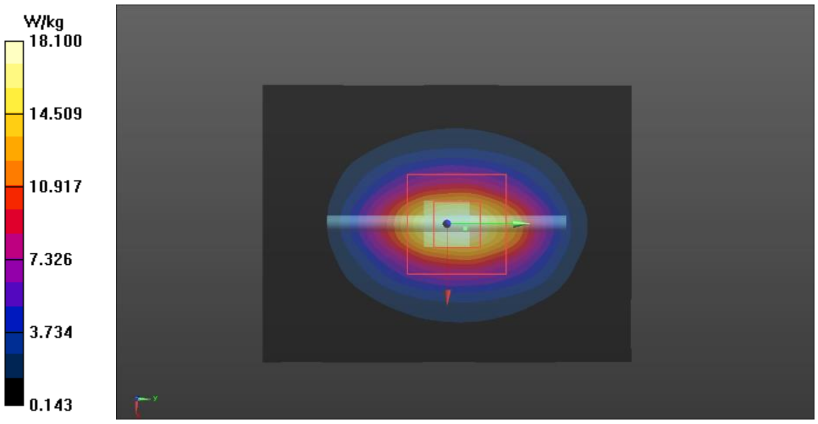
- Probe: EX3DV4 - SN7447; ConvF(7.7, 7.5, 7.63) @ 2450 MHz; Calibrated: 17.2.23
  - Sensor-Surface: 1.4mm (Mechanical Surface Detection), Sensor-Surface: 1.4mm (Mechanical Surface Detection (Locations From Previous Scan Used)), z = 31.0, -4.0
  - Electronics: DAE4 Sn1332; Calibrated: 15.2.23
  - Phantom: SAR1_Phantom1_ELI; Type: QD OVA 002 AA;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Configuration/system check 2450Mhz 2/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 108.0 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 21.6 W/kg
SAR(1 g) = 11.8 W/kg; SAR(10 g) = 5.57 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 9 mm
Ratio of SAR at M2 to SAR at M1 = 53.2%

Maximum value of SAR (measured) = 18.1 W/kg

Configuration/system check 2450Mhz 2/Area Scan (61x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 18.3 W/kg



APPENDIX C: MEASUREMENT SCANS

Plot 4

Date/Time: 12.10.22 15:14:14

Test Laboratory: Verkotan Oy

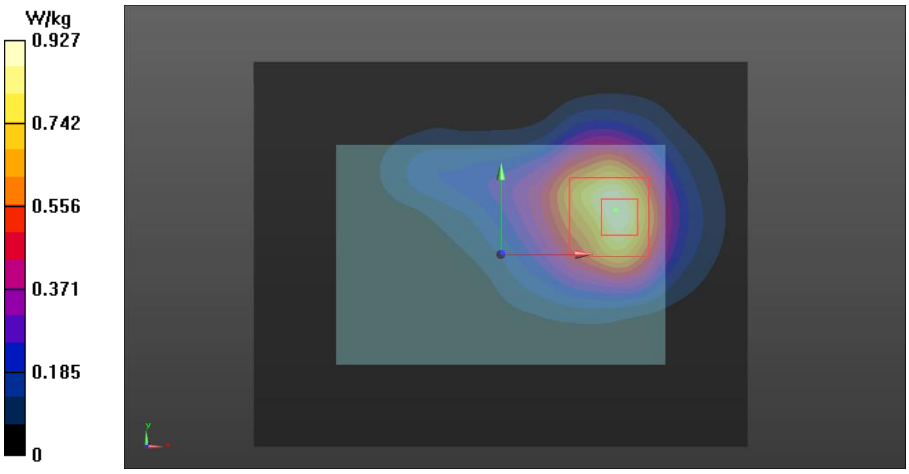
DUT: Mobilaris

Communication System: UID 0, WLAN 2.4 (0); Communication System Band: WLAN2.4GHz; Frequency: 2437 MHz;
Communication System PAR: 0 dB;
Medium parameters used (interpolated): f = 2437 MHz; σ = 1.699 S/m; ε_r = 38.192; ρ = 1000 kg/m^3
Phantom section: Center Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.66, 7.66, 7.66) @ 2437 MHz; Calibrated: 12.4.22
  - Sensor-Surface: 1.4mm (Mechanical Surface Detection (Locations From Previous Scan Used)), Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = -4.0, 31.0
  - Electronics: DAE4 Sn705; Calibrated: 12.4.22
  - Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Configuration/WLAN 2.4GHz , MID CH 6, Data Rate 1 Mbps, Front 5mm/Area Scan (91x71x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.927 W/kg
Configuration/WLAN 2.4GHz , MID CH 6, Data Rate 1 Mbps, Front 5mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 8.041 V/m; Power Drift = -0.16 dB
Peak SAR (extrapolated) = 0.961 W/kg
SAR(1 g) = 0.547 W/kg; SAR(10 g) = 0.295 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 12 mm
Ratio of SAR at M2 to SAR at M1 = 55.7%
Maximum value of SAR (measured) = 0.797 W/kg



