SAR Compliance Test Report

Date of Report	13/12/2022	**Client's Contact person:**	Jari Kolehmainen
Number of pages:	29		
		Responsible Test engineer:	Kalle Orava
Testing laboratory:	**Verkotan Oy** Elektroniikkatie 17 90590 Oulu Finland	**Client:**	**iLOQ Oy** Elektroniikkatie 10 90590 Oulu Finland

Tested device	K55S.1 / P55S.1
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** 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:

For the contents:

13.12.2022

Miia Nurkkala

Digitaalinen allekirjoittaja: Miia Nurkkala
Päiväys: 2022.12.13 09:12:56 +02'00'

Laboratory Manager

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1. SUMMARY OF SAR TEST REPORT

1.1 Test Details

Device under Test (DUT):

Product:	Key Fob
Manufacturer:	iLOQ Oy
Serial Number:	34656749
FCC ID Number:	2A2HZ-FOB55S1
IC ID Number:	27428-FOB55S1
Model:	K55S.1 / P55S.1
Equipment product code:	FOB55S1
Product market name:	K55S.1, P55S.1
Unique product name:	FOB55S1
FVIN:	K55S.1 P55S1.1
DUT Number:	21472
Battery Type used in testing:	Rechargeable Li-ion Battery
State of the Sample	Production sample

Testing information:

Testing Performed:	28.11.2022 – 30.11.2022
Notes:	-
Document ID:	FCC_ISED_SAR report_iLOQ FOB_ID5909_30112022.docx
Document History	Initial version
Temperature °C	22±2 / Controlled
Humidity RH%	20±20 / Controlled
Measurement performed by:	Kalle Orava
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 Health Canada's RF exposure guideline, Safety Code 6 and in FCC 47 CFR part 2 (2.1093) is SAR1g 1.6 W/kg.

System	Highest Reported* SAR_{1g}(W/kg) in Body-worn Condition, 0mm separation	Result
NFC	0.03	PASS

* Reported SAR Values are scaled to maximum theoretical output power.

1.2.1 Maximum Drift

Maximum Drift During Measurements	0.25dB*

*Drifts >5% have been considered in the scaling factor

1.2.2 Measurement Uncertainty

4MHz – 300MHz frequency range

Expanded Uncertainty (k=2) 95 %	±22.9%

2. DESCRIPTION OF THE DEVICE UNDER TEST (DUT)

The DUT is a Key Fob which is used for operating digital lock cylinders.

In “K55S.1” mode Both Bluetooth and NFC are used, the product is used as a key for single lock.
In “P55S.1” mode only NFC is used. The product is used as master key for the whole locking system. This report applies for both “K55S.1” and “P55S.1”.

Datasheet of the AMCA31-2R450G-S1F-T3 states that the Bluetooth’s maximum antenna gain is 0.5 dBi.

Figure 1. Overview of the DUT

Device Category	Portable
Exposure Environment	Uncontrolled

2.1 Supported Frequency Bands and Operational Modes

TX Frequency bands	**Modes of Operation**	**Transmitter Frequency Range [MHz]**
	Bluetooth	2402 – 2480
	NFC	13.56

2.2 Simultaneous Transmission

The Device does not support simultaneous transmission.

2.3 Test Exclusions

2.3.1 FCC

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

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

where

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

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

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

Transmission mode	**Frequency [GHz]**	**Separation distance [cm]**	**P_{th} [mW]**
Bluetooth	2.4	0.5	2.7

2.3.1.1 Maximum defined Output Power and ERP

Maximum output power of the DUT's Bluetooth transmitter 0 dBm i.e. 1 mW.

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 output power is greater than the ERP of the DUT for Bluetooth 2.4GHz, it is used for SAR test exclusion.

Transmission mode	**Output power [dBm]**	**Output power [mW]**	**Power Gain of Antenna, G [dBi]**	**ERP Output power [dBm]**	**ERP Output power [mW]**	**P_{th} [mW]**
Bluetooth	0	**1**	0.5	-1.65	0.68	**2.7**

The maximum output power for Bluetooth is below the test exclusion threshold.

2.3.2 ISED

SAR test exemption output power limits based on frequency and separation distance are from RSS-102, issue 5, 2015:

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance[4,5]

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

SAR test exclusion power threshold for 2450MHz is 4mW at ≤5mm separation distance.

2.3.2.1 Maximum defined output power and EIRP

Maximum output power of the DUT's Bluetooth transmitter is 0 dBm i.e. 1 mW. Since the EIRP output power is greater than the maximum output power of the DUT for Bluetooth, it is used for SAR test exclusion.

Transmission mode	Output power [dBm]	Output power [mW]	Power Gain of Antenna, G [dBi]	EIRP Output power [dBm]	EIRP Output power [mW]
Bluetooth	0	1	0.5	0.5	**1.12**

EIRP output power of the Bluetooth is below the test exclusion threshold.

3. OUTPUT POWER

3.1 Maximum Output Power

From the Customer, maximum defined output power, including tune-up tolerance.

Bluetooth	Max Output Power [dBm]
Bluetooth	0

NFC	Max Output Power [dBm]
NFC 13.56 MHz	18.45

3.2 Tested Conducted Power

NFC	Max Output Power [dBm]
13.56 MHz	13.66*

*Due to NFC integrated circuit impedance matching in the output and NFC antenna not being 50Ω, the measured conducted power underestimates the actual output power of the module. Mismatch with the cable for conducted power testing cable is larger than with the antenna. The measured conducted power value is used in scaling of the NFC SAR results thus the reported SAR values are overestimated.

4. TEST EQUIPMENT

Dasy52 near field scanning systems, manufactured by SPEAG were 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.

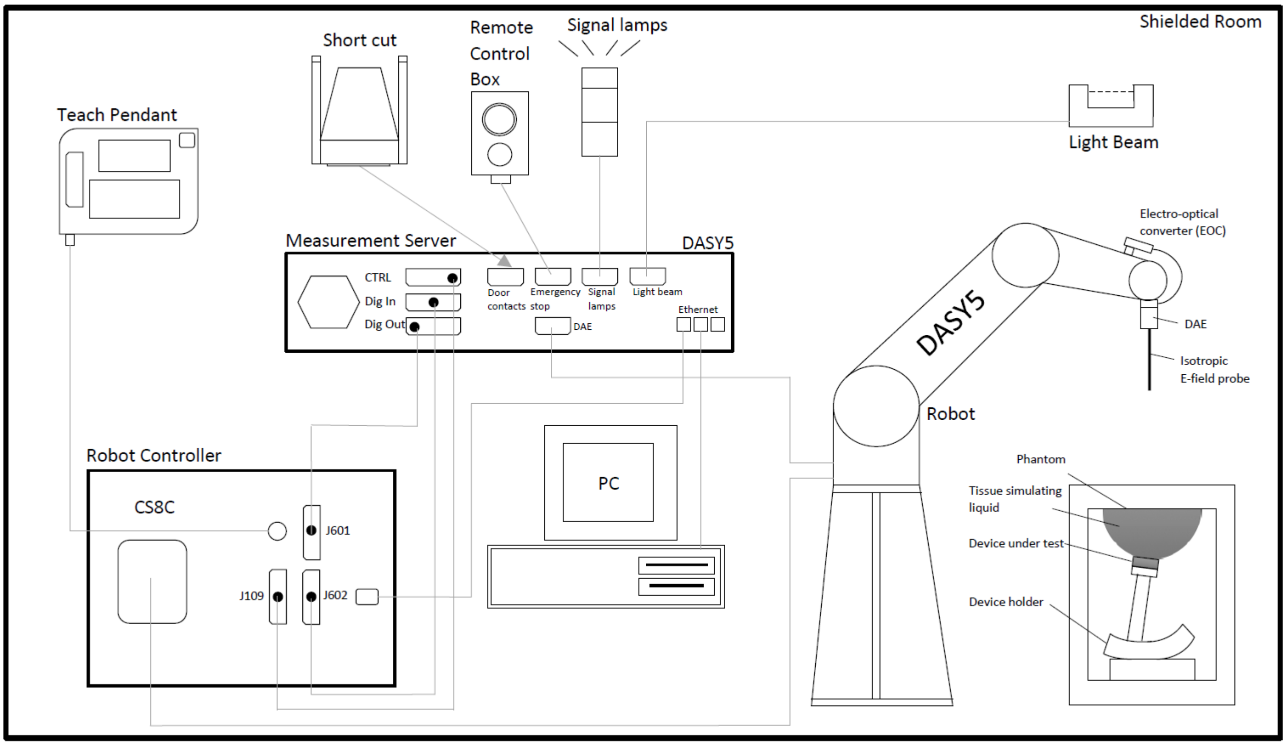


Figure 2 Schematic Laboratory Picture

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	710	10.2022
Probe	EX3DV4	7447	02.2022
Dipole	CLA-13	1012	03.2021
DASY5 Software	52.8.8.1258	-	NA
Signal generator	Anritsu MG3710A	6261911026	02.2022
Amplifier	TVA-R5-13A+	2202002	NA
Power Sensor	NRP-Z11	100265	12.2021

Dipole calibration period supporting data:

		Measured on 11/2022			Calibrated		
Antenna and serial number	**Frequency [MHz]**	**Return loss [dB]**	**Impedance [Ω]**		**Return loss [dB]**	**Impedance [Ω]**	
CLA13, SN: 1012	13	-25.39	55.22	5.26	-23.29	54.5	5.4

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 Tip diameter: 2.5 mm Distance from probe tip to dipole centers: 1.0 mm
Application	General dosimetry up to 6 GHz Compliance tests of mobile phones Fast automatic scanning in arbitrary phantoms

4.2 Phantoms

4.2.1 ELI Phantom

The phantom used in SAR tests in the 13MHz frequency area 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 4 MHz to 6 GHz. ELI is fully compatible with the to the requirements of IEEE 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 IEEE 1528 and FCC published RF Exposure KDB Procedures. The dielectric parameters of the used tissue simulants were within ±10% of the recommended values for frequencies below 3 GHz and ±5% for frequencies between 3 – 6 GHz. 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.

Head 10-400 MHz 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] Head tissue simulant	Conductivity σ [S/m] Head tissue simulant	Validation Done
13	CLA 13 - SN: 1012	EX3DV4 - SN: 7447	CW	DAE 4 / 1332	52.95	0.71	04.2022*

*Probe isotropy at 13 MHz was tested to be ±0.55dB. The probes consist of a sensor, the diode and two highly resistive lines. According to the probe manufacturer the performance of these lines is reduced at lower frequencies.

4.5 System Check

Date	Tissue Type	Tissue Temp. [°C]	Frequency [MHz]	Input Power [mW]	Measured SAR1g [W/kg]	1 W Target SAR1g [W/kg]	1 W Normalized SAR1g [W/kg]	Deviation 1g [%]	Plot #
28.11.2022	LB Head	22	13	250	0.141	0.555	0.564	1.62	1

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 [%]
28.11.2022	LB Head	22.1	13.0	55.0	0.75	53.46	0.7	-2.8	-6.3
28.11.2022	LB Head	22.1	13.56	55.0	0.75	53.44	0.7	-2.8	-6.3

5. TEST PROCEDURE

Testing was carried out in accordance with FCC KDB Publication 447498 D01 and RSS-102. All sides of the DUT were measured at separation distance of 0mm.

Control software was used to set the DUT to transmit at maximum power, with duty cycle of 100%. Normal duty cycle of the device is 73%. Thus, reported SAR values are conservative.

Due to NFC integrated circuit impedance matching in the output and NFC antenna not being 50Ω, the measured conducted power underestimates the actual output power of the module. Mismatch with the cable for conducted power testing cable is larger than with the antenna. The measured conducted power value is used in scaling of the NFC SAR results thus the reported SAR values are overestimated.

5.1 Test Positions

Photos of the test positions are presented in appendix A

5.1.1 Body-worn, 0mm separation distance

The device was placed in the SPEAG holder and lifted towards the phantom until the distance between the phantom and the device was 0mm.

5.2 Scan Procedures

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

5.3 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: 4MHz - 300MHz 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	±13.3%	N	√2	1	1	±6.65%	±6.65%
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	±0.8%	R	√3	1	1	±0.5%	±0.5%
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*sys*	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}	±5.4%	R	√3	0.78	0.71	±2.4%	±2.2%
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						±11.4%	±11.3%
U	**Expanded Uncertainty**						±22.9%	±22.6%

7. TEST RESULTS

7.1 SAR Results

7.1.1 Body-worn Condition, 0 mm separation distance

Band	Frequency [MHz]	Maximum Power [dBm]	Conducted Power [dBm]	Test position	Duty Cycle [%]	Measured SAR_{1g} [W/kg]	Power Drift* [dB]	Scaling Factor	Reported SAR_{1g} [W/kg]	Plot #
NFC	13.56	18.45	13.66	Front 0mm	100	0.00036	0**	3.01	0.0011	
NFC	13.56	18.45	13.66	Back 0mm	100	0.01	0**	3.01	0.034	2
NFC	13.56	18.45	13.66	Left 0mm	100	0.0010	0**	3.01	0.0030	
NFC	13.56	18.45	13.66	Right 0mm	100	0.00075	-0.25	3.19	0.0024	
NFC	13.56	18.45	13.66	Top 0mm	100	0.00066	0**	3.01	0.0020	

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

The pictures of the test positions are presented in Appendix A.

APPENDIX A: PHOTOS OF THE DUT

Diameter of the DUT is 40mm with height of 12mm.

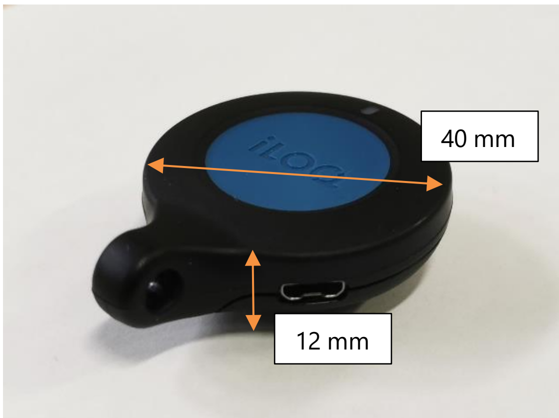


Figure 3. Overview of the DUT

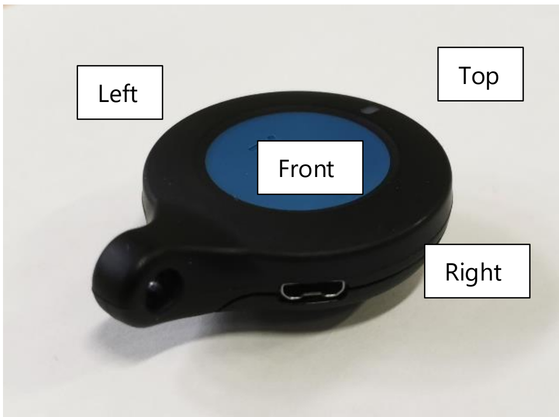


Figure 4. Definition of the sides

Figure 5. Definition of the sides

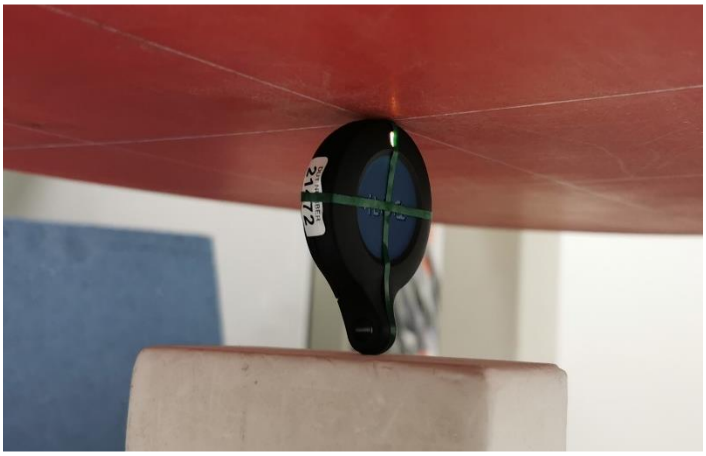


Figure 6. Top side of the device, 0mm

Figure 7. Left side of the device, 0mm

Figure 8. Back side of the device, 0mm

Figure 9. Front side of the device, 0mm

Figure 10. Right side of the device, 0mm

APPENDIX B: SYSTEM CHECK SCAN

Plot 1

Date/Time: 28.11.22 11:14:14

Test Laboratory: Verkotan Oy

DUT: CLA-13 - SN1012; Type: CLA-13; Serial: SN1007

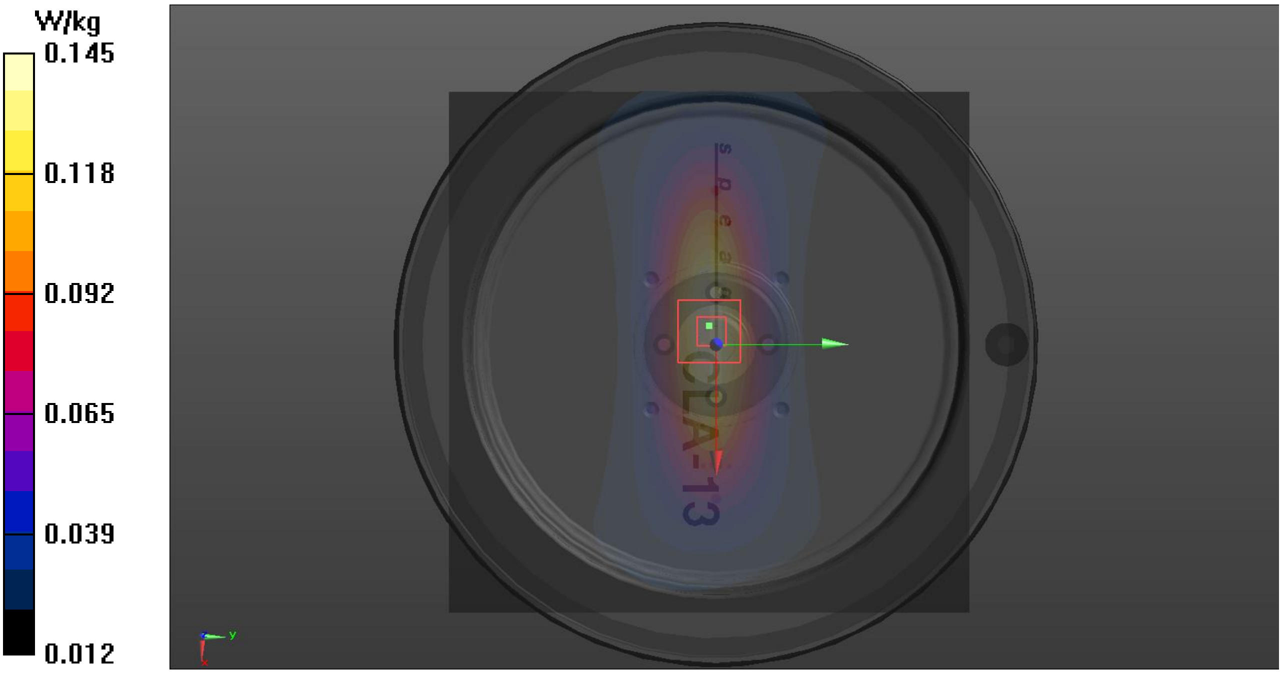
Communication System: UID 0, CW (0); Communication System Band: CLA13 (13.0MHz); Frequency: 13 MHz;
Communication System PAR: 0 dB;
Medium parameters used: f = 13 MHz; σ = 0.703 S/m; ε_r = 53.464; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN7447; ConvF(15.43, 15.43, 15.43) @ 13 MHz; Calibrated: 28.2.22
    - Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 31.0, -4.0
    - Electronics: DAE4 Sn705; Calibrated: 12.4.22
    - Phantom: SAR1_Phantom1_ELI; Type: QD OVA 002 AA;
    - DASY52 52.10.2(1495); SEMCAD X 14.6.14(7483)

Configuration/System check, 13MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 14.42 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 0.213 W/kg
SAR(1 g) = 0.141 W/kg; SAR(10 g) = 0.090 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 = 64.8%
Maximum value of SAR (measured) = 0.145 W/kg

Configuration/System check, 13MHz/Area Scan (121x121x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.213 W/kg



APPENDIX C: MEASUREMENT SCAN

Plot 2

Date/Time: 28.11.22 12:49:21

Test Laboratory: Verkotan Oy

DUT: iLOQ Fob;

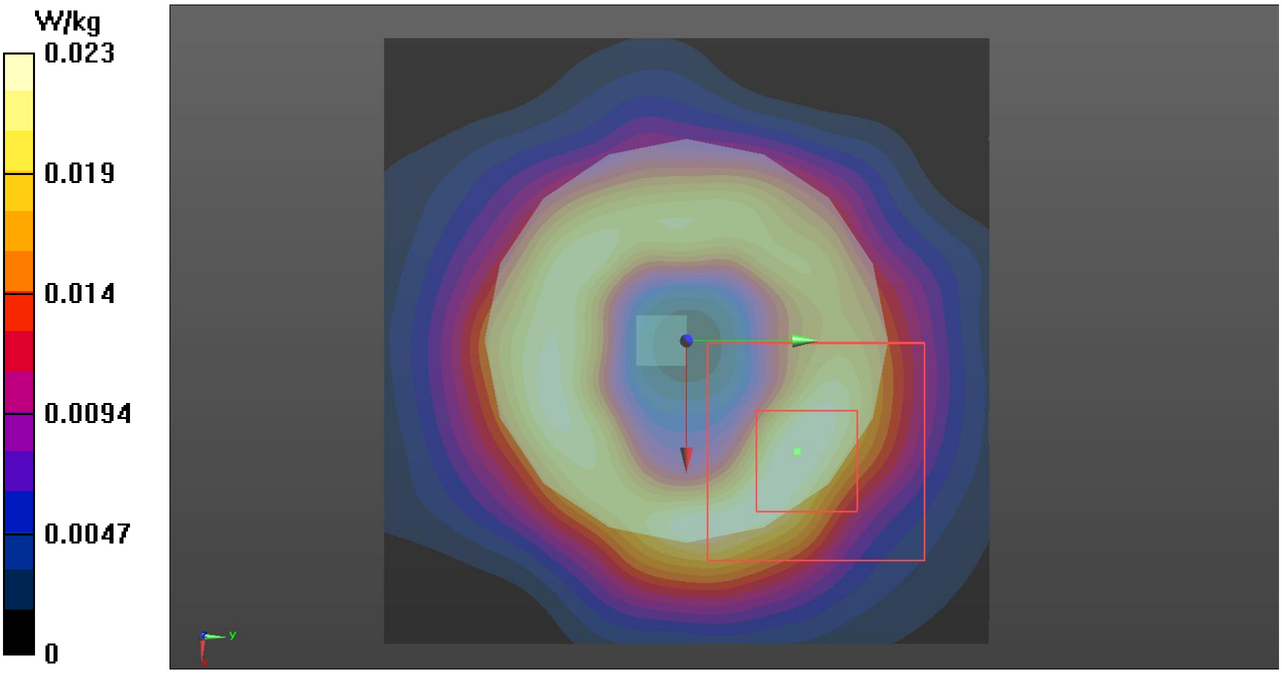
Communication System: UID 0, NFC 13.56MHz (0); Communication System Band: NFC; Frequency: 13.56 MHz;
Communication System PAR: 0 dB;
Medium parameters used: f = 14 MHz; σ = 0.703 S/m; ε_r = 53.436; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC)

DASY Configuration:

- Probe: EX3DV4 - SN7447; ConvF(15.43, 15.43, 15.43) @ 13.56 MHz; Calibrated: 28.2.22
    - Sensor-Surface: 1.4mm (Mechanical Surface Detection), z = 31.0, -4.0
    - Electronics: DAE4 Sn705; Calibrated: 12.4.22
    - Phantom: SAR1_Phantom1_ELI; Type: QD OVA 002 AA;
    - DASY52 52.10.2(1495); SEMCAD X 14.6.14(7483)

Configuration/NFC, 13.56MHz, back, 0mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 0.4420 V/m; Power Drift = 5.81 dB
Peak SAR (extrapolated) = 0.0390 W/kg
SAR(1 g) = 0.011 W/kg; SAR(10 g) = 0.00382 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 = 25.6%
Maximum value of SAR (measured) = 0.0229 W/kg

Configuration/NFC, 13.56MHz, back, 0mm/Area Scan (61x61x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.0206 W/kg



APPENDIX D: RELEVANT PAGES FROM PROBE CALIBRATION

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
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: EX3-7447_Feb22

CALIBRATION CERTIFICATE

Object: EX3DV4 - SN:7447

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: February 28, 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	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: CC2552 (20x)	09-Apr-21 (No. 217-03343)	Apr-22
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:	Niels Kuster	Quality Manager	

Issued: March 1, 2022

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Certificate No: EX3-7447_Feb22 Page 1 of 9

DASY/EASY - 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]	0.40	0.43	0.44	± 10.1 %
DCP (mV)[B]	93.5	95.0	96.2	

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	155.9	±2.5 %	± 4.7 %
		Y	0.0	0.0	1.0		167.3		
		Z	0.0	0.0	1.0		159.8		

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:7447

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)
13	55.0	0.75	15.43	15.43	15.43	0.00	1.00	± 13.3 %
750	41.9	0.89	10.39	10.39	10.39	0.42	0.80	± 12.0 %
900	41.5	0.97	9.90	9.90	9.90	0.45	0.80	± 12.0 %
1750	40.1	1.37	8.42	8.42	8.42	0.28	0.85	± 12.0 %
1950	40.0	1.40	8.13	8.13	8.13	0.26	0.85	± 12.0 %
2150	39.7	1.53	8.14	8.14	8.14	0.25	0.85	± 12.0 %
2300	39.5	1.67	8.09	8.09	8.09	0.21	0.90	± 12.0 %
2450	39.2	1.80	7.77	7.77	7.77	0.15	0.90	± 12.0 %
2600	39.0	1.96	7.61	7.61	7.61	0.24	0.90	± 12.0 %
3300	38.2	2.71	6.85	6.85	6.85	0.30	1.30	± 13.1 %
5250	35.9	4.71	5.20	5.20	5.20	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.50	4.50	4.50	0.40	1.80	± 13.1 %
5750	35.4	5.22	4.60	4.60	4.60	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.

APPENDIX E: RELEVANT PAGES FROM DIPOLE CALIBRATION REPORTS

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

ilac-MRA

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Accreditation No.: SCS 0108

Client **Verkotan** **Certificate No: CLA13-1012_Mar21**

CALIBRATION CERTIFICATE

Object	CLA13 - SN: 1012
Calibration procedure(s)	QA CAL-15.v9 Calibration Procedure for SAR Validation Sources below 700 MHz
Calibration date:	March 11, 2021

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	01-Apr-20 (No. 217-03100/03101)	Apr-21
Power sensor NRP-Z91	SN: 103244	01-Apr-20 (No. 217-03100)	Apr-21
Power sensor NRP-Z91	SN: 103245	01-Apr-20 (No. 217-03101)	Apr-21
Reference 20 dB Attenuator	SN: CC2552 (20x)	31-Mar-20 (No. 217-03106)	Apr-21
Type-N mismatch combination	SN: 310982 / 06327	31-Mar-20 (No. 217-03104)	Apr-21
Reference Probe EX3DV4	SN: 3877	30-Dec-20 (No. EX3-3877_Dec20)	Dec-21
DAE4	SN: 654	26-Jun-20 (No. DAE4-654_Jun20)	Jun-21

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 Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	M.Weber
Approved by:	Katja Pokovic	Technical Manager	

Issued: March 12, 2021

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Certificate No: CLA13-1012_Mar21 Page 1 of 6

Calibration Laboratory of
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Accreditation No.: SCS 0108

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The source is mounted in a touch configuration below the center marking of the flat phantom.
- *Return Loss:* This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	ELI4 Flat Phantom	Shell thickness: 2 ± 0.2 mm
EUT Positioning	Touch Position	
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	13 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	55.0	0.75 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	53.8 ± 6 %	0.72 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	1 W input power	0.540 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**0.555 W/kg ± 18.4 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	1 W input power	0.337 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**0.346 W/kg ± 18.0 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.5 Ω + 5.4 jΩ
Return Loss	- 23.4 dB

Additional EUT Data

Manufactured by	SPEAG

DASY5 Validation Report for Head TSL

Date: 11.03.2021

Test Laboratory: SPEAG, Zurich, Switzerland

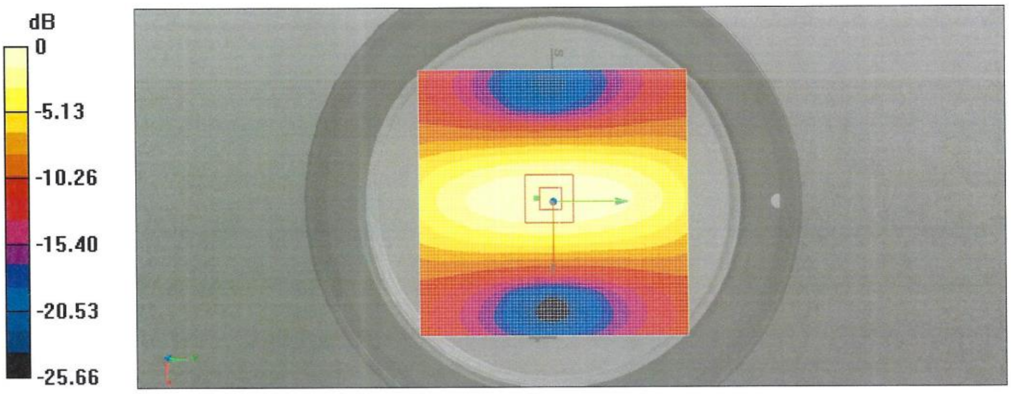
DUT: CLA13; Type: CLA13; Serial: CLA13 - SN: 1012

Communication System: UID 0 - CW; Frequency: 13 MHz
Medium parameters used: f = 13 MHz; $\sigma = 0.72$ S/m; $\varepsilon_r = 53.8$; $\rho = 1000$ kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: EX3DV4 - SN3877; ConvF(15.33, 15.33, 15.33) @ 13 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 26.06.2020
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

CLA Calibration for HSL-LF Tissue/CLA-13, touch configuration, Pin=1W/Zoom Scan, dist=1.4mm (8x10x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 30.71 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 1.09 W/kg
SAR(1 g) = 0.549 W/kg; SAR(10 g) = 0.337 W/kg
Smallest distance from peaks to all points 3 dB below: Larger than measurement grid (> 30mm)
Ratio of SAR at M2 to SAR at M1 = 78.3%
Maximum value of SAR (measured) = 0.789 W/kg



0 dB = 0.789 W/kg = -1.03 dBW/kg

Impedance Measurement Plot for Head TSL