SAR Compliance Test Report

Date of Report	17/04/2023	**Client's Contact person:**	Loek Janssen
Number of pages:	30		
		Responsible Test engineer:	Ilari Kinnunen
Testing laboratory:	**Verkotan Oy** Elektroniikkatie 17 90590 Oulu Finland	**Client:**	**XYZ Reality** 338-346 Goswell Road EC1V 7LQ London United Kingdom
Tested device	**XYZ-13-01**		
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** **IEC/IEEE 62209-1528, 2020** 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		
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:	17.04.2023 **Laboratory Manager** Miia Nurkkala Digitaalinen allekirjoittaja: Miia Nurkkala Päiväys: 2023.04.17 13:41:09 +03'00'		

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1. SUMMARY OF SAR TEST REPORT

1.1 Test Details

Equipment under Test (DUT):

Product:	Hard Hat
Manufacturer:	XYZ Reality
Model:	Atom
Serial Number:	XYZ-13-01
FCC ID Number:	2A3C5XYZ1301 (Contains FCC ID PD99260NG)
DUT Number:	21342 (130005)
Battery Type used in testing:	Li-Ion Battery
State of the Sample:	Production sample

Testing information:

Testing performed:	09.03.2023 – 14.03.2023
Notes:	-
Document history:	This report replaces "FCC SAR report_Atom_ID5959_13042023". DUT number changed.
Document ID:	FCC SAR report_Atom_ID5959_17042023.docx
Temperature °C	22±2 / Controlled
Humidity RH%	30±20 / Controlled
Measurement performed by:	Ilari Kinnunen
FCC Test Firm Designation Number:	FI0005

1.2 Maximum Results

The maximum reported* SAR values for Body-worn 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 Occupational Exposure SAR limit specified in FCC 47 CFR part 2 (2.1093) for Head/Body SAR_{1g} is 8.0 W/kg.

1.2.1 Standalone SAR

System	Highest Reported* SAR_{1g}(W/kg) in Body-Worn Exposure Condition, 0mm separation distance	Result
2.4 GHz WLAN	**2.58**	**PASS**

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

1.2.2 Simultaneous Transmission SAR

Highest Simultaneous Transmission SAR	SAR_{1g}(W/kg) in Body-Worn Exposure Condition	Result
WLAN 2.4 GHz + WLAN 2.4 GHz + Proprietary	**5.07**	**PASS**

1.2.3 Maximum Drift

Maximum Drift During Measurements	0.6dB*

*Larger than 5% drifts included to scaling factors

1.2.4 Measurement Uncertainty

SAR 1g: 0.3 – 3 GHz:

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

2. DESCRIPTION OF THE DEVICE UNDER TEST (DUT)

The DUT is a custom-built engineering tool combining a construction safety headset, augmented reality displays and in-built computing power.

The Intel AC-9260 module has 2 antenna ports for 2x2 WLAN. It supports WLAN 2.4GHz, Bluetooth and Proprietary (nRF24LU1P) wireless technologies.

The DUT has three antennas; WLAN uses antennas A and B, Bluetooth uses antenna A and nRF24LU1P has its own antenna. The antenna model is 1461531150 and it has maximum gain of 3.0dBi according to datasheet "WIFI 6E FLEX CABLE BALANCE ANTENNA APPLICATION SPECIFICATION".

Device Category	Portable
Exposure Environment	Occupational

2.1 Supported Frequency Bands and Operational Modes

TX Frequency bands	**Modes of Operation**	**Transmitter Frequency Range [MHz]**
	2.4GHz WLAN	2412 – 2462
	Proprietary (nRF24LU1P)	2402 – 2480
	Bluetooth	2402 – 2480

2.2 Simultaneous transmission

Bluetooth + WLAN 2.4GHz + Proprietary (nRF24LU1P) can be operated simultaneously.

Following simultaneous transmission combinations are supported:

WLAN 2.4GHz + WLAN 2.4GHz + Proprietary (nRF24LU1P)
WLAN 2.4GHz + Bluetooth + Proprietary (nRF24LU1P)

2.3 Test Exclusions

2.3.1 FCC

FCC SAR test exclusion threshold is calculated according to 447498 D04 Interim General RF Exposure Guidance, equation B.2 and B.1:

$$Pth\ (mW) = \begin{cases} ERP_{20\,cm}\,(d\ /\ 20cm)^{x} & d \le 20cm \\ ERP_{20\,cm} & 20cm < d \le 40cm \end{cases} \quad \text{(Equation 1)}$$

where

$$x = -\log_{10}\left(\frac{60}{ERP_{20\,cm}\sqrt{f}}\right) \quad \text{(Equation 2)}$$

and frequency f is in GHz, d is the separation distance (cm), and ERP20cm is per Equation 3 (B.1) below.