Plot 5

Date/Time: 13.10.22 15:25:03

Test Laboratory: Verkotan Oy

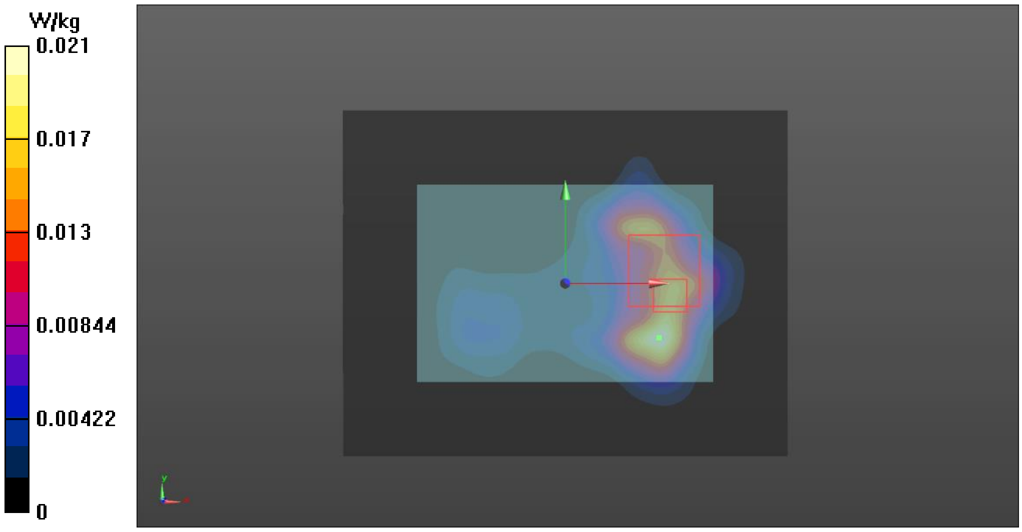
DUT: Mobilaris

Communication System: UID 0, Bluetooth (0); Communication System Band: BLE; Frequency: 2402 MHz;
Communication System PAR: 4.771 dB;
Medium parameters used (interpolated): f = 2402 MHz; σ = 1.691 S/m; ε_r = 39.258; ρ = 1000 kg/m^3
Phantom section: Center Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN3892; ConvF(7.66, 7.66, 7.66) @ 2402 MHz; Calibrated: 12.4.22
  - Sensor-Surface: 1.4mm (Mechanical Surface Detection), Sensor-Surface: 1.4mm (Mechanical Surface Detection (Locations From Previous Scan Used)), z = 31.0, -4.0
  - Electronics: DAE4 Sn705; Calibrated: 12.4.22
  - Phantom: MFP_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Configuration/FCC BLE LOW CH 37,Front 5mm/Zoom Scan (8x11x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 2.534 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 0.0280 W/kg
SAR(1 g) = 0.0135 W/kg; SAR(10 g) = 0.00643 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below: Larger than measurement grid
Ratio of SAR at M2 to SAR at M1 = 43.1%
Maximum value of SAR (measured) = 0.0211 W/kg
Configuration/FCC BLE LOW CH 37,Front 5mm/Area Scan (91x71x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.0395 W/kg



APPENDIX D: RELEVANT PAGES FROM PROBE CALIBRATION REPORTS

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accreditation No.: **SCS 0108**

Client Verkotan

Certificate No: EX3-3892_Apr22

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3892
Calibration procedure(s)	QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v6, QA CAL-23.v5, QA CAL-25.v7 Calibration procedure for dosimetric E-field probes
Calibration date:	April 12, 2022

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: CC2552 (20x)	04-Apr-22 (No. 217-03527)	Apr-23
DAE4	SN: 660	13-Oct-21 (No. DAE4-660_Oct21)	Oct-22
Reference Probe ES3DV2	SN: 3013	27-Dec-21 (No. ES3-3013_Dec21)	Dec-22
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-20)	In house check: Jun-22
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Aidonia Georgiadou	Laboratory Technician	
Approved by:	Sven Kühn	Deputy Manager	

Issued: April 12, 2022

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Certificate No: EX3-3892_Apr22 Page 1 of 9

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3892

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (μV/(V/m)²)[A]	0.47	0.38	0.47	± 10.1 %
DCP (mV)[B]	102.0	105.5	101.6	

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Max dev.	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	154.3	± 3.0 %	± 4.7 %
		Y	0.0	0.0	1.0		165.8		
		Z	0.0	0.0	1.0		158.8		

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 5).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3892

