

SAR Compliance Test Report

Date of Report	16/09/2016	Client's Contact person:	Sanna Lindholm
Number of pages:	29	Responsible Test engineer:	Ilpo Joensuu
Testing laboratory:	Verkotan Oy Elektroniikkatie 17 90590 Oulu Finland	Client:	Oxford Instruments Analytical Oy Derby Business Park Tarvonsalmenkatu 17 02631 Espoo
Tested device	Metal Analyzer (LMDS2850)		
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 Evaluation Procedure for Mobile and Portable Radio Transmitters with Respect to Health Canada's Safety Code 6 for Exposure of Humans to Radio Frequency Fields IEEE 1528 - 2013 IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Technique		
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:	16.09.2016		
For the contents:			

Laboratory Manager

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1. SUMMARY OF SAR TEST REPORT

1.1 Test Details

Equipment under Test (EUT):

Product:	Metal Analyzer
Manufacturer:	Oxford Instruments Oy
Type:	LMDS2850
Serial Number:	SN:10008, SN:1005
FCC ID Number:	Z64-WL18MODGB
IC ID Number:	451I- WL18MODGB
Hardware Version:	HW 3.0
DUT Number:	23137, 23138
Battery Type used in testing:	ND203FD31
Portable/ Mobile device	Portable
State of the Sample	Prototype

Testing information:

Testing performed:	7-8.9.2016
Notes:	-
Document name:	FCC SAR report_MLDS2850_160916.docx
Temperature °C	22±2 / Controlled
Humidity RH%	40±20 / Controlled
Measurement performed by:	Ilpo Joensuu

1.2 Maximum Results

The maximum reported* SAR values for Body-worn configurations is 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) for Body is SAR_{1g} 1.6 W/kg,

Equipment Class	System	Highest Reported* SAR _{1g} (W/kg) in Body-Worn Condition	Result
DTS	2.4 GHz WLAN	0.2	PASS

* Reported SAR Values are scaled to, or measured at, upper limit of power tuning tolerance.

1.2.1 Maximum Drift

Maximum Drift During Measurements	-0.142 dB
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1.2.2 Measurement Uncertainty

Expanded Uncertainty (k=2) 95 %	±24.5 %
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2. DESCRIPTION OF THE DEVICE UNDER TEST (DUT)

The tested device is a hand held metal analyzer. The product can also be used in a bodyworn configuration i.e. hanging in a neck strap.

Device Category	Portable
Exposure Environment	Uncontrolled

2.1 Supported Frequency Bands and Operational Modes

TX Frequency bands	Modes of Operation	Modulation Mode	Transmitter Frequency Range (MHz)
	WLAN 2.4G	DSSS/OFDM	2412 - 2462

Common features	
Output Power and Batteries	The can be used with a ND203FD31 battery and with power supply cable.

2.2 Simultaneous transmission

DUT has no simultaneous transmission possibility.

2.3 Antenna location and SAR test Exclusion

Picture of the location is presented in Appendix A.

SAR test exclusion table based on antenna location;

Separation distances ≤50mm						
Test Position	Frequency [GHz] (high channel)	Max power (including tune-up tolerance)	Max Power [mW]	Antenna to edge distance [mm]	Result (4.3.1 a))	SAR test required (≤3.0)
Display	2.462	15.4	35	13.3	4.1	YES
Right Hand Side	2.462	15.4	35	7	7.8	YES

Separation distances >50mm, freq>1500MHz						
Test Position	Frequency [GHz] (high channel)	Max power (including tune-up tolerance)	Max Power [mW]	Antenna to edge distance [mm]	Threshold (4.3.1 b 2)) [mW]	SAR test required (power > threshold)
Left Hand side	2.462	15.4	35	84	436	NO
Rear	2.462	15.4	35	210	1696	NO
Top	2.462	15.4	35	86	456	NO
Bottom	2.462	15.4	35	165	1246	NO

Standalone SAR test exclusion considerations has been made to according to KDB 447498 D01 General RF Exposure Guidance v06, section 4.3.1, for test separation distances ≤50mm and >50mm.
SAR test exclusion was defined according to equation

$$\left[\frac{(\text{max. power of channel, including tune-up tolerance, mW})}{(\text{min. test separation distance, mm})} \right] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0$$
, for separation distances ≤50mm)

and

$$\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot 10]\} \text{ mW}$$
, for > 1500 MHz and ≤ 6 GHz, separation distances >50mm.

Maximum power of 15.4 dBm and frequency of 2.462 MHz were used in the calculation for a conservative definition of SAR test exclusion.

3. OUTPUT POWER

3.1 Maximum specified conducted output power

From a Customer;

				Tuning Target (dBm)			Upper Limit (dBm)		
Standard	Transmission mode	Modulation	Data rate [Mbps]	CH 1 2.412 GHz	CH 6 2.437 GHz	CH 11 2.462 GHz	CH 1 2.412 GHz	CH 6 2.437 GHz	CH 11 2.462 GHz
802.11b	DSSS	BPSK	1	14.4	14.1	13.8	15.4	15.1	14.8
802.11b	DSSS	QPSK	11	13.9	13.7	13.4	14.9	14.7	14.4
802.11g	OFDM	BPSK	6	11.2	13.5	10.8	12.2	14.5	11.8
802.11g	OFDM	64QAM	54	8.7	8.7	8.7	9.7	9.7	9.7

3.2 Tested conducted power

				Measured Power (dBm)		
Standard	Transmission mode	Modulation	Data rate [Mbps]	CH 1 2.412 GHz	CH 6 2.437 GHz	CH 11 2.462 GHz
802.11b	DSSS	BPSK	1	15.3	14.3	14.2
802.11b	DSSS	QPSK	2	14.1	13.9	13.9
802.11b	DSSS	QPSK	5.5	13.3	13.1	13.0
802.11b	DSSS	QPSK	11	12.4	12.3	12.1
802.11g	OFDM	BPSK	6	10.9	12.2	10.6
802.11g	OFDM	BPSK	9	10.1	11.5	9.9
802.11g	OFDM	QPSK	12	9.6	10.9	9.3
802.11g	OFDM	QPSK	18	8.6	9.9	8.4
802.11g	OFDM	16QAM	24	7.7	9.1	7.6
802.11g	OFDM	16QAM	36	6.7	7.7	6.4
802.11g	OFDM	64QAM	48	5.9	6.2	5.5
802.11g	OFDM	64QAM	54	5.0	5.0	4.8

4. TEST EQUIPMENT

Dasy4 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.

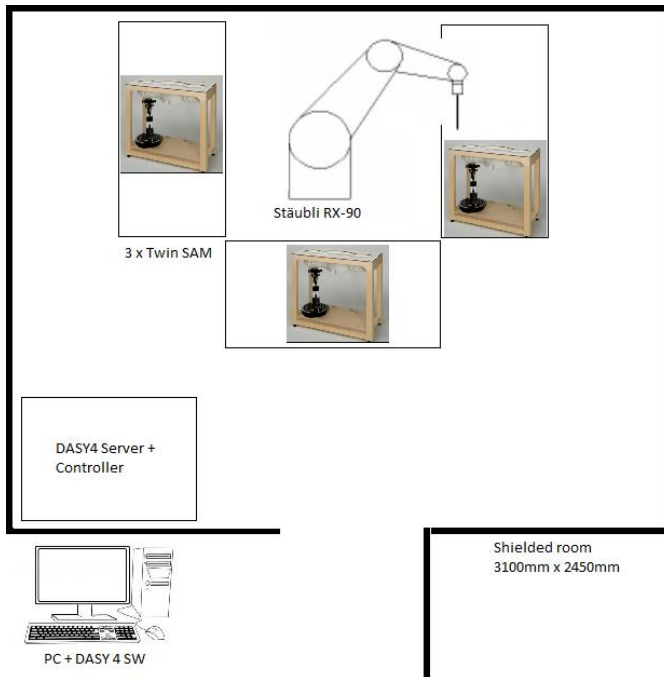


Figure 1 Schematic Laboratory Picture

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	Calibration Expiry
DAE	DAE3	371	01/2016	01/2017
Probe	EX3DV4	3570	01/2016	01/2017
Dipole	D2450V2	758	01/2016	01/2019
DASY Software	v4.7	na	na	na
Signal Generator	SMIQ06B	834968/023	na	na
Amplifier	AR 5S1G4	27573	na	na
Power Reflection Meter	R&S NRT	835065/049	12/2015	12/2016
Power Sensor	NRT Z-44	835374/021	01/2016	01/2017

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 μ W/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

The phantom used in SAR tests was the flat phantom section of the twin-headed "SAM Phantom", manufactured by SPEAG. The phantom conforms 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 $\pm 5\%$ of the recommended values in all frequencies used. SAR testing was carried out within 24 hours of measuring the dielectric parameters. Depth of the tissue simulant was at least 15.0 cm from the inner surface of the flat phantom.

4.3.1 Recipes

Ingredient	Body (% by weight)
	2350-2700 MHz
Deionised Water	70.2
Tween 20	29.62
Salt	0.18

4.4 System Validation Status

Frequency [MHz]	Dipole Type / SN	Probe Type / SN	Calibrated Signal Type	DAE Unit / SN	Validation Done	
					Head tissue simulant	Body tissue simulant
2450	D2450V2 / 758	EX3DV4 / 3570	CW	DAE3 / 371	02/2016	02/2016

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 _{1g} (%)	Plot #
7.9.201620.	M2450	22.4	2450	250mW	12.4	51.2	49.6	3.1%	1

4.5.1 Tissue Simulant Verification

Date	Tissue Type	Tissue Temp. [°C]	Frequency [MHz]	Target		Measured		Deviation σ (%)	Deviation ϵ (%)
				Conductivity, σ [S/m]	Dielectric Constant ϵ	Conductivity σ [S/m]	Dielectric Constant ϵ		
7.9	M2450	22	2450	1.95	52.7	1.9	52.2	-2.6	-0.9
7.9	M2450	22	2412	1.91	52.8	1.86	52.3	-3.1	-0.8

5. TEST PROCEDURE

The DUT was set to transmit continuously at a maximum power level using a manufacturer specified software. It was tested standalone with a fully charged battery. Worst case standalone SAR test was repeated with a power supply cable.

5.1 Test Positions

5.1.1 Body-worn Configuration, 0 mm separation distance

The DUT was placed below the flat phantom using a SPEAG device holder. The holder grip was from the handle of the DUT. The DUT was lifted towards the phantom until it was in touch with the phantom. Pictures of the test positions are in appendix A.



5.2 Scan Procedures

First, area scans were used for determination of the field distribution. Next, a zoom scan, a minimum of 5x5x7 points below 2GHz, 7x7x7 points between 2 and 3 GHz and 8x8x7 points above 5GHz covering a volume of at least 30x30x30mm at frequencies below 3GHz and 22x22x22mm at frequencies above 5GHz, 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 is averaged over a cube of tissue using interpolation and extrapolation.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor o_set. Several measurements at different distances are necessary for the extrapolation.

The interpolation, extrapolation and maximum search routines within Dasy47 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).

6. MEASUREMENT UNCERTAINTY

Uncertainty Budget								
Error Description	Uncert. value	Prob. Dist.	Div.	(c _i) 1g	(c _i) 10g	Std. Unc. (1g)	Std. Unc. (10g)	(v _i) v _{eff}
Measurement System								
Probe Calibration	±6.55 %	N	1	1	1	±6.55 %	±6.55 %	∞
Axial Isotropy	±4.7 %	R	$\sqrt{2}$	0.7	0.7	±1.9 %	±1.9 %	∞
Hemispherical Isotropy	±9.6 %	R	$\sqrt{2}$	0.7	0.7	±3.9 %	±3.9 %	∞
Boundary Effects	±2.0 %	R	$\sqrt{2}$	1	1	±1.2 %	±1.2 %	∞
Linearity	±4.7 %	R	$\sqrt{2}$	1	1	±2.7 %	±2.7 %	∞
System Detection Limits	±1.0 %	R	$\sqrt{2}$	1	1	±0.6 %	±0.6 %	∞
Modulation Response ^m	±2.4 %	R	$\sqrt{2}$	1	1	±1.4 %	±1.4 %	∞
Readout Electronics	±0.3 %	N	1	1	1	±0.3 %	±0.3 %	∞
Response Time	±0.8 %	R	$\sqrt{2}$	1	1	±0.5 %	±0.5 %	∞
Integration Time	±2.6 %	R	$\sqrt{2}$	1	1	±1.5 %	±1.5 %	∞
RF Ambient Noise	±3.0 %	R	$\sqrt{2}$	1	1	±1.7 %	±1.7 %	∞
RF Ambient Reflections	±3.0 %	R	$\sqrt{2}$	1	1	±1.7 %	±1.7 %	∞
Probe Positioner	±0.8 %	R	$\sqrt{2}$	1	1	±0.5 %	±0.5 %	∞
Probe Positioning	±6.7 %	R	$\sqrt{2}$	1	1	±3.9 %	±3.9 %	∞
Max. SAR Eval.	±4.0 %	R	$\sqrt{2}$	1	1	±2.3 %	±2.3 %	∞
Test Sample Related								
Device Positioning	±2.9 %	N	1	1	1	±2.9 %	±2.9 %	145
Device Holder	±3.6 %	N	1	1	1	±3.6 %	±3.6 %	5
Power Drift	±5.0 %	R	$\sqrt{2}$	1	1	±2.9 %	±2.9 %	∞
Power Scaling ^p	±0 %	R	$\sqrt{2}$	1	1	±0.0 %	±0.0 %	∞
Phantom and Setup								
Phantom Uncertainty	±6.6 %	R	$\sqrt{2}$	1	1	±3.8 %	±3.8 %	∞
SAR correction	±1.9 %	R	$\sqrt{2}$	1	0.84	±1.1 %	±0.9 %	∞
Liquid Conductivity (mea.) ^{DAK}	±2.5 %	R	$\sqrt{2}$	0.78	0.71	±1.1 %	±1.0 %	∞
Liquid Permittivity (mea.) ^{DAK}	±2.5 %	R	$\sqrt{2}$	0.26	0.26	±0.3 %	±0.4 %	∞
Temp. unc. - Conductivity ^{BB}	±3.4 %	R	$\sqrt{2}$	0.78	0.71	±1.5 %	±1.4 %	∞
Temp. unc. - Permittivity ^{BB}	±0.4 %	R	$\sqrt{2}$	0.23	0.26	±0.1 %	±0.1 %	∞
Combined Std. Uncertainty						±12.3 %	±12.2 %	748
Expanded STD Uncertainty						±24.6 %	±24.5 %	

7. TEST RESULTS

7.1 Body-Worn Configuration, 0 mm separation distance

Band	Channel	Test Position	Maximum Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle	Measured SAR _{1g} [mW/g]	Scaling Factor	Reported SAR _{1g} [mW/g]	Plot #
802.11b DSSS 1Mbps	1	Display	15.4	15.3	-0.012	1	0.12	1.02	0.12	2
802.11b DSSS 1Mbps	1	Right hand side	15.4	15.3	-0.124	1	0.19	1.02	0.19	3

Max SAR tested with a power supply cable

Band	Channel	Test Position	Maximum Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Duty Cycle	Measured SAR _{1g} [mW/g]	Scaling Factor	Reported SAR _{1g} [mW/g]	Plot #
802 DSSS 1Mbps.11b	1	Right hand side	15.4	15.3	0.009	1	0.2	1.02	0.2	4

APPENDIX A: PHOTOS OF THE DUT

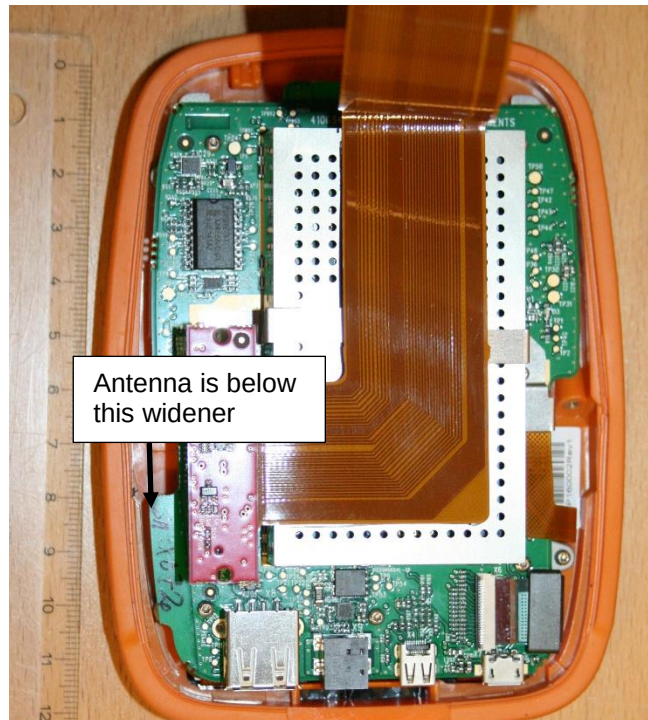
Display side of the device;

Antenna location marked with blue.



Rear side of the display;

Antenna below the widener.





Test Position for display side testing.



Test position right hand side testing.



APPENDIX B: SYSTEM CHECK SCAN

Date/Time: 07.09.2016 15:28:18

Test Laboratory: Verkotan Oy

File Name: 070916 BODY SystemPerformanceCheck-D2450.da4

Plot 1

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:758

Program Name: System Performance Check at 2450 MHz

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.9$ mho/m; $\epsilon_r = 52.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3570; ConvF(6.5, 6.5, 6.5); Calibrated: 15.01.2016
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn371; Calibrated: 21.01.2016
- Phantom: SAM_1; Type: SAM Twin; Serial: TP-1128
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

d=10mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 85.3 V/m; Power Drift = 0.125 dB

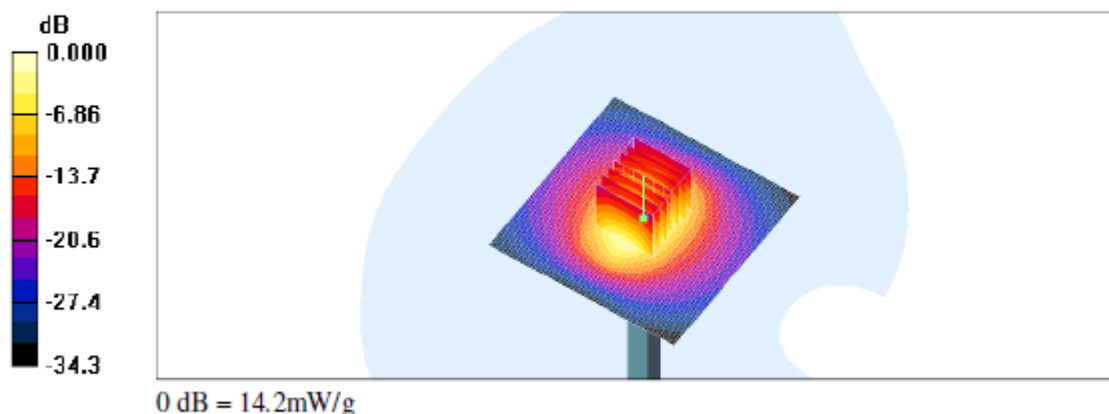
Peak SAR (extrapolated) = 24.8 W/kg

SAR(1 g) = 12.4 mW/g; SAR(10 g) = 5.83 mW/g

Maximum value of SAR (measured) = 14.4 mW/g

d=10mm, Pin=250mW/Area Scan (81x81x1): Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 14.2 mW/g



APPENDIX C: MEASUREMENT SCAN

Date/Time: 08.09.2016 09:29:47

Test Laboratory: Verkotan Oy
File Name: [802.11b FCC.da4](#)

Plot 2
DSSS 1Mbps

DUT: LMDS2850; Type: Handheld Device; Serial: 10005
Program Name: Body Configuration

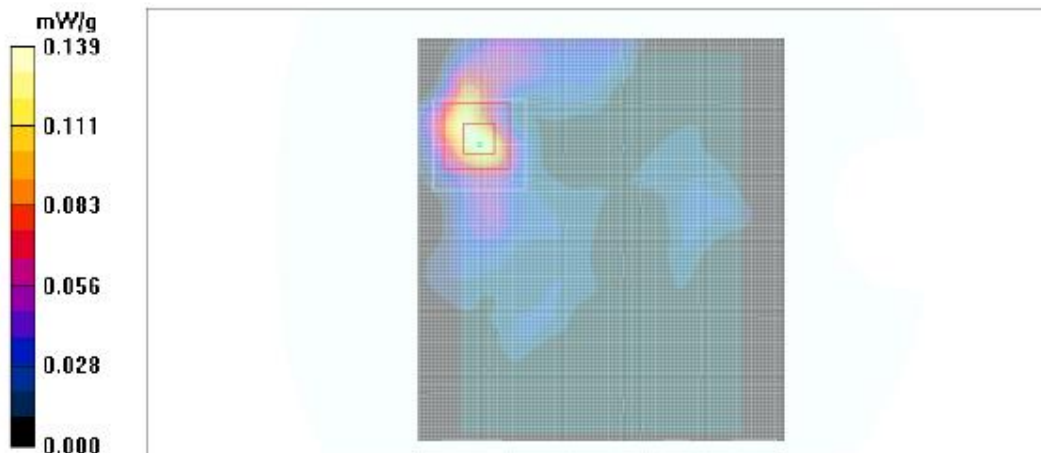
Communication System: WLAN; Frequency: 2412 MHz; Duty Cycle: 1:1
Medium parameters used: $f = 2412$ MHz; $\sigma = 1.86$ mho/m; $\epsilon_r = 52.3$; $\rho = 1000$ kg/m³
Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3570; ConvF(6.5, 6.5, 6.5); Calibrated: 15.01.2016
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn371; Calibrated: 21.01.2016
- Phantom: SAM_1; Type: SAM Twin; Serial: TP-1128
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

WLAN 82.11b Display/Area Scan (101x111x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (interpolated) = 0.136 mW/g

WLAN 82.11b Display/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 2.42 V/m; Power Drift = -0.012 dB
Peak SAR (extrapolated) = 0.249 W/kg
SAR(1 g) = 0.120 mW/g; SAR(10 g) = 0.054 mW/g
Maximum value of SAR (measured) = 0.139 mW/g



Date/Time: 08.09.2016 10:06:56

Test Laboratory: Verkotan Oy
File Name: [802.11b FCC.da4](#)

Plot 3
DSSS
1Mbps

DUT: LMDS2850; Type: Handheld Device; Serial: 10005
Program Name: Body Configuration

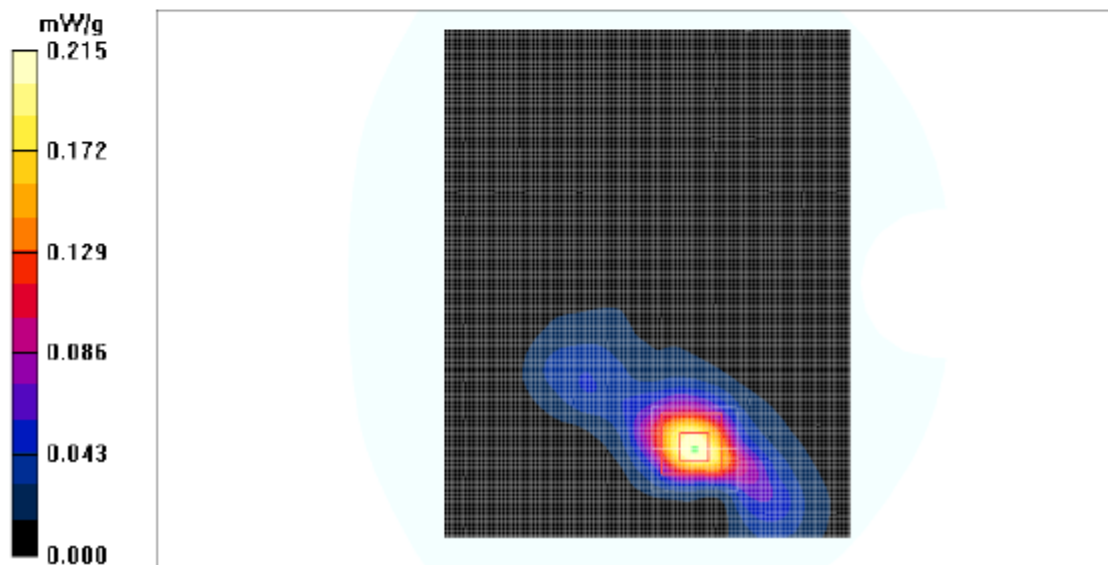
Communication System: WLAN; Frequency: 2412 MHz; Duty Cycle: 1:1
Medium parameters used: $f = 2412 \text{ MHz}$; $\sigma = 1.86 \text{ mho/m}$; $\epsilon_r = 52.3$; $\rho = 1000 \text{ kg/m}^3$
Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3570; ConvF(6.5, 6.5, 6.5); Calibrated: 15.01.2016
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn371; Calibrated: 21.01.2016
- Phantom: SAM_1; Type: SAM Twin; Serial: TP-1128
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

WLAN 82.11b Right Side/Area Scan (121x151x1): Measurement grid: $dx=12\text{mm}$, $dy=12\text{mm}$
Maximum value of SAR (interpolated) = 0.238 mW/g

WLAN 82.11b Right Side/Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$
Reference Value = 1.65 V/m; Power Drift = -0.124 dB
Peak SAR (extrapolated) = 0.348 W/kg
SAR(1 g) = 0.188 mW/g; SAR(10 g) = 0.092 mW/g
Maximum value of SAR (measured) = 0.215 mW/g



Date/Time: 08.09.2016 10:37:49

Test Laboratory: Verkotan Oy
File Name: [802.11b FCC.da4](#)

Plot 4
DSSS
1Mbps

DUT: LMDS2850; Type: Handheld Device; Serial: 10005
Program Name: Body Configuration

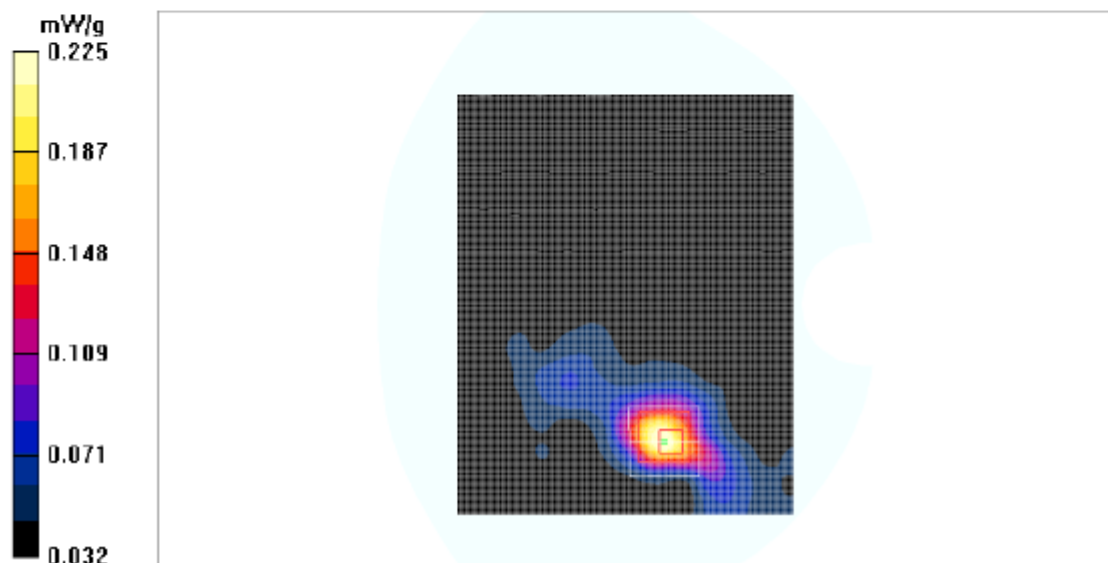
Communication System: WLAN; Frequency: 2412 MHz; Duty Cycle: 1:1
Medium parameters used: $f = 2412 \text{ MHz}$; $\sigma = 1.86 \text{ mho/m}$; $\epsilon_r = 52.3$; $\rho = 1000 \text{ kg/m}^3$
Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3570; ConvF(6.5, 6.5, 6.5); Calibrated: 15.01.2016
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 Sn371; Calibrated: 21.01.2016
- Phantom: SAM_1; Type: SAM Twin; Serial: TP-1128
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

WLAN 82.11b Right Side with power cord/Area Scan (121x151x1): Measurement grid:
 $dx=12\text{mm}$, $dy=12\text{mm}$
Maximum value of SAR (interpolated) = 0.241 mW/g

WLAN 82.11b Right Side with power cord/Zoom Scan (7x7x7)/Cube 0: Measurement grid:
 $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$
Reference Value = 4.68 V/m; Power Drift = 0.009 dB
Peak SAR (extrapolated) = 0.371 W/kg
SAR(1 g) = 0.199 mW/g; SAR(10 g) = 0.115 mW/g
Maximum value of SAR (measured) = 0.225 mW/g



APPENDIX D: RELEVANT PAGES FROM PROBE CALIBRATION REPORTS

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Verkotan**

Certificate No: **EX3-3570_Jan16**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3570**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6**
Calibration procedure for dosimetric E-field probes

Calibration date: **January 15, 2016**

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 E4419B	GB41293874	01-Apr-15 (No. 217-02128)	Mar-16
Power sensor E4412A	MY41498087	01-Apr-15 (No. 217-02128)	Mar-16
Reference 3 dB Attenuator	SN: S5054 (3c)	01-Apr-15 (No. 217-02129)	Mar-16
Reference 20 dB Attenuator	SN: S5277 (20x)	01-Apr-15 (No. 217-02132)	Mar-16
Reference 30 dB Attenuator	SN: S5129 (30b)	01-Apr-15 (No. 217-02133)	Mar-16
Reference Probe ES3DV2	SN: 3013	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: **Jeton Kastrati** Laboratory Technician

Approved by: **Katja Pokovic** Technical Manager

Issued: January 19, 2016

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Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization ϕ	ϕ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- 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
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z}** = NORM_{x,y,z} * frequency_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}**: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

EX3DV4– SN:3570

January 15, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3570

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.50	0.47	0.49	$\pm 10.1 \%$
DCP (mV) ^B	102.5	99.6	99.8	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	156.4	$\pm 2.5 \%$
		Y	0.0	0.0	1.0		150.7	
		Z	0.0	0.0	1.0		140.1	

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 Pages 5 and 6).

^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.

EX3DV4- SN:3570

January 15, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3570

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)
750	41.9	0.89	8.68	8.68	8.68	0.48	0.80	± 12.0 %
835	41.5	0.90	8.08	8.08	8.08	0.21	1.45	± 12.0 %
1750	40.1	1.37	7.19	7.19	7.19	0.31	0.85	± 12.0 %
1900	40.0	1.40	6.99	6.99	6.99	0.30	0.87	± 12.0 %
2450	39.2	1.80	6.38	6.38	6.38	0.35	0.87	± 12.0 %
2600	39.0	1.96	6.19	6.19	6.19	0.39	0.85	± 12.0 %
5250	35.9	4.71	4.30	4.30	4.30	0.40	1.80	± 13.1 %
5600	35.5	5.07	3.70	3.70	3.70	0.50	1.80	± 13.1 %
5750	35.4	5.22	4.00	4.00	4.00	0.50	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. 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.

EX3DV4- SN:3570

January 15, 2016

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3570

Calibration Parameter Determined in Body 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)
750	55.5	0.96	8.41	8.41	8.41	0.43	0.93	± 12.0 %
835	55.2	0.97	8.17	8.17	8.17	0.27	1.25	± 12.0 %
1750	53.4	1.49	6.96	6.96	6.96	0.39	0.83	± 12.0 %
1900	53.3	1.52	6.77	6.77	6.77	0.27	1.03	± 12.0 %
2450	52.7	1.95	6.50	6.50	6.50	0.35	0.86	± 12.0 %
2600	52.5	2.16	6.26	6.26	6.26	0.23	1.05	± 12.0 %
5250	48.9	5.36	3.78	3.78	3.78	0.50	1.90	± 13.1 %
5600	48.5	5.77	3.25	3.25	3.25	0.55	1.90	± 13.1 %
5750	48.3	5.94	3.48	3.48	3.48	0.60	1.90	± 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. 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

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Accreditation No.: **SCS 0108**

Client **Verkotan**

Certificate No: **D2450V2-758_Jan16**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 758**

Calibration procedure(s) **QA CAL-05.v9**
Calibration procedure for dipole validation kits above 700 MHz

Calibration date: **January 14, 2016**

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 EPM-442A	GB37480704	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	US37292783	07-Oct-15 (No. 217-02222)	Oct-16
Power sensor HP 8481A	MY41092317	07-Oct-15 (No. 217-02223)	Oct-16
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe EX3DV4	SN: 7349	31-Dec-15 (No. EX3-7349_Dec15)	Dec-16
DAE4	SN: 601	30-Dec-15 (No. DAE4-601_Dec15)	Dec-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100972	15-Jun-15 (in house check Jun-15)	In house check: Jun-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

Calibrated by: **Michael Weber** **Laboratory Technician** 

Approved by: **Katja Pokovic** **Technical Manager** 

Issued: January 15, 2016

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Certificate No: D2450V2-758_Jan16

Page 1 of 8

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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:

- 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
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- 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 dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. 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	V52.8.8
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 $\pm$ 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 $\pm$ 0.2) °C	37.8 $\pm$ 6 %	1.87 mho/m $\pm$ 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	13.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.1 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.1 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	51.2 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.2 W/kg $\pm$ 16.5 % (k=2)

DASY5 Validation Report for Body TSL

Date: 14.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN: 758

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 52.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 106.8 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 26.3 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.14 W/kg

Maximum value of SAR (measured) = 21.4 W/kg