$$ERP20cm\ (mW) = \begin{cases} 2040f & 0.3 \le f < 1.5GHz \\ 3060 & 1.5GHz \le f \le 6GHz \end{cases} \quad \text{(Equation 3)}$$

Transmission mode	Frequency [GHz]	Separation distance [cm]	P_{th} [mW]
Bluetooth	2.480	2.0	38
Proprietary (nRF24LU1P)	2.480	1.8	31

2.3.1.1 Maximum defined Output Power and ERP

Bluetooth:

The DUT has 3.0dBi antenna gain for Bluetooth according to datasheet "WIFI 6E FLEX CABLE BALANCE ANTENNA APPLICATION SPECIFICATION". Maximum specified output power of the Bluetooth transmitter is 9dBm i.e. 7.9mW. Maximum ERP of the Bluetooth transmitter is 9.85dBm i.e. 9.7mW. Bluetooth maximum source-based duty cycle is 85%. The separation distance between the Bluetooth antenna and the inner shell of the device is 20.39mm.

According to Appendix A at 447498D04 Interim General RF Exposure Guidance, the equation (B.2.) defines the thresholds for available maximum time-averaged power or maximum time-averaged ERP, whichever is greater. Since the maximum ERP is greater than the output power, it is used for SAR test exclusion.

Transmission mode	Maximum Output power [dBm]	Maximum Output power [mW]	Power Gain of Antenna, G [dBi]	Maximum Source-Based Duty Cycle [%]	Maximum Time Averaged Output power [dBm]	Maximum Time Averaged Output power [mW]	Maximum Time Averaged ERP [dBm]	Maximum Time Averaged ERP [mW]	P_{th} [mW]
Bluetooth	9.0	7.9	3.0	85	8.29	6.8	**9.14**	**8.2**	**38**

The maximum ERP of Bluetooth is below the test exclusion threshold.

Proprietary (nRF24LU1P):

The DUT has 3.0dBi antenna gain for nRF24LU1P according to datasheet "WIFI 6E FLEX CABLE BALANCE ANTENNA APPLICATION SPECIFICATION". Maximum specified output power of the nRF24LU1P transmitter is -3.0dBm i.e. 0.5mW. Maximum ERP of the nRF24LU1P transmitter is -2.15dBm i.e. 0.6mW. The separation distance between the nRF24LU1P antenna and the inner shell of the device is 18.78mm.

According to Appendix A at 447498D04 Interim General RF Exposure Guidance, the equation (B.2.) defines the thresholds for available maximum time-averaged power or maximum time-averaged ERP, whichever is greater. Since the maximum ERP is greater than the output power, it is used for SAR test exclusion.

Transmission mode	Maximum Output power [dBm]	Maximum Output power [mW]	Power Gain of Antenna, G [dBi]	Maximum ERP [dBm]	Maximum ERP [mW]	P_{th} [mW]
Proprietary (nRF24LU1P)	-3.0	0.5	3.0	**-2.15**	**0.6**	**31**

The maximum output power for Proprietary (nRF24LU1P) is below the test exclusion threshold.

3. OUTPUT POWER

3.1 Maximum specified conducted output power

From the customer, including tune-up tolerances;

WLAN 2.4GHz	Max Output Power [dBm]
802.11b	20.5
802.11g	20.5
802.11n, 20MHz	20.5
802.11n, 40MHz	14.5

Proprietary	Max Output Power [dBm]
nRF24LU1P	-3.0

Bluetooth	Max Output Power [dBm]
Bluetooth	9.0

3.2 Tested conducted power

Conducted power measurements done by TUV SUD:

WLAN 2.4 GHz:

Low and High channels were measured using channels 2 and 10 as the maximum specified output power is higher on these channels than on channels 1 and 11.

Radio Access	Channel	Frequency	Antenna A Measured Power	Antenna B Measured Power
802.11 b	2	2417	20.21	19.75
802.11 b	6	2437	20.01	19.86
802.11 b	10	2457	20.2	19.77
802.11 b	11	2462	19.23	19.65
802.11 g	3	2422	19.32	18.65
802.11 g	6	2437	19.06	19.07
802.11 g	9	2452	19.9	19.15
802.11 n 20	3	2422	19.14	18.85
802.11 n 20	6	2437	19.42	18.96
802.11 n 20	9	2452	19.78	19.27

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.

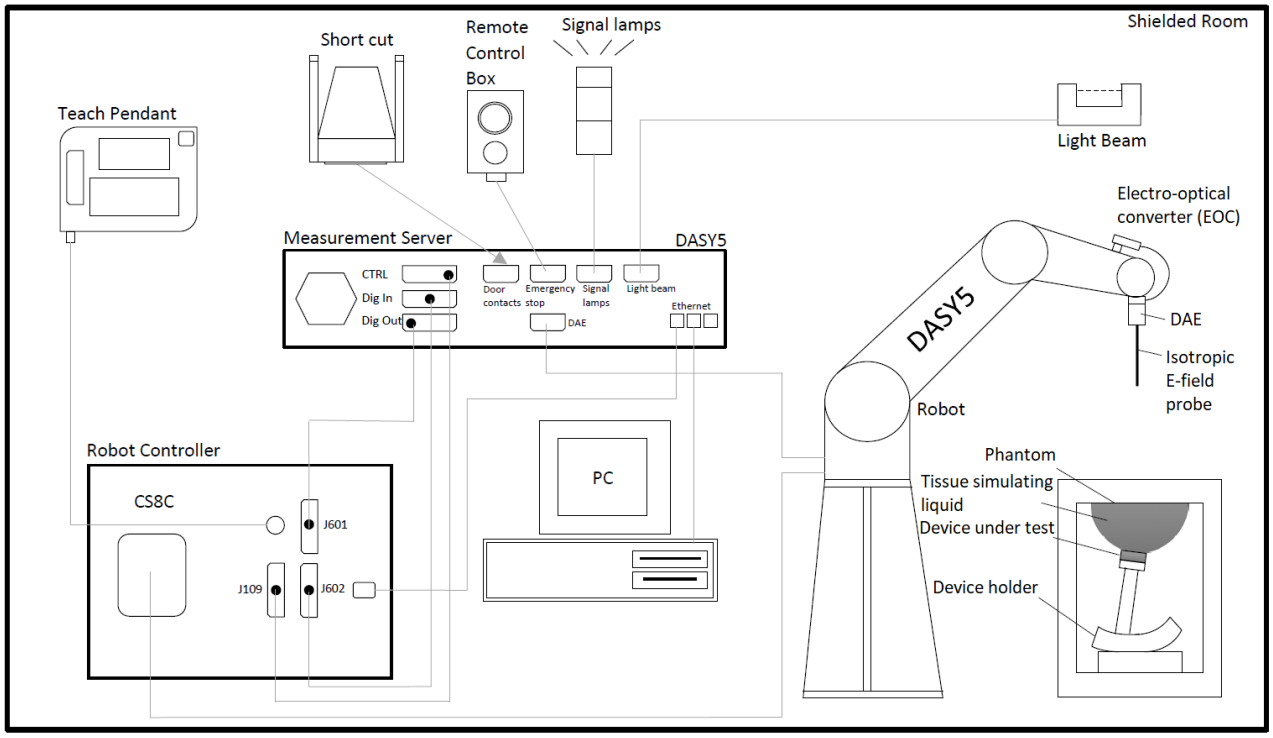


Figure 1 Schematic Laboratory Picture

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
DASY5 Software	52.8.8.1258	-	NA
DAE4, converter	DAE4	1332	02/2023
Isotropic DOS probe	EX3DV4	7447	02/2023
System validation dipole	D2450V2	729	07/2022
Vector Network Analyzer	P5008A	MY58100258	01/2023
Vector Signal Generator	MG3710A	6261911026	NA
Amplifier, 800MHz-4200MHz, 10W	10S1G4A	320421	NA
Inline Peak Power Sensor	MA24105A	2102058	11/2022

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 Phantoms

Eli Phantom:

The phantom used in SAR tests was an ELI phantom, manufactured by SPEAG. ELI phantom is used for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. The phantom conforms to the requirements of IEC/IEEE 62209-1528 and FCC published RF Exposure KDB Procedures.

4.3 Tissue Simulants

Recommended values for the dielectric parameters of the tissue simulants are given in IEC/IEEE 62209-1528 and FCC published RF Exposure KDB Procedures. The dielectric parameters of the used tissue simulants were within ±10% of the recommended values at

frequencies under 3GHz. 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 liquid Ingredients
Deionized Water, tween, salt

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]	Head tissue simulant
2450	D2450V2 / 729	EX3DV4 / 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 [mW]	Measured SAR_{1g} [W/kg]	1 W Target SAR_{1g} [W/kg]	1 W Normalized SAR_{1g} [W/kg]	Deviation (%)	Plot #
09.03.2023	WB Head	22	2450	250	12.2	52.3	48.8	-6.7	1
13.03.2023	WB Head	22	2450	250	12.5	52.3	50.0	-4.4	2

4.5.1 Tissue Simulant Verification

				Target		Measured		Deviation	
Date	Tissue Type	Tissue Temp [°C]	Frequency [MHz]	Dielectric Constant [ε] Target	Conductivity σ [S/m] Target	Dielectric Constant [ε]	Conductivity σ [S/m]	ε (%)	σ (%)
09.03.2023	WB Head	22	2417	39.3	1.77	41.6	1.69	6.0	-4.8
09.03.2023	WB Head	22	2437	39.2	1.79	41.6	1.70	6.0	-5.0
09.03.2023	WB Head	22	2450	39.2	1.80	41.5	1.71	6.0	-5.1
09.03.2023	WB Head	22	2457	39.2	1.81	41.5	1.71	6.0	-5.3
13.03.2023	WB Head	22	2417	39.3	1.77	41.3	1.69	5.2	-4.7
13.03.2023	WB Head	22	2437	39.2	1.79	41.3	1.70	5.2	-4.8
13.03.2023	WB Head	22	2450	39.2	1.80	41.3	1.71	5.2	-4.8
13.03.2023	WB Head	22	2457	39.2	1.81	41.2	1.72	5.2	-5.0

5. TEST PROCEDURE

Testing was carried out in accordance with FCC KDB Publications 447498 D04 Interim General RF Exposure Guidance v01 and 248227 D01 802.11 Wi-Fi SAR.

A control software for WLAN was used to select the transmitting antenna and set the DUT to transmit at maximum power.

The WLAN transmission modes for testing were selected according to largest channel bandwidth configuration, lowest order modulation and lowest data rate.

WLAN 2.4GHz was tested with 802.11b standard with 20 MHz bandwidth and 1 Mbps data rate. Antennas A and B were measured separately in SISO mode.

WLAN 2.4GHz Low and High channels were measured using channels 2 and 10 as the maximum specified output power is higher on these channels than on channels 1 and 11.

5.1 Device Holder

The device was placed in the device holder that is supplied by SPEAG as an integral part of the Dasy system.

5.2 Test Positions

5.2.1 Body-worn Exposure Condition, 0 mm separation distance

The device was placed in the SPEAG holder and lifted against the flat phantom. The device was measured from the outer surface on left and right side of helmet where the two antennas are located. The outer surface provides a shorter separation distance to the antennas compared to the inner surface. Therefore, it can be considered as the worst case.

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.	(ci) 1g	(ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)
Measurement System Errors								
CF	Probe Calibration	±12.0%	N	√2	1	1	±6.0%	±6.0%
CF_{drift}	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%
Δ_{syz}	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%
$LIQ(T_\sigma)$	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%
D_{xyz}	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%
RF_{drift}	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 Exposure Condition with 0mm separation

2.4GHz WLAN:

Mode	Data Rate [Mbps]	Antenna	Channel	Frequency [MHz]	Test position	Maximum Power [dBm]	Conducted Power [dBm]	Measured SAR_{1g} [W/kg]	Power Drift [dB]*	Scaling Factor	Duty Cycle [%]	Reported SAR_{1g} [W/kg]	Plot #
802.11b	1	A	2	2417	Left	20.5	20.21	2.32	-0.02	1.07	99	2.48	-
802.11b	1	A	6	2437	Left	20.5	20.01	2.18	0.05	1.12	99	2.44	-
802.11b	1	A	10	2457	Left	20.5	20.2	2.06	0.51	1.21	99	2.48	3
802.11b	1	B	2	2417	Right	20.5	19.75	1.93	0.05	1.19	99	2.29	-
802.11b	1	B	6	2437	Right	20.5	19.86	1.94	0.6	1.33	99	2.58	4
802.11b	1	B	10	2457	Right	20.5	19.77	1.84	0.03	1.18	99	2.18	-

*Larger than 5% drifts included to scaling factors
** Due to low e-field generated by DUT at the location of drift measurement, the measurements are not applicable.

7.2 Calculated Bluetooth SAR

For simultaneous transmission evaluation the estimated standalone SAR values are calculated according to the following equation 4.

$SAREstimated$=0.4∗$Pant/Pth$ [w/kg] (Equation 4)

where

$Pant = 8.2\text{mW}$
$Pth = 38\text{mW}$

Estimated Bluetooth SAR_{1g} = 0.09 W/kg

7.3 Calculated nRF24LU1P SAR

For simultaneous transmission evaluation the estimated standalone SAR values are calculated according to the following equation 4.

$SAREstimated$=0.4∗$Pant/Pth$ [w/kg] (Equation 4)

where

$Pant = 0.6\text{mW}$
$Pth = 31\text{mW}$

Estimated nRF24LU1P SAR_{1g} = 0.008 W/kg

7.4 Simultaneous Transmission Analysis

Simultaneous transmission analysis for the maximum WLAN 2.4GHz (Antenna A) + WLAN 2.4GHz (Antenna B) + Proprietary (nRF24LU1P) SAR is in the table below. Direct summation of SAR results was performed.

Body SAR:

Exposure Condition	Body SAR_{1g} [W/kg]	
Test Position	**Left**	**Right**
WLAN 2.4GHz, Antenna A	2.48	-
WLAN 2.4GHz, Antenna B	-	2.58
Bluetooth, Antenna A	0.09	
Proprietary (nRF24LU1P)	0.008	
Maximum Antenna A	2.48	
Maximum Antenna B	2.58	
SAR Summation:	**5.07**	

APPENDIX A: PHOTOS OF THE DUT

Size of the DUT is: 31 x 25 x 21 cm

Figure 2 DUT in Left Test Position, 0mm separation distance

Figure 3 DUT in Right Test Position, 0mm separation distance

APPENDIX B: SYSTEM CHECK SCAN

Plot 1

Date/Time: 09.03.2023 15.06.19

Test Laboratory: Verkotan Oy

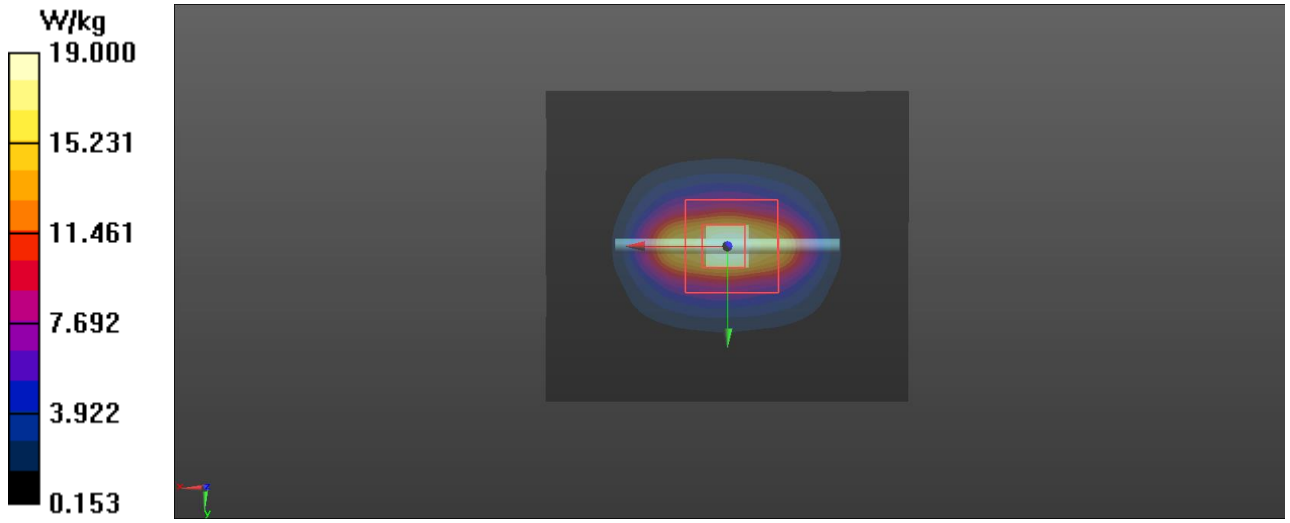
DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:729

Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;
Communication System PAR: 0 dB;
Medium parameters used: f = 2450 MHz; σ = 1.708 S/m; ε_r = 41.544; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN7447; ConvF(7.7, 7.5, 7.63) @ 2450 MHz; Calibrated: 17.02.2023
  - Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = -4.0, 31.0
  - Electronics: DAE4 Sn1332; Calibrated: 15.02.2023
  - Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

System check/Area Scan (71x61x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 19.8 W/kg
System check/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 113.0 V/m; Power Drift = 0.19 dB
Peak SAR (extrapolated) = 23.3 W/kg
SAR(1 g) = 12.2 W/kg; SAR(10 g) = 5.66 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 8.6 mm
Ratio of SAR at M2 to SAR at M1 = 51.5%
Maximum value of SAR (measured) = 19.0 W/kg



Plot 2

Date/Time: 13.03.2023 9.26.46

Test Laboratory: Verkotan Oy

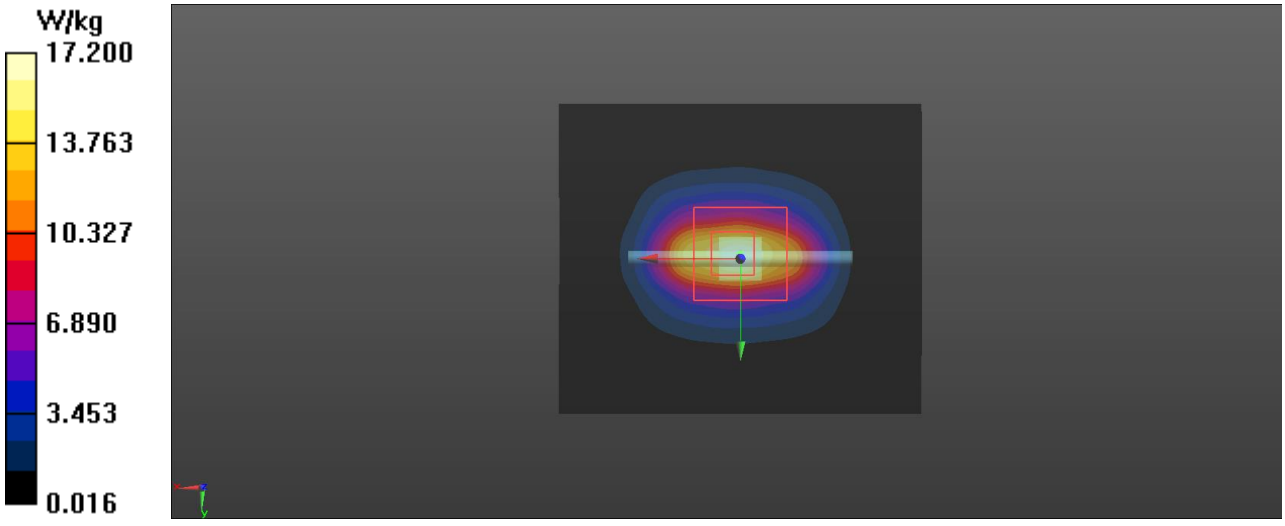
DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:729

Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;
Communication System PAR: 0 dB;
Medium parameters used: f = 2450 MHz; σ = 1.713 S/m; ε_r = 41.256; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN7447; ConvF(7.7, 7.5, 7.63) @ 2450 MHz; Calibrated: 17.02.2023
  - 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: 15.02.2023
  - Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

System check/Zoom Scan (7x9x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 113.0 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 24.0 W/kg
SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.79 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 8.1 mm
Ratio of SAR at M2 to SAR at M1 = 51.1%
Maximum value of SAR (measured) = 19.8 W/kg
System check/Area Scan (71x61x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 17.2 W/kg



APPENDIX C: MEASUREMENT SCANS

Plot 3

Date/Time: 10.3.2023 14.44.00

Test Laboratory: Verkotan Oy

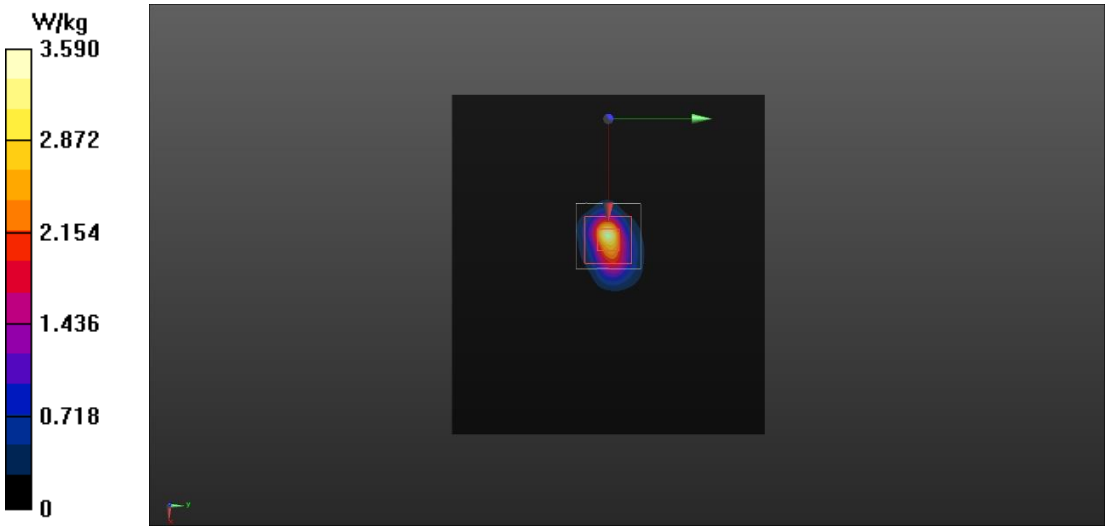
DUT: Atom

Communication System: UID 0, WLAN 2.4 (0); Communication System Band: WLAN2.4GHz; Frequency: 2457 MHz;
Communication System PAR: 0 dB;
Medium parameters used: f = 2457 MHz; σ = 1.713 S/m; ε_r = 41.533; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN7447; ConvF(7.7, 7.5, 7.63) @ 2457 MHz; Calibrated: 17.2.2023
  - Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = -4.0, 31.0
  - Electronics: DAE4 Sn1332; Calibrated: 15.2.2023
  - Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

WLAN 2.4GHz, FCC, 802.11b, 20MHz, CH10/Area Scan (131x121x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 3.59 W/kg
WLAN 2.4GHz, FCC, 802.11b, 20MHz, CH10/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 2.974 V/m; Power Drift = 0.51 dB
Peak SAR (extrapolated) = 5.03 W/kg
SAR(1 g) = 2.06 W/kg; SAR(10 g) = 0.771 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 6.7 mm
Ratio of SAR at M2 to SAR at M1 = 43.9%
Maximum value of SAR (measured) = 3.77 W/kg



Plot 4

Date/Time: 14.3.2023 9.52.39

Test Laboratory: Verkotan Oy

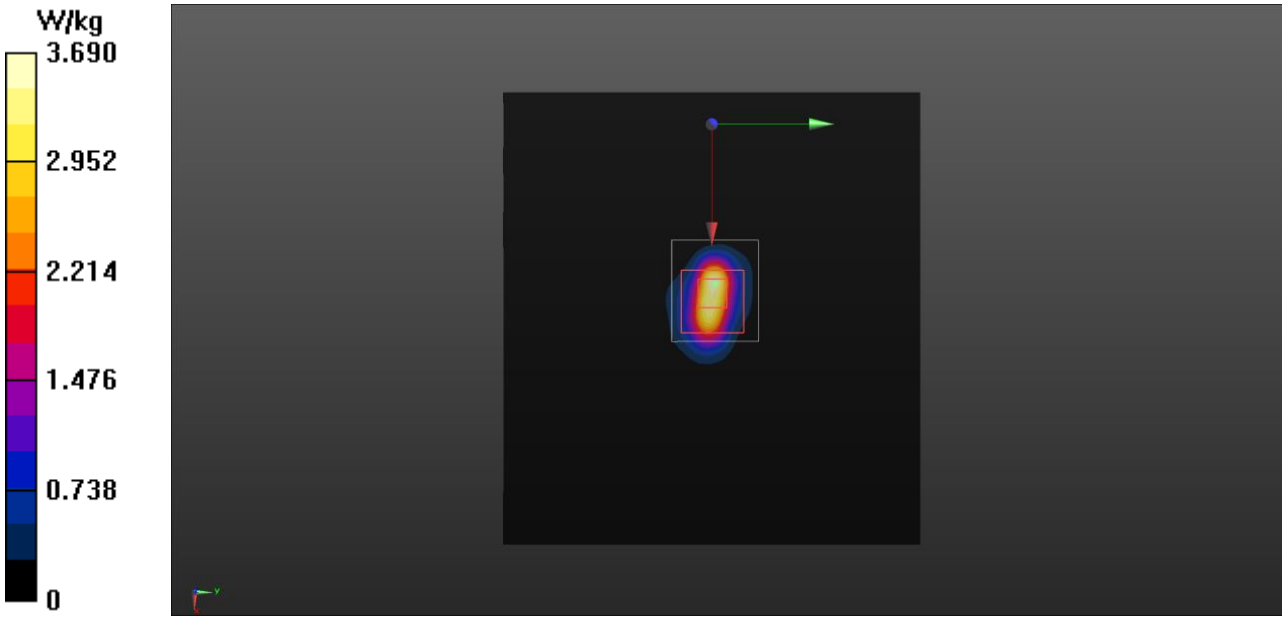
DUT: Atom

Communication System: UID 0, WLAN 2.4 (0); Communication System Band: WLAN2.4GHz; Frequency: 2437 MHz;
Communication System PAR: 0 dB;
Medium parameters used: f = 2437 MHz; σ = 1.703 S/m; ε_r = 41.273; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN7447; ConvF(7.7, 7.5, 7.63) @ 2437 MHz; Calibrated: 17.2.2023
  - Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = -4.0, 31.0
  - Electronics: DAE4 Sn1332; Calibrated: 15.2.2023
  - Phantom: SAR2_Phantom1_ELI; Type: QD OVA 002 AA;
  - DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

WLAN 2.4GHz, FCC, 802.11b, 20MHz, CH6/Area Scan (131x121x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 3.69 W/kg
WLAN 2.4GHz, FCC, 802.11b, 20MHz, CH6/Zoom Scan (8x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 4.397 V/m; Power Drift = 0.60 dB
Peak SAR (extrapolated) = 4.81 W/kg
SAR(1 g) = 1.94 W/kg; SAR(10 g) = 0.745 W/kg (SAR corrected for target medium)
Smallest distance from peaks to all points 3 dB below = 6 mm
Ratio of SAR at M2 to SAR at M1 = 41.6%
Maximum value of SAR (measured) = 3.59 W/kg



APPENDIX D: RELEVANT PAGES FROM PROBE CALIBRATION REPORTS

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

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

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

Certificate No: EX-7447_Feb23 Page 1 of 9

Parameters of Probe: EX3DV4 - SN:7447

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc ($k = 2$)
Norm (μV/(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

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.

Parameters of Probe: EX3DV4 - SN:7447

Calibration Parameter Determined in Head Tissue Simulating Media

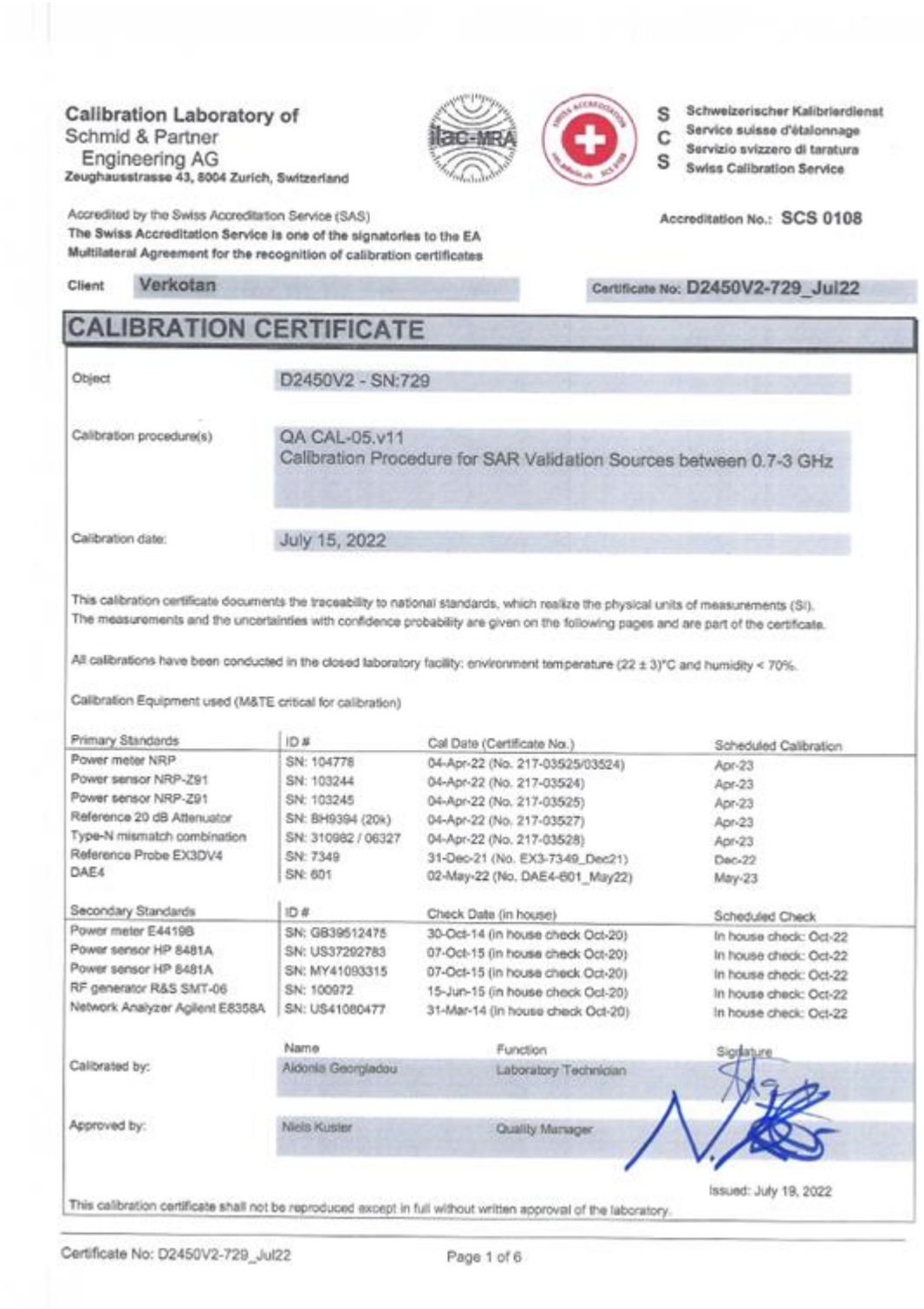
f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc ($k = 2$)
13	55.0	0.75	17.42	17.42	17.42	0.00	1.25	±13.3%
750	41.9	0.89	9.91	8.74	9.52	0.31	1.27	±12.0%
900	41.5	0.97	9.37	8.45	8.89	0.32	1.27	±12.0%
1750	40.1	1.37	8.45	7.97	8.40	0.25	1.27	±12.0%
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.

APPENDIX E: RELEVANT PAGES FROM DIPOLE CALIBRATION REPORTS



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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

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:	Aldonia 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 cm³ (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 cm³ (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)**