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) C	Relative Permittivity F	Conductivity (S/m) F	ConvF X	ConvF Y	ConvF Z	Alpha G	Depth G (mm)	Unc (k=2)
600	42.7	0.88	10.43	10.43	10.43	0.10	1.25	± 13.3 %
750	41.9	0.89	10.26	10.26	10.26	0.48	0.80	± 12.0 %
900	41.5	0.97	9.95	9.95	9.95	0.36	0.91	± 12.0 %
1900	40.0	1.40	8.31	8.31	8.31	0.29	0.86	± 12.0 %
2450	39.2	1.80	7.66	7.66	7.66	0.33	0.90	± 12.0 %
2600	39.0	1.96	7.55	7.55	7.55	0.39	0.90	± 12.0 %
4400	36.9	3.84	6.08	6.08	6.08	0.40	1.60	± 13.1 %
4800	36.4	4.25	5.65	5.65	5.65	0.40	1.80	± 13.1 %

C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz.
F At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.
G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

Calibration Laboratory of
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Accreditation No.: SCS 0108

Client Verkotan

Certificate No EX-7447_Feb23

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7447
Calibration procedure(s)	QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6, QA CAL-25.v8 Calibration procedure for dosimetric E-field probes
Calibration date	February 17, 2023

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
OCP DAK-3.5 (weighted)	SN: 1249	20-Oct-22 (OCP-DAK3.5-1249_Oct22)	Oct-23
OCP DAK-12	SN: 1016	20-Oct-22 (OCP-DAK12-1016_Oct22)	Oct-23
Reference 20 dB Attenuator	SN: CC2552 (20x)	04-Apr-22 (No. 217-03527)	Apr-23
DAE4	SN: 660	10-Oct-22 (No. DAE4-660_Oct22)	Oct-23
Reference Probe ES3DV2	SN: 3013	06-Jan-23 (No. ES3-3013_Jan23)	Jan-24

Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-22)	In house check: Jun-24
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24

	Name	Function	Signature
Calibrated by	Joanna Lleshaj	Laboratory Technician	
Approved by	Niels Kuster	Quality Manager	

Issued: February 21, 2023

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Parameters of Probe: EX3DV4 - SN:7447

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm ($\mu V/(V/m)^2$) [A]	0.43	0.43	0.43	±10.1%
DCP (mV) [B]	90.0	91.0	96.0	±4.7%

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B $dB\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc[E] $k = 2$
0	CW	X	0.00	0.00	1.00	0.00	130.7	±2.3%	±4.7%
		Y	0.00	0.00	1.00		130.1		
		Z	0.00	0.00	1.00		134.6		

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 5).
[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Parameters of Probe: EX3DV4 - SN:7447

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc ($k = 2$)
13	55.0	0.75	17.42	17.42	17.42	0.00	1.25	±13.3%
750	41.9	0.89	9.91	8.74	9.52	0.31	1.27	±12.0%
900	41.5	0.97	9.37	8.45	8.89	0.32	1.27	±12.0%
1750	40.1	1.37	8.45	7.97	8.40	0.25	1.27	±12.0%
1950	40.0	1.40	8.05	7.59	7.97	0.29	1.27	±12.0%
2150	39.7	1.53	8.01	7.58	7.90	0.28	1.27	±12.0%
2300	39.5	1.67	7.85	7.46	7.80	0.28	1.27	±12.0%
2450	39.2	1.80	7.70	7.50	7.63	0.28	1.27	±12.0%
2600	39.0	1.96	7.55	7.37	7.73	0.28	1.27	±12.0%
3300	38.2	2.71	7.02	6.71	7.02	0.34	1.27	±14.0%
5250	35.9	4.71	5.18	4.99	5.17	0.39	1.53	±14.0%
5600	35.5	5.07	4.40	4.29	4.43	0.38	1.77	±14.0%
5750	35.4	5.22	4.47	4.33	4.53	0.38	1.85	±14.0%

[C] Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10%. If TSL with deviations from the target of less than ±5% are used, the calibration uncertainties are 11.1% for 0.7 - 3 GHz and 13.1% for 3 - 6 GHz.
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

Parameters of Probe: EX3DV4 - SN:7447

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	-139.3°
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

Note: Measurement distance from surface can be increased to 3–4 mm for an *Area Scan* job.

APPENDIX E: RELEVANT PAGES FROM DIPOLE CALIBRATION REPORTS

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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Accreditation No.: **SCS 0108**

Client: **Verkotan**

Certificate No: **D2450V2-729_Jul22**

CALIBRATION CERTIFICATE

Object: D2450V2 - SN:729

Calibration procedure(s): QA CAL-05.v11
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz

Calibration date: July 15, 2022

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23
Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23
Reference Probe EX3DV4	SN: 7349	31-Dec-21 (No. EX3-7349_Dec21)	Dec-22
DAE4	SN: 601	02-May-22 (No. DAE4-601_May22)	May-23

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

	Name	Function	Signature
Calibrated by:	Aidonia Georgiadou	Laboratory Technician	
Approved by:	Niels Kuster	Quality Manager	

Issued: July 19, 2022

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

Certificate No: D2450V2-729_Jul22 Page 1 of 6

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.9 ± 6 %	1.85 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.3 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.21 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.5 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.1 Ω + 0.8 jΩ
Return Loss	- 30.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.147 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG