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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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S Swiss Calibration Service

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Accreditation No.: SCS 0108

Client **UL CCS USA**

Certificate No: D2450V2-706_May17

CALIBRATION CERTIFICATE

Object	D2450V2 - SN:706
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	May 09, 2017

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-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 7349	31-Dec-16 (No. EX3-7349_Dec16)	Dec-17
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: May 11, 2017

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

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, "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
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 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	V52.10.0
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 %	1.88 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**52.1 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.20 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.4 W/kg ± 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 ± 0.2) °C	52.4 ± 6 %	2.03 mho/m ± 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	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**50.6 W/kg ± 17.0 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.01 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**23.8 W/kg ± 16.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.4 Ω + 5.1 jΩ
Return Loss	- 25.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.1 Ω + 6.2 jΩ
Return Loss	- 23.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.144 ns

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	May 28, 2002

DASY5 Validation Report for Head TSL

Date: 09.05.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:706

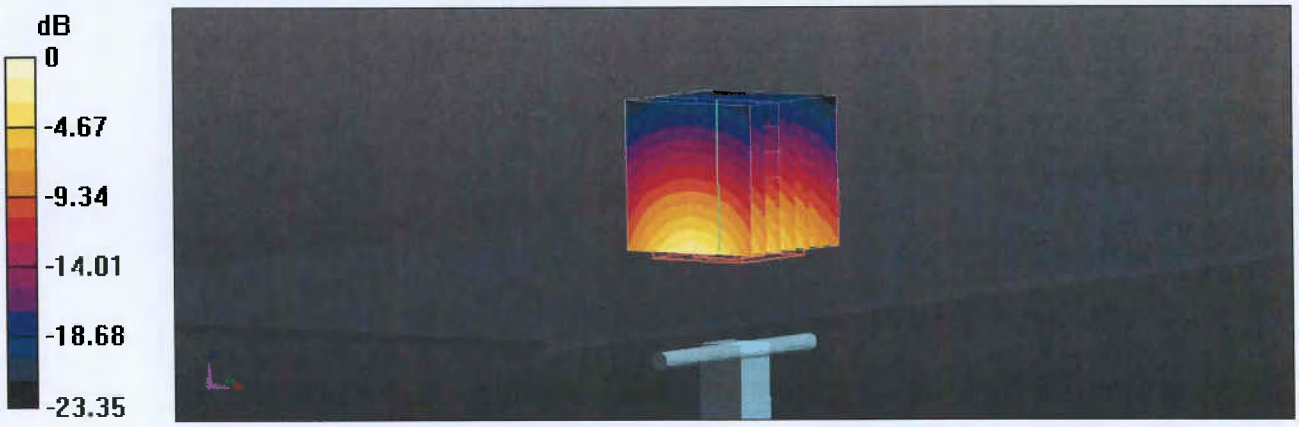
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 1.88 S/m; ε_r = 37.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.72, 7.72, 7.72); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1442); SEMCAD X 14.6.10(7413)

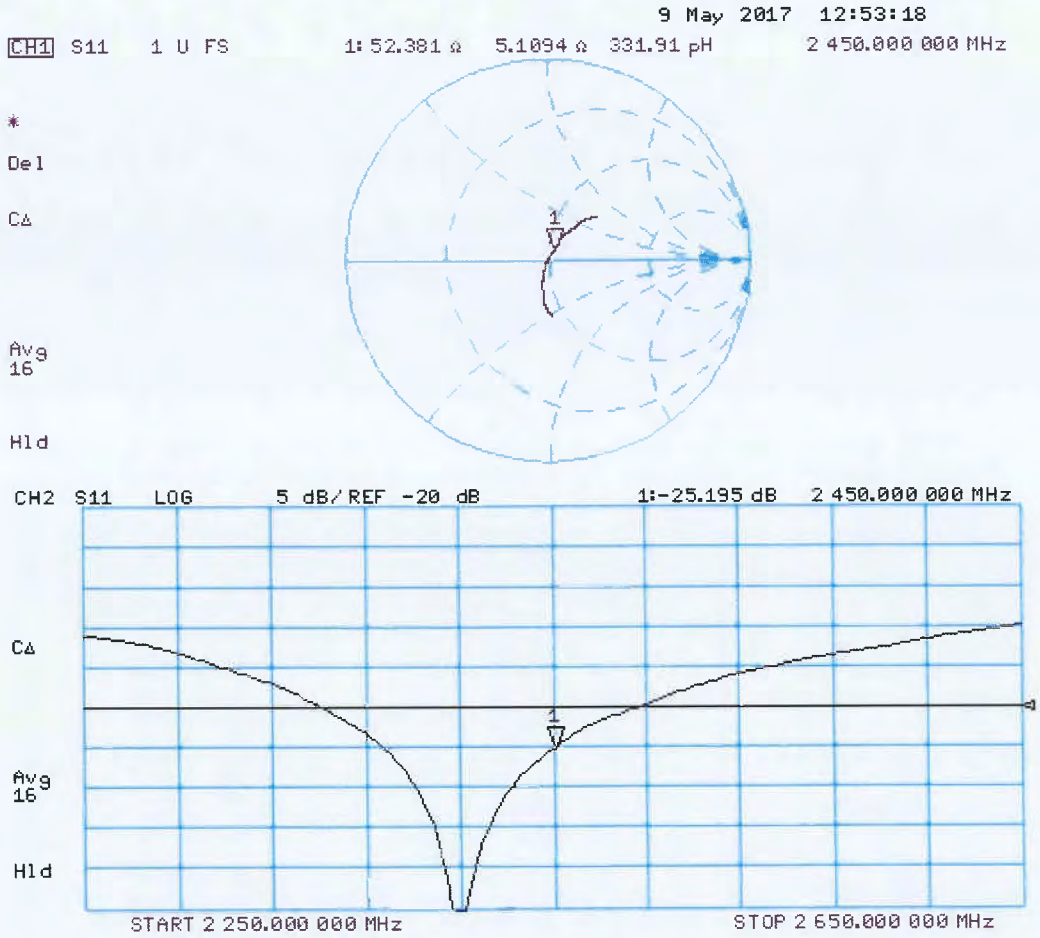
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 113.9 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 27.6 W/kg
SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.2 W/kg
Maximum value of SAR (measured) = 22.2 W/kg



0 dB = 22.2 W/kg = 13.46 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 09.05.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:706

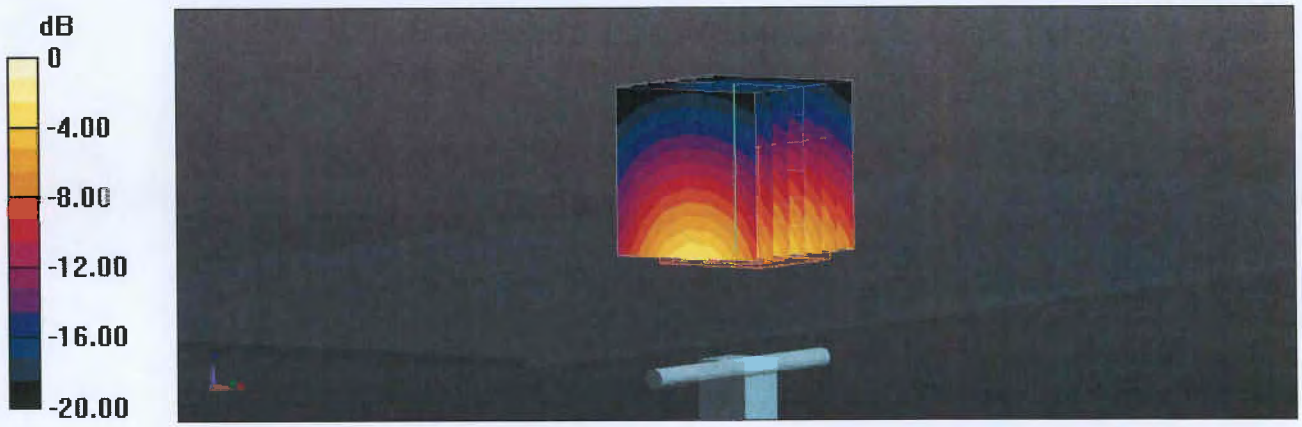
Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; σ = 2.03 S/m; ε_r = 52.4; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1442); SEMCAD X 14.6.10(7413)

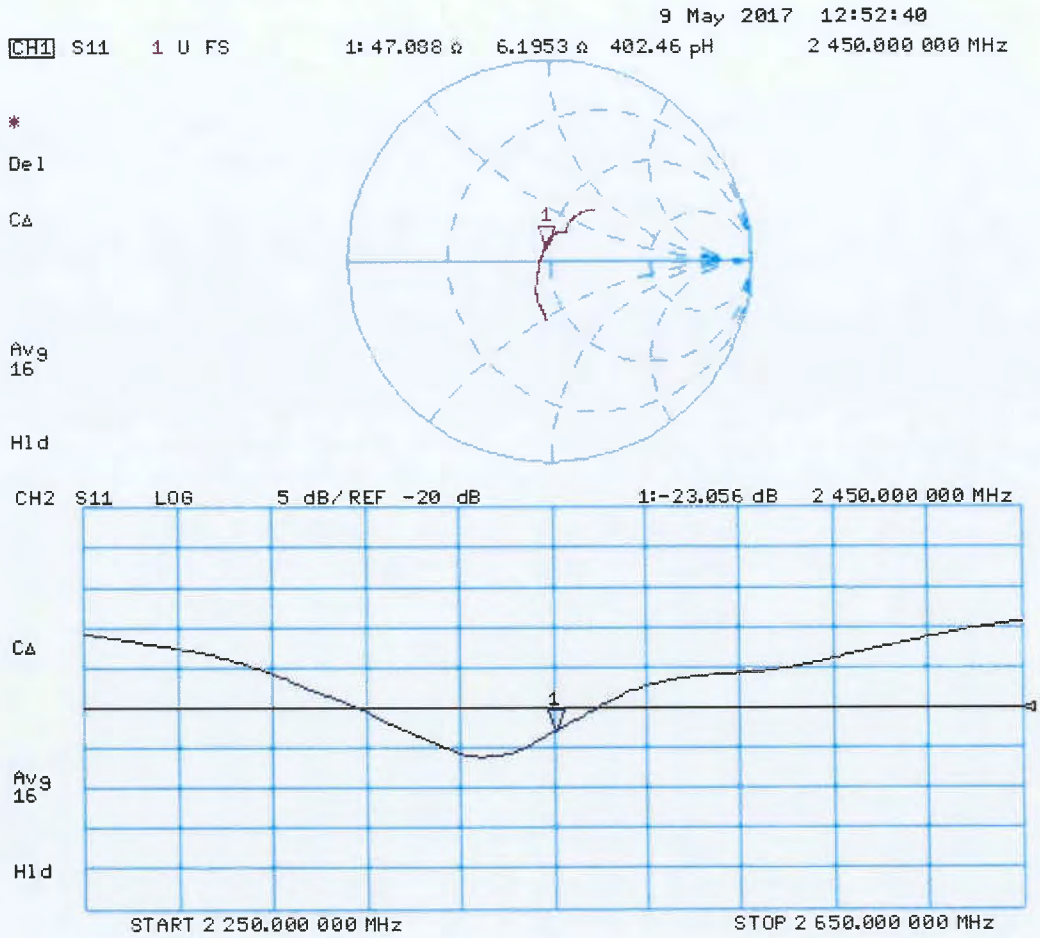
Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 105.5 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 25.4 W/kg
SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.01 W/kg
Maximum value of SAR (measured) = 20.3 W/kg



0 dB = 20.3 W/kg = 13.07 dBW/kg

Impedance Measurement Plot for Body TSL



Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Condition

Phantom	SAM Head Phantom	For usage with cSAR3D**V2**-R/L

SAR result with SAM Head (Top)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	250 mW input power	13.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**55.9 W/kg ± 17.5 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.49 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**26.1 W/kg ± 16.9 % (k=2)**

SAR result with SAM Head (Mouth)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	250 mW input power	14.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**57.0 W/kg ± 17.5 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	250 mW input power	6.82 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**27.4 W/kg ± 16.9 % (k=2)**

SAR result with SAM Head (Neck)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	250 mW input power	13.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**53.7 W/kg ± 17.5 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	250 mW input power	6.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**25.0 W/kg ± 16.9 % (k=2)**

SAR result with SAM Head (Ear)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	250 mW input power	8.56 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**34.4 W/kg ± 17.5 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	250 mW input power	4.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**17.4 W/kg ± 16.9 % (k=2)**

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 19/Feb/2018 CERTIFICATE NUMBER : 12129912JD01A

5248

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APPROVED SIGNATORY

.....

Naseer Mirza

Customer :
UL VS Inc
47173 Benicia Street
Fremont, CA 94538, USA

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	09/Feb/2018
Manufacturer:	Speag		
Type/Model Number:	D2450V2		
Serial Number:	748		
Calibration Date:	14/Feb/2018		
Calibrated By:	Chanthu Thevarajah Laboratory Engineer		
Signature:	.....		

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}C and humidity < 70%

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Use of the UKAS mark demonstrates that compliance with the requirements of BS/EN/ISO/IEC 17025 has been independently assessed.

The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2005**: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
2. **IEC 62209-2:2010:** 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)
3. **IEEE 1528: 2013:** IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques
4. FCC KDB Publication Number**: "KDB865664 D01 SAR Measurement 100 MHz to 6 GHz"**
5. **SPEAG DASY4/ DASY5 System Handbook**

The measuring equipment used to perform the calibration, documented in this certificate has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2110	Data Acquisition Electronics	SPEAG	DAE4	431	08 Nov 2017	12
A2077	Probe	SPEAG	EX3DV4	3814	28 Sep 2017	12
A1322	Dipole	SPEAG	D2450V2	725	19 Sep 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
PRE0176448	Power Sensor	Rhode & Schwarz	NRP-Z51	103459	20 June 2017	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	10 Oct 2017	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2016	24
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	09 May 2016	12
M1838	Signal Generator	Rhode & Schwarz	SME06	831377/005	30 March 2017	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F14/5T5ZA1/A/01
DASY Version:	DASY 52 (v52.8.8.1258)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	10 mm (with spacer)
Frequency:	2450 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	2450	22.0 ℃	22.0 ℃	21.6℃	22.0℃	**εr**	39.20	38.11	± 5%
						σ	1.80	1.78	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	13.30 W/Kg	**52.94 W/Kg**	± 17.57%
	SAR averaged over 10g	6.18 W/Kg	**24.60 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	52.358 Ω 3.89 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	27.52	± 2.03 dB

Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	2450	22.0 ℃	22.0 ℃	21.6℃	22.0℃	**εr**	52.70	50.63	± 5%
						σ	1.95	2.02	± 5%

SAR Results – Body Simulating Liquid (MSL)

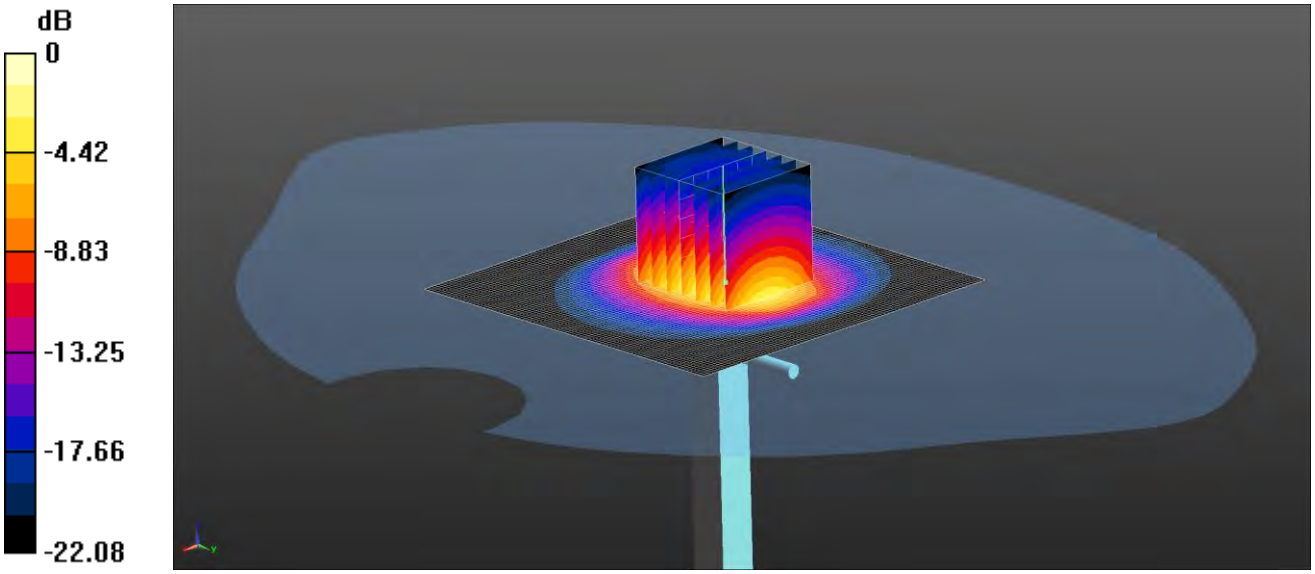
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	12.80 W/Kg	**50.95 W/Kg**	± 18.06%
	SAR averaged over 10g	5.98 W/Kg	**23.80 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	52.47 Ω -1.10 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	30.00	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D2450V2 - SN748; Type: D2450V2; Serial: SN748

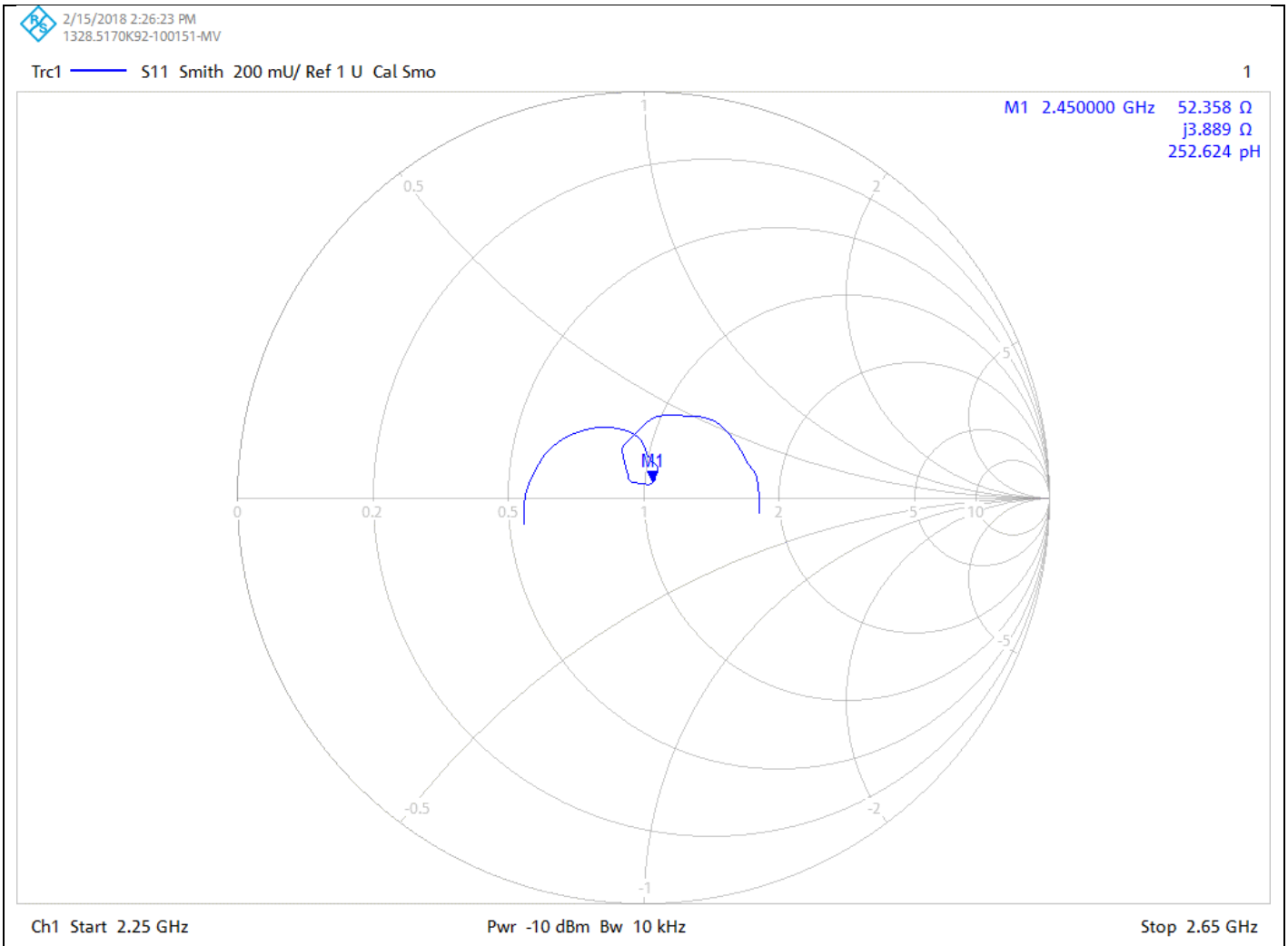


0 dB = 17.6 W/kg = 12.46 dBW/kg

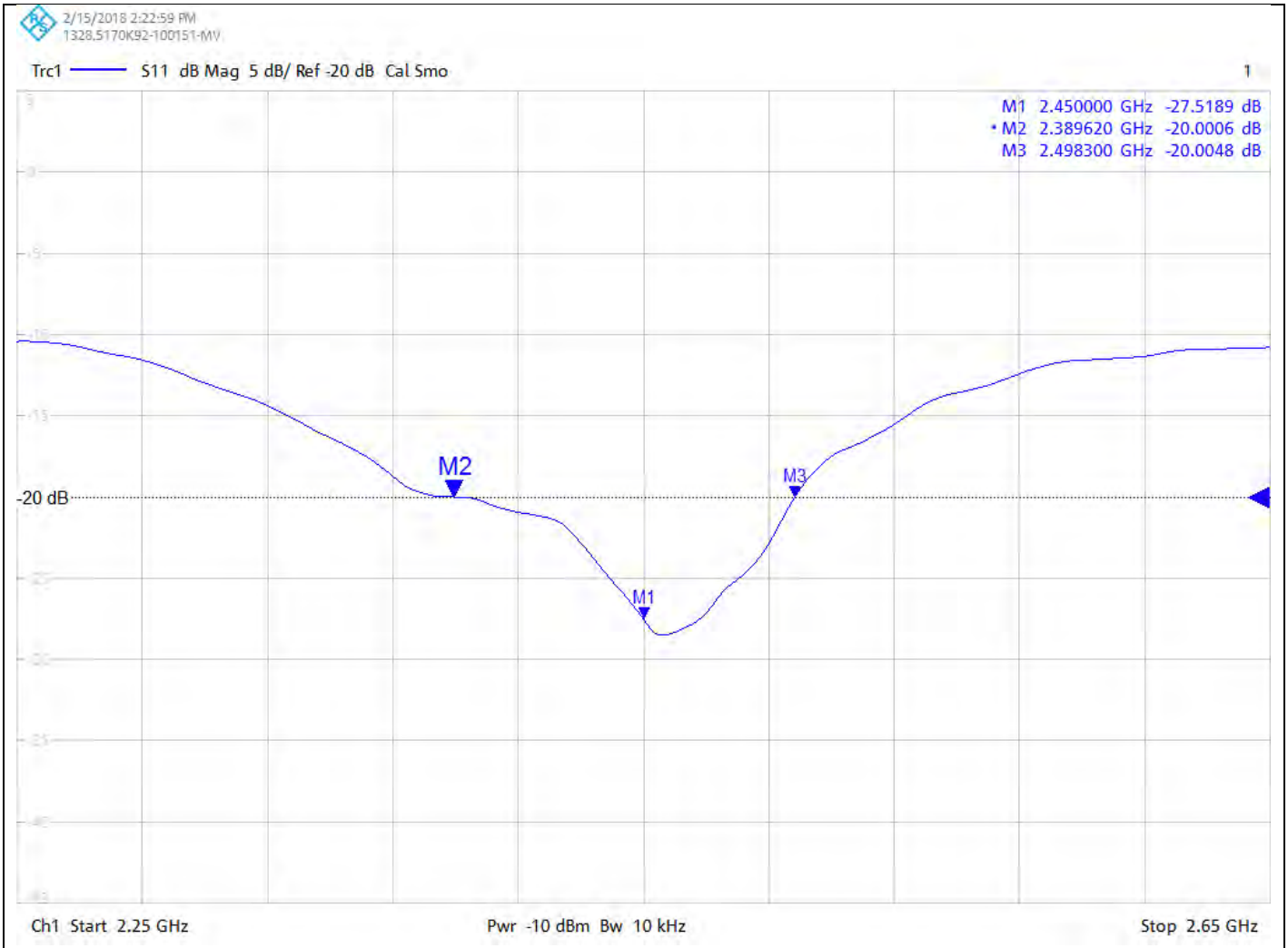
Communication System: UID 0, CW (0); Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: 2450 MHz HSL Medium parameters used: f = 2450 MHz; σ = 1.779 S/m; ε_r = 38.111; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.04, 7.04, 7.04); Calibrated: 28/09/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn431; Calibrated: 08/11/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:1818
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW /Area Scan (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 17.9 W/kg
Configuration/d=10mm, Pin=250mW /Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 97.54 V/m; Power Drift = 0.14 dB
Peak SAR (extrapolated) = 27.6 W/kg
SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.18 W/kg
Maximum value of SAR (measured) = 17.6 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

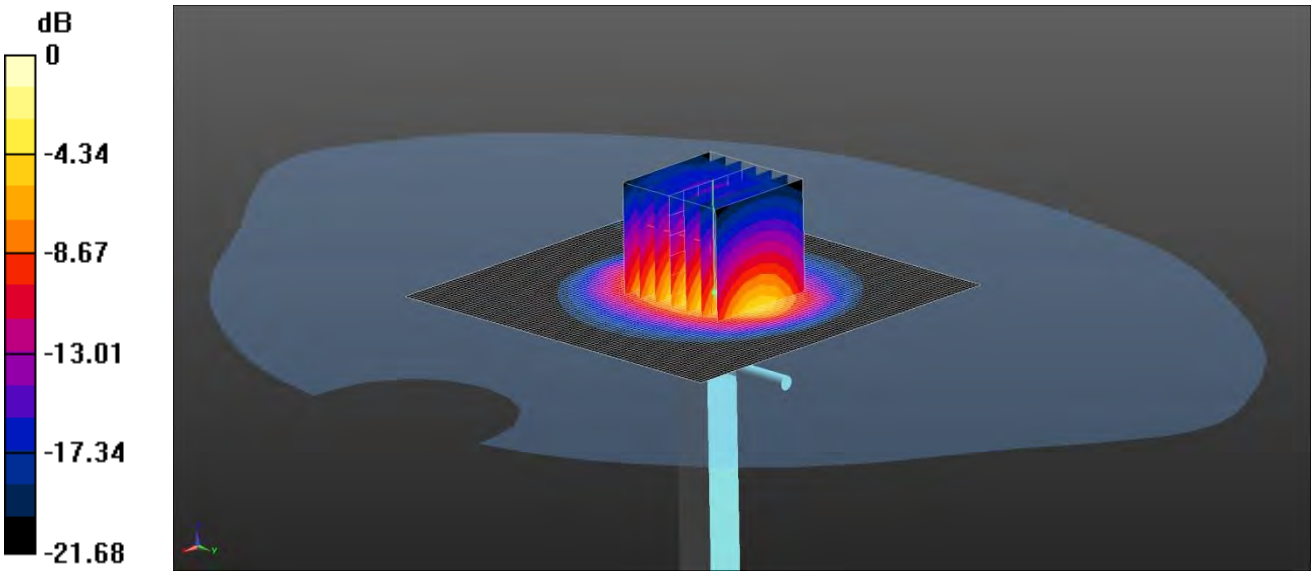


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D2450V2 - SN748; Type: D2450V2; Serial: SN748

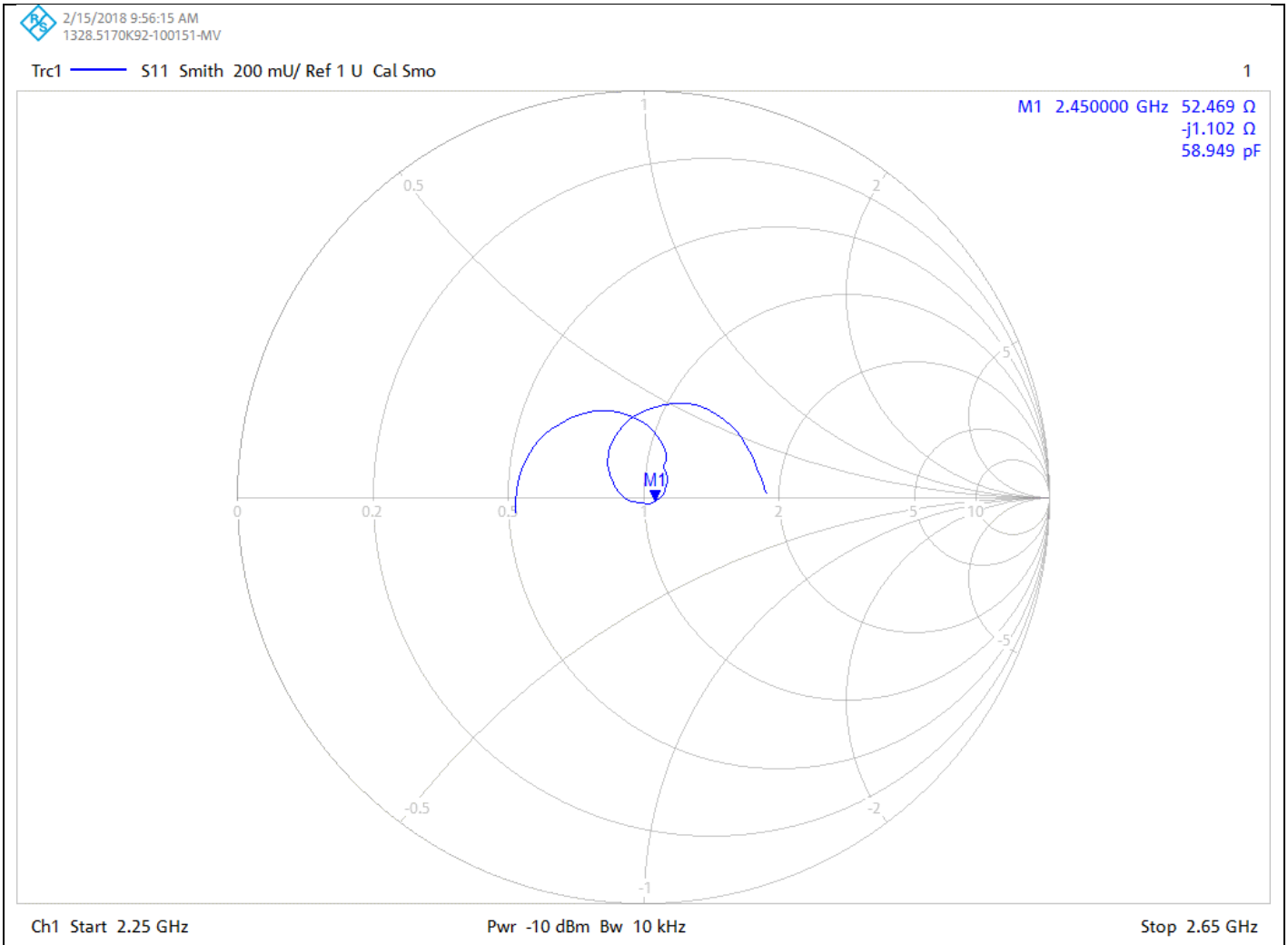


0 dB = 19.4 W/kg = 12.88 dBW/kg

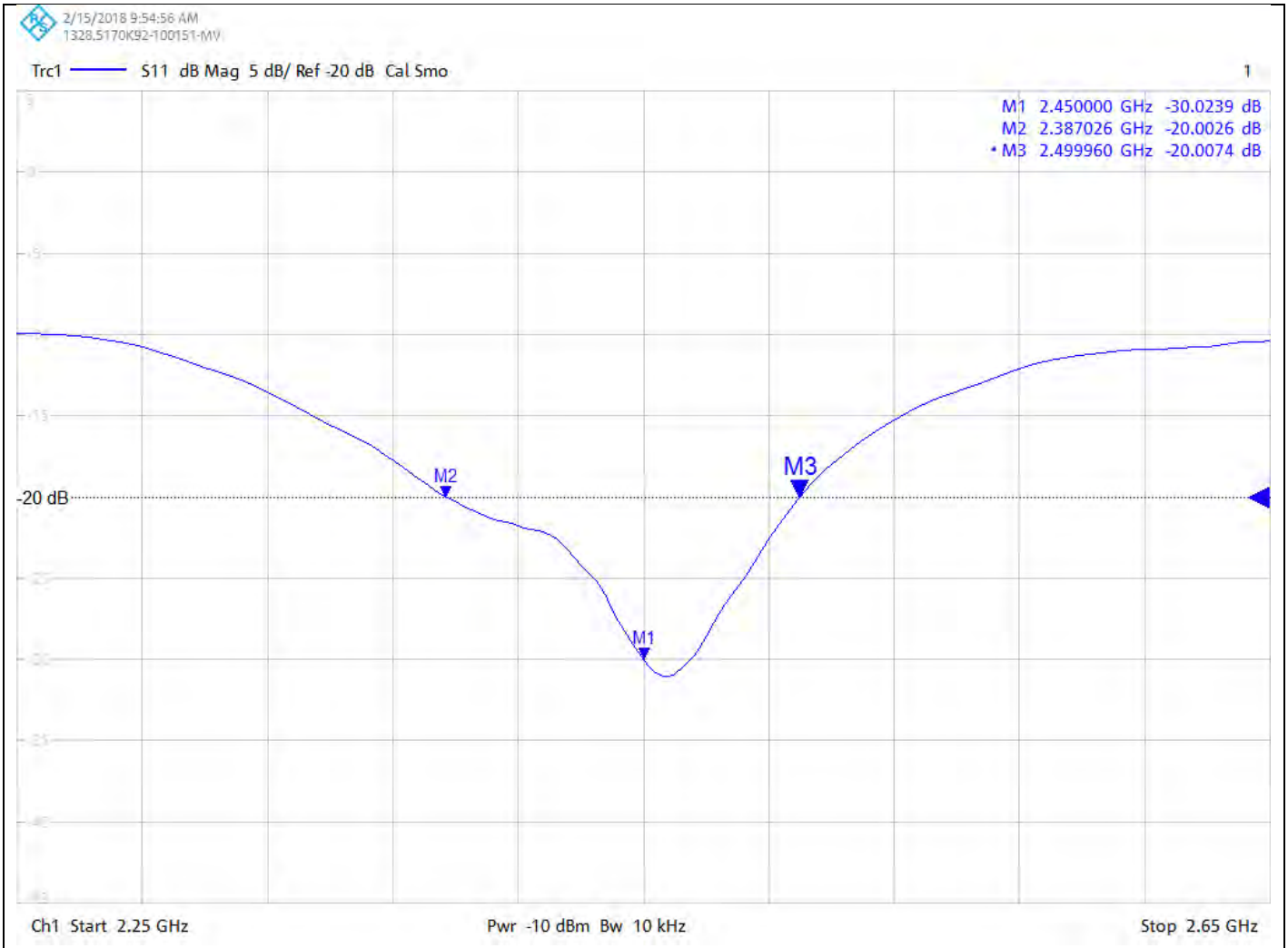
Communication System: UID 0, CW (0); Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: 2450 MSL Medium parameters used: f = 2450 MHz; σ = 2.02 S/m; ε_r = 50.632; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.2, 7.2, 7.2); Calibrated: 28/09/2017;
- Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn431; Calibrated: 08/11/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:1818
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW /Area Scan (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 15.4 W/kg
Configuration/d=10mm, Pin=250mW /Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 85.33 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 25.8 W/kg
SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.98 W/kg
Maximum value of SAR (measured) = 19.4 W/kg

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12129912JD01A Instrument ID: 748 Calibration Date: 14/Feb/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12129912JD01A Instrument ID: 748 Calibration Date: 14/Feb/2018 Calibration Due Date:

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

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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 **UL CCS USA**

Certificate No: D5GHzV2-1003_Feb17

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN:1003
Calibration procedure(s)	QA CAL-22.v2 Calibration procedure for dipole validation kits between 3-6 GHz
Calibration date:	February 13, 2017

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	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
Reference Probe EX3DV4	SN: 3503	31-Dec-16 (No. EX3-3503_Dec16)	Dec-17
DAE4	SN: 601	04-Jan-17 (No. DAE4-601_Jan17)	Jan-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-16 (No. 217-02222)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-16 (No. 217-02222)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-16 (No. 217-02223)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: February 15, 2017

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

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 62209-2, "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
c) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

d) 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 V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.4 ± 6 %	4.45 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.68 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**76.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**21.8 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.7 ± 6 %	4.85 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**83.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.8 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.4 ± 6 %	5.05 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.87 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**78.1 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.1 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.0 ± 6 %	5.34 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.08 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**70.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	1.99 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**19.8 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.2 ± 6 %	5.87 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.87 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**78.3 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.21 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.0 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.9 ± 6 %	6.15 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.38 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**73.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.5 W/kg ± 19.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	48.3 Ω - 10.3 jΩ
Return Loss	- 19.5 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	54.5 Ω - 3.1 jΩ
Return Loss	- 25.7 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.5 Ω - 7.2 jΩ
Return Loss	- 20.9 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	49.9 Ω - 8.8 jΩ
Return Loss	- 21.1 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	56.8 Ω - 0.7 jΩ
Return Loss	- 23.9 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	58.6 Ω - 5.8 jΩ
Return Loss	- 20.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.207 ns

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	July 08, 2003

Date: 13.02.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1003

Communication System: UID 0 - CW;
Frequency: 5200 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.45 S/m; ε_r = 35.4; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 4.85 S/m; ε_r = 34.7; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 5.05 S/m; ε_r = 34.4; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

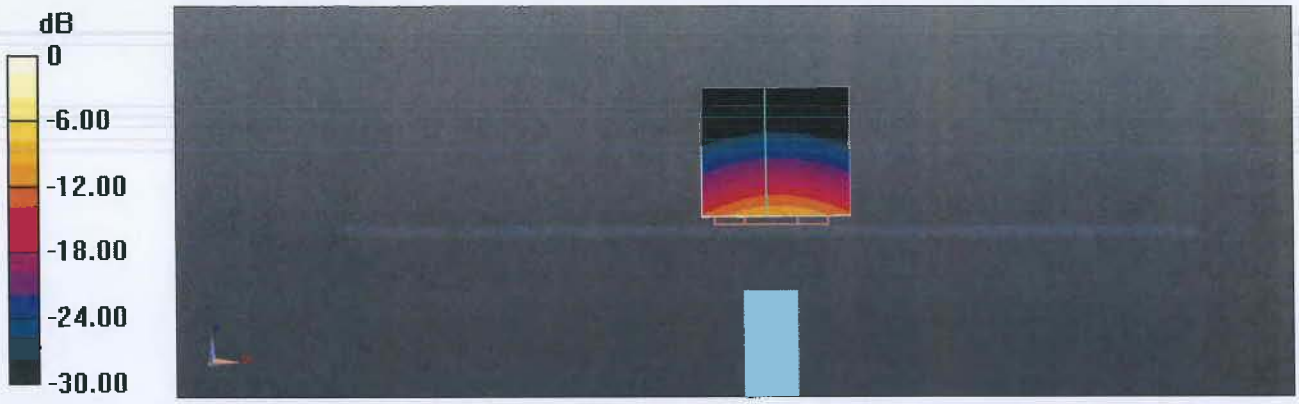
DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.76, 5.76, 5.76); Calibrated: 31.12.2016, ConvF(5.09, 5.09, 5.09); Calibrated: 31.12.2016, ConvF(5.01, 5.01, 5.01); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.83 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 28.8 W/kg
SAR(1 g) = 7.68 W/kg; SAR(10 g) = 2.19 W/kg
Maximum value of SAR (measured) = 17.7 W/kg

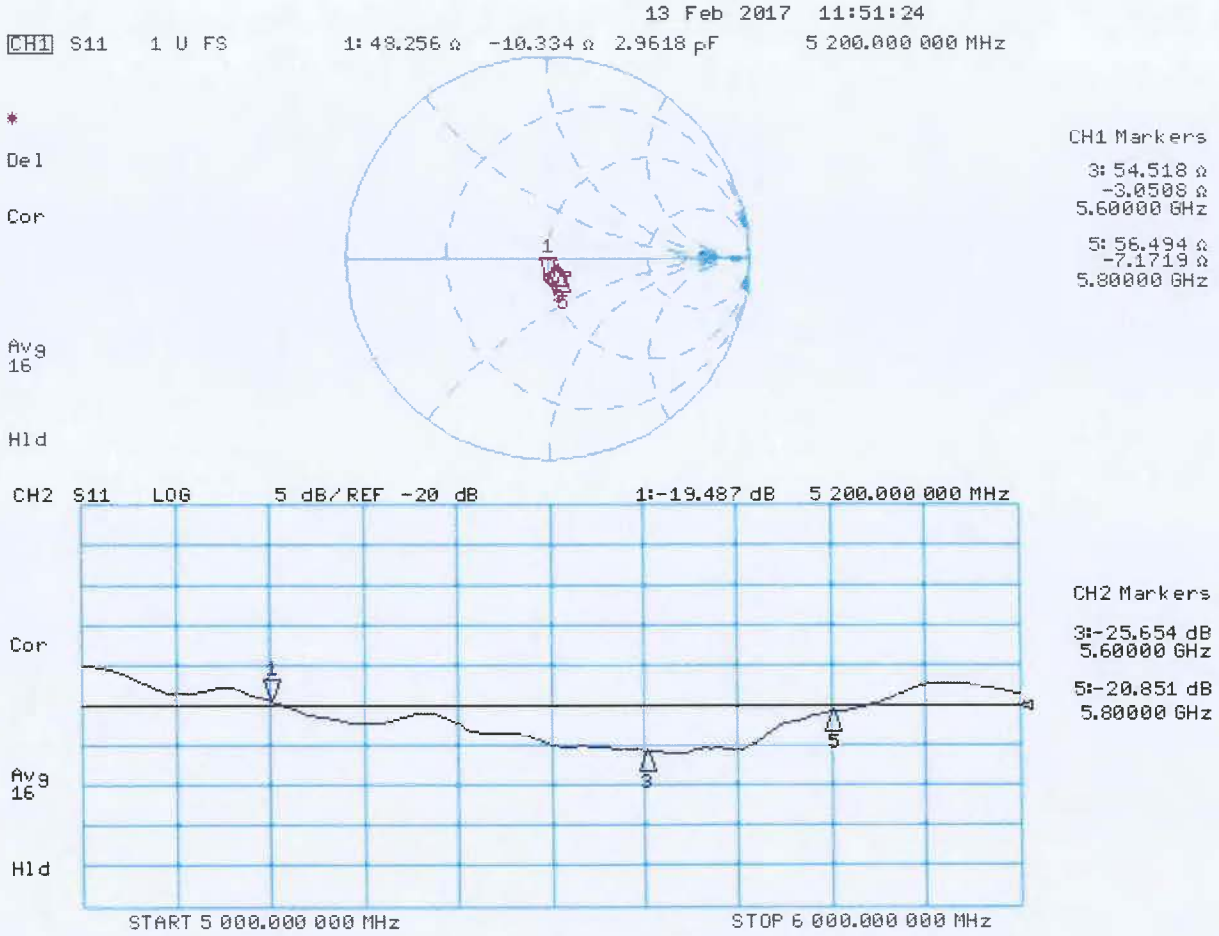
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 68.68 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 33.9 W/kg
SAR(1 g) = 8.39 W/kg; SAR(10 g) = 2.4 W/kg
Maximum value of SAR (measured) = 20.2 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.85 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 33.3 W/kg
SAR(1 g) = 7.87 W/kg; SAR(10 g) = 2.23 W/kg
Maximum value of SAR (measured) = 19.1 W/kg



0 dB = 17.7 W/kg = 12.48 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 10.02.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1003

Communication System: UID 0 - CW;
Frequency: 5200 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.34 S/m; ε_r = 48; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 5.87 S/m; ε_r = 47.2; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 6.15 S/m; ε_r = 46.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

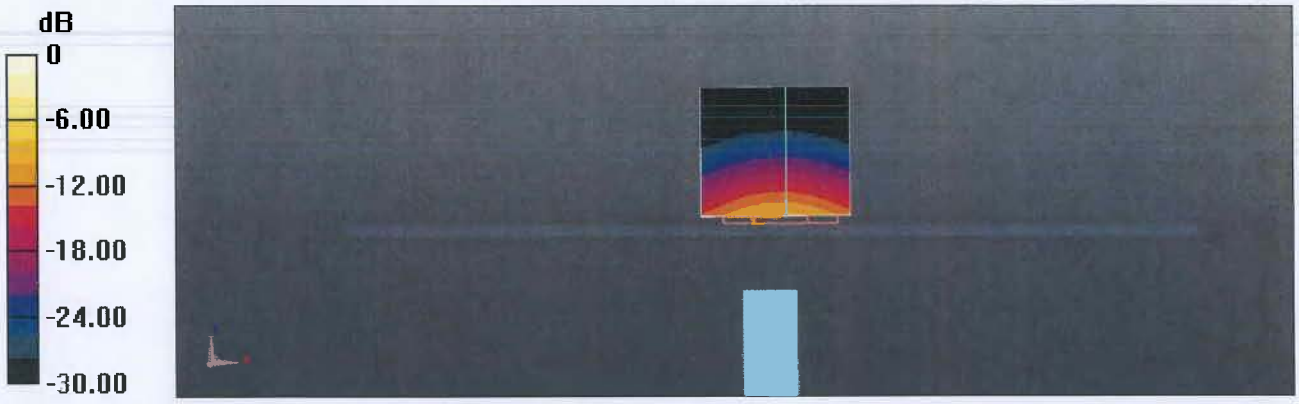
DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.29, 5.29, 5.29); Calibrated: 31.12.2016, ConvF(4.57, 4.57, 4.57); Calibrated: 31.12.2016, ConvF(4.48, 4.48, 4.48); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- 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=100mW, dist=10mm, f=5200MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.13 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 27.1 W/kg
SAR(1 g) = 7.08 W/kg; SAR(10 g) = 1.99 W/kg
Maximum value of SAR (measured) = 16.9 W/kg

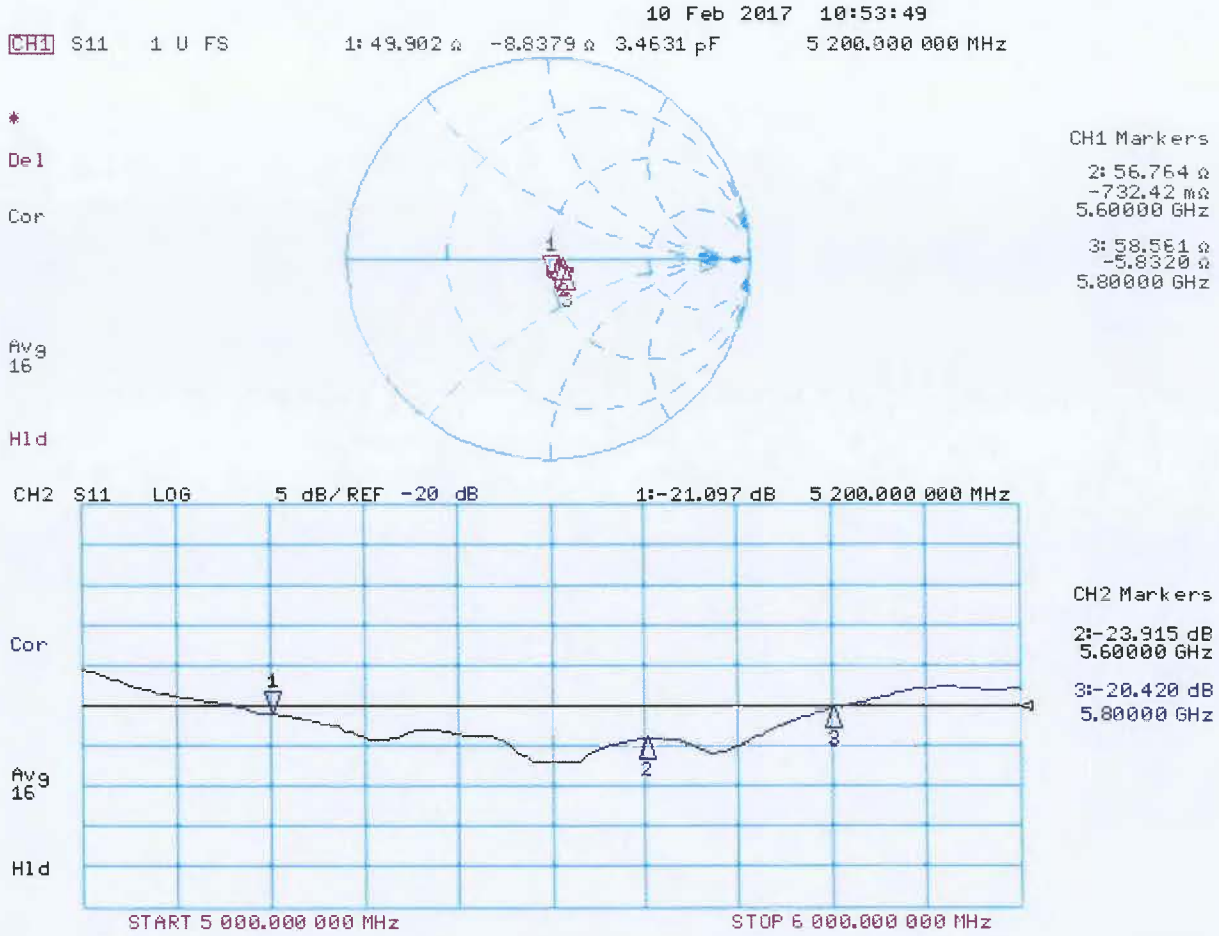
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.15 V/m; Power Drift = -0.052 dB
Peak SAR (extrapolated) = 33.3 W/kg
SAR(1 g) = 7.87 W/kg; SAR(10 g) = 2.21 W/kg
Maximum value of SAR (measured) = 19.1 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 62.29 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 32.9 W/kg
SAR(1 g) = 7.38 W/kg; SAR(10 g) = 2.06 W/kg
Maximum value of SAR (measured) = 18.2 W/kg



0 dB = 16.9 W/kg = 12.28 dBW/kg

Impedance Measurement Plot for Body TSL



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

S Schweizerischer Kalibrierdienst
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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 UL CCS USA

Certificate No: D5GHzV2-1138_Oct17

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN:1138
Calibration procedure(s)	QA CAL-22.v2 Calibration procedure for dipole validation kits between 3-6 GHz
Calibration date:	October 26, 2017

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-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX3DV4	SN: 3503	31-Dec-16 (No. EX3-3503_Dec16)	Dec-17
DAE4	SN: 601	28-Mar-17 (No. DAE4-601_Mar17)	Mar-18
DAE4	SN: 781	13-Jul-17 (No. DAE4-781_Jul17)	Jul-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-16 (No. 217-02222)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-16 (No. 217-02222)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-16 (No. 217-02223)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: October 26, 2017

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

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 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	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.1 ± 6 %	4.50 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.77 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**77.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.2 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	**Permittivity**	**Conductivity**
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	4.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**83.2 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.7 W/kg ± 19.5 % (k=2)**

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.3 ± 6 %	5.11 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.98 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**79.7 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.7 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.1 ± 6 %	5.44 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.40 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**73.4 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.08 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**20.6 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.3 ± 6 %	5.97 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.01 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**79.5 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**22.3 W/kg ± 19.5 % (k=2)**

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.0 ± 6 %	6.25 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm^3 (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.74 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**76.8 W/kg ± 19.9 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	**21.3 W/kg ± 19.5 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	49.0 Ω - 8.1 jΩ
Return Loss	- 21.7 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	56.1 Ω - 1.8 jΩ
Return Loss	- 24.4 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	54.7 Ω - 2.1 jΩ
Return Loss	- 26.1 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	50.4 Ω - 7.4 jΩ
Return Loss	- 22.7 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	57.9 Ω - 1.7 jΩ
Return Loss	- 22.6 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	54.9 Ω - 2.2 jΩ
Return Loss	- 25.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.203 ns

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	May 07, 2012

DASY5 Validation Report for Head TSL

Date: 26.10.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1138

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.5 S/m; ε_r = 36.1; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 4.9 S/m; ε_r = 35.5; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 5.11 S/m; ε_r = 35.3; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

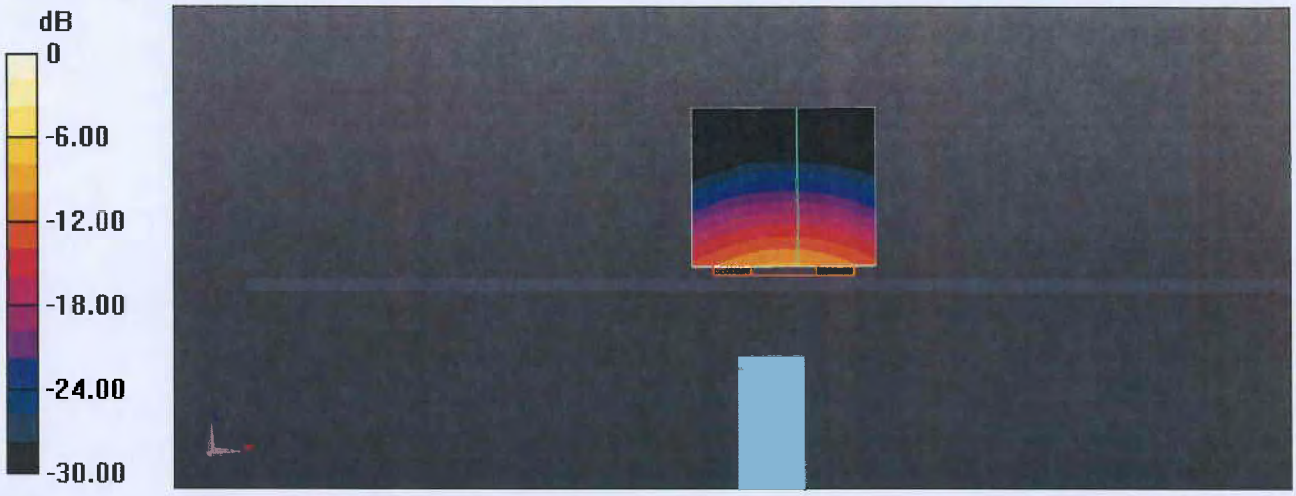
DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.76, 5.76, 5.76); Calibrated: 31.12.2016, ConvF(5.09, 5.09, 5.09); Calibrated: 31.12.2016, ConvF(5.01, 5.01, 5.01); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn781; Calibrated: 13.07.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 69.15 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 27.6 W/kg
SAR(1 g) = 7.77 W/kg; SAR(10 g) = 2.22 W/kg
Maximum value of SAR (measured) = 17.3 W/kg

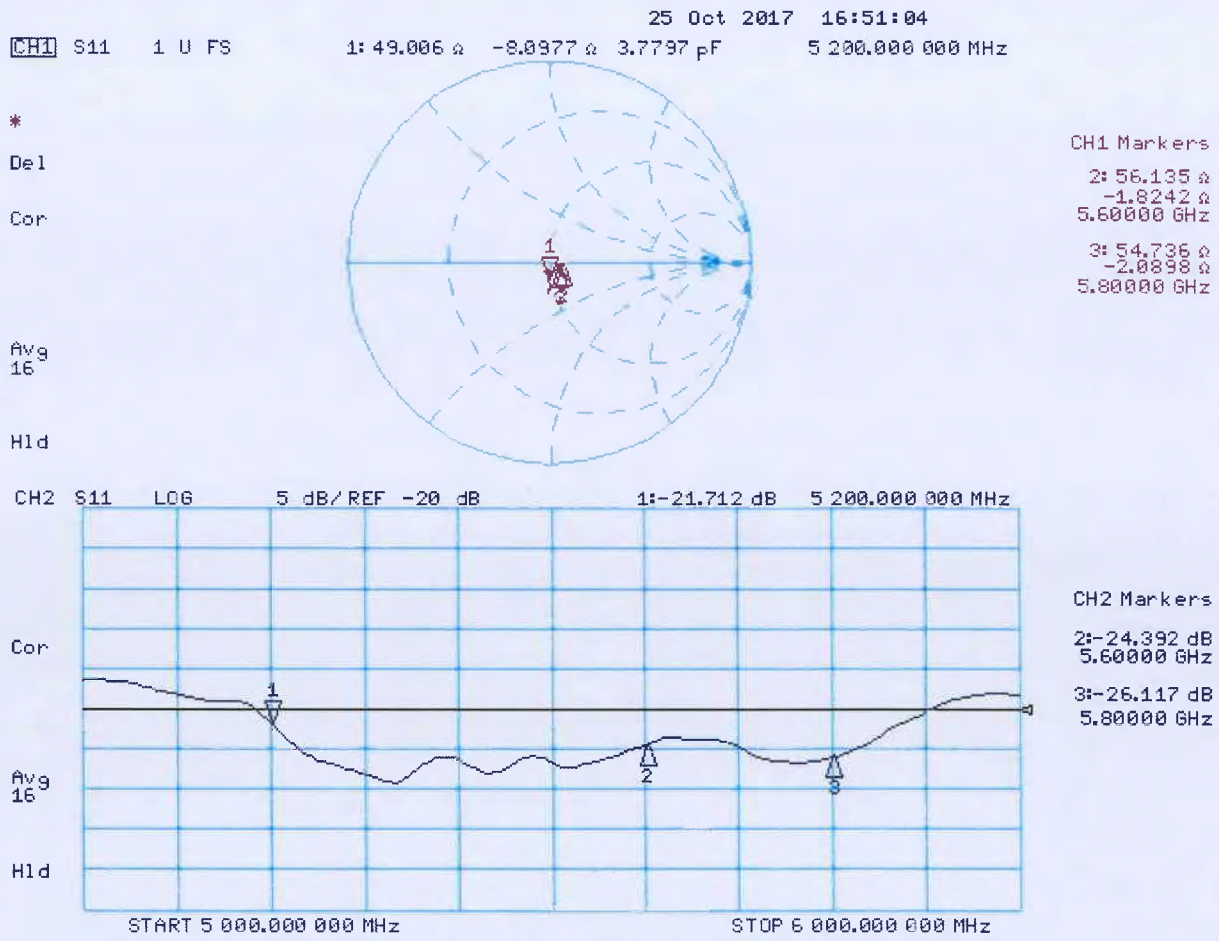
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.42 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 31.7 W/kg
SAR(1 g) = 8.33 W/kg; SAR(10 g) = 2.37 W/kg
Maximum value of SAR (measured) = 19.1 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 68.10 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 31.5 W/kg
SAR(1 g) = 7.98 W/kg; SAR(10 g) = 2.27 W/kg
Maximum value of SAR (measured) = 18.7 W/kg



0 dB = 17.3 W/kg = 12.38 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 25.10.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1138

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.44 S/m; ε_r = 47.1; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5600 MHz; σ = 5.97 S/m; ε_r = 46.3; ρ = 1000 kg/m^3 ,
Medium parameters used: f = 5800 MHz; σ = 6.25 S/m; ε_r = 46; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

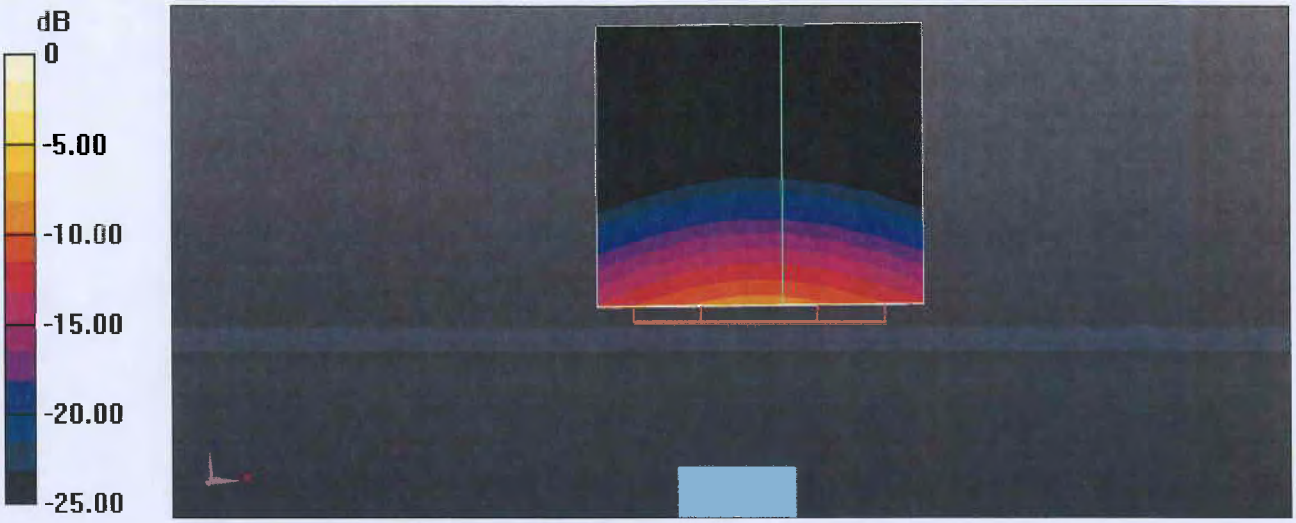
DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.29, 5.29, 5.29); Calibrated: 31.12.2016, ConvF(4.57, 4.57, 4.57); Calibrated: 31.12.2016, ConvF(4.48, 4.48, 4.48); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 63.83 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 27.9 W/kg
SAR(1 g) = 7.4 W/kg; SAR(10 g) = 2.08 W/kg
Maximum value of SAR (measured) = 16.8 W/kg

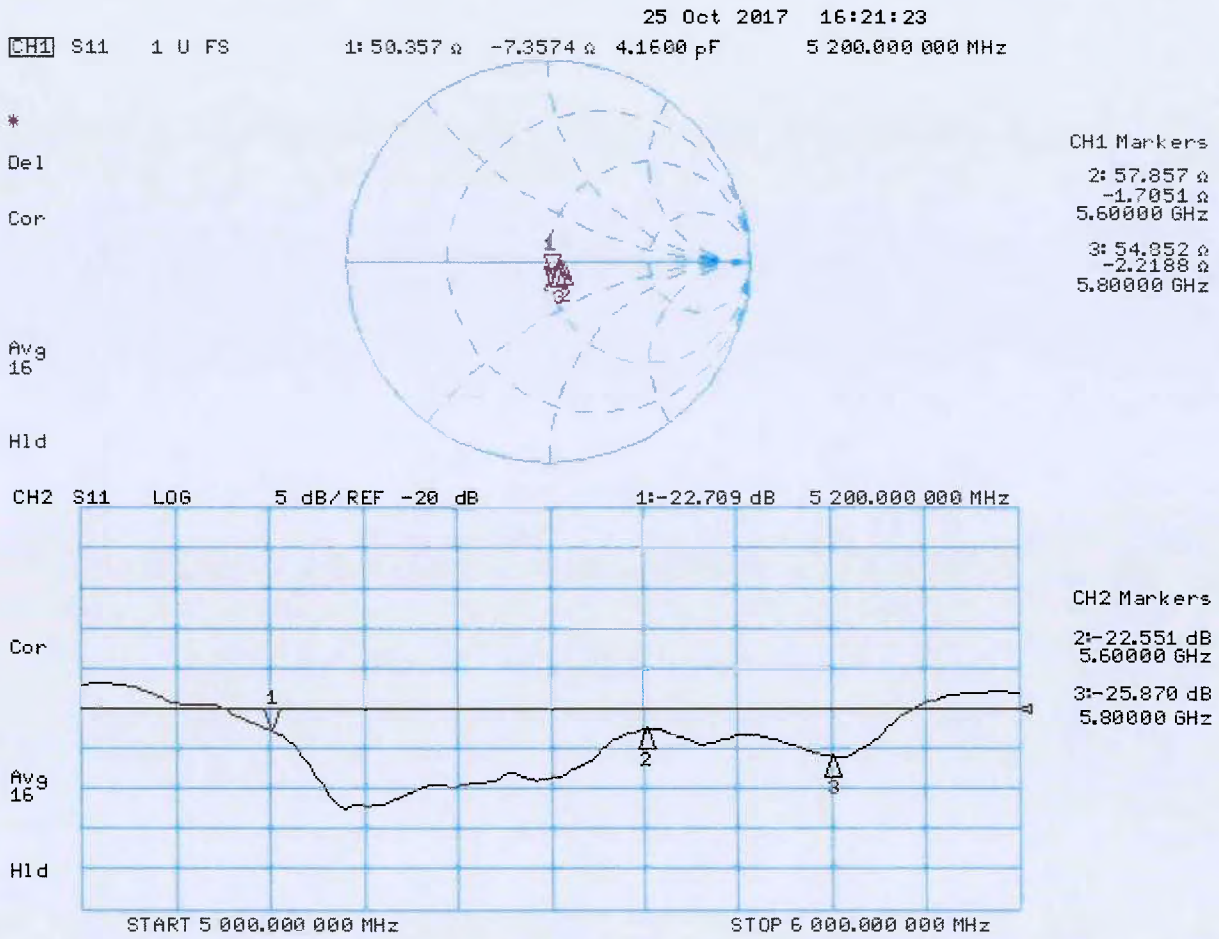
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.58 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 33.3 W/kg
SAR(1 g) = 8.01 W/kg; SAR(10 g) = 2.25 W/kg
Maximum value of SAR (measured) = 19.0 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 62.86 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 34.2 W/kg
SAR(1 g) = 7.74 W/kg; SAR(10 g) = 2.15 W/kg
Maximum value of SAR (measured) = 18.9 W/kg



0 dB = 18.9 W/kg = 12.76 dBW/kg

Impedance Measurement Plot for Body TSL



Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Conditions (f=5200 MHz)

Phantom	SAM Head Phantom	For usage with cSAR3D**V2**-R/L

SAR result with SAM Head (Top)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	8.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**83.9 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**24.2 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Mouth)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	8.89 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**88.6 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	2.58 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**25.7 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Neck)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	8.50 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**84.5 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.9 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Ear)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	5.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**54.0 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	1.85 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**18.4 W/kg ± 19.9 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Conditions (f=5600 MHz)

Phantom	SAM Head Phantom	For usage with cSAR3D**V2**-R/L

SAR result with SAM Head (Top)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	9.18 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**91.1 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.60 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**25.7 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Mouth)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	9.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**93.0 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	2.69 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**26.6 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Neck)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	8.80 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**87.4 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	2.40 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.8 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Ear)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	6.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**62.3 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	2.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**20.8 W/kg ± 19.9 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Conditions (f=5800 MHz)

Phantom	SAM Head Phantom	For usage with cSAR3D**V2**-R/L

SAR result with SAM Head (Top)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	8.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**82.8 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**23.4 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Mouth)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	9.10 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**90.6 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	2.60 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**25.9 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Neck)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	8.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**81.7 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**22.8 W/kg ± 19.9 % (k=2)**

SAR result with SAM Head (Ear)

SAR averaged over 1 cm^3 (1 g) of Head TSL	Condition	
SAR (average measured)	100 mW input power	5.81 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**57.7 W/kg ± 20.3 % (k=2)**

SAR averaged over 10 cm^3 (10 g) of Head TSL	condition	
SAR (average measured)	100 mW input power	1.95 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	**19.3 W/kg ± 19.9 % (k=2)**

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 30/Nov/2017 CERTIFICATE NUMBER : 11903932JD01F

5248

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APPROVED SIGNATORY

.....

Naseer Mirza

Customer :
UL VS Inc
47173 Benicia Street
Fremont, CA 94538, USA

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	20/Nov/2017
Manufacturer:	Speag		
Type/Model Number:	D5GHzv2		
Serial Number:	1168		
Calibration Date:	23/Nov/2017		
Calibrated By:	Chanthu Thevarajah Laboratory Engineer		
Signature:	.....		

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}C and humidity < 70%

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.
Use of the UKAS mark demonstrates that compliance with the requirements of BS/EN/ISO/IEC 17025 has been independently assessed.

The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2005**: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
2. **IEC 62209-2:2010:** 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)
3. **IEEE 1528: 2013:** IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques
4. FCC KDB Publication Number: **"KDB865664 D01 SAR Measurement 100 MHz to 6 GHz"**
5. **SPEAG DASY4/ DASY5 System Handbook**

The measuring equipment used to perform the calibration, documented in this certificate has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2546	Data Acquisition Electronics	SPEAG	DAE4	1435	10 Feb 2017	12
A2545	Probe	SPEAG	ES3DV4	3395	04 May 2017	12
A1377	Dipole	SPEAG	D5GHzV2	1016	16 Feb 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
M1855	Power Sensor	Rhode & Schwarz	NRP-Z51	103246	08 Nov 2017	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	10 Oct 2017	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	22 Nov 2016	24
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	02 Dec 2016	12
M1838	Signal Generator	Rhode & Schwarz	SME06	831377/005	30 Mars 2017	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F14/5T5ZA1/A/01
DASY Version:	DASY 52 (v52.8.8.1258)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	10 mm (with spacer)

Frequency: 5250 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	5250	21.0 °C	21.0 °C	21.0°C	21.0°C	**εr**	35.9	36.445	± 5%
						σ	4.71	4.578	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	8.09 W/Kg	**80.9 W/Kg**	± 18.75%
	SAR averaged over 10g	2.28 W/Kg	**22.8 W/Kg**	± 18.63%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	62.365 Ω 2.721 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	19.18	± 1.48 dB

Frequency: 5600 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	5600	21.0 °C	21.0 °C	21.0°C	21.0°C	**εr**	35.5	36.195	± 5%
						σ	5.07	5.011	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	8.72 W/Kg	**87.2 W/Kg**	± 18.75%
	SAR averaged over 10g	2.44 W/Kg	**24.4 W/Kg**	± 18.63%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	47.404 Ω 4.886 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	25.69	± 1.48 dB

Frequency: 5750 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	5750	21.0 °C	21.0 °C	21.0°C	21.0°C	εr	35.4	35.945	± 5%
						σ	5.22	5.214	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	7.91 W/Kg	**79.1 W/Kg**	± 18.75%
	SAR averaged over 10g	2.21 W/Kg	**22.1 W/Kg**	± 18.63%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	58.626 Ω -3.403 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	20.65	± 1.48 dB

Frequency: 5250 MHz

Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	5250	22.0 °C	21.0 °C	21.0°C	21.0°C	εr	48.9	47.644	± 5%
						σ	5.36	5.312	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	**SAR Measured**	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	7.07 W/Kg	**70.7 W/Kg**	± 18.53%
	SAR averaged over 10g	1.97 W/Kg	**19.7 W/Kg**	± 18.61%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	60.697 Ω 2.711 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	20.08	± 1.48 dB

Frequency: 5600 MHz

Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	5600	22.0 °C	21.0 °C	21.0°C	21.0°C	εr	48.5	46.782	± 5%
						σ	5.77	5.777	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	**SAR Measured**	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	7.56 W/Kg	**75.6 W/Kg**	± 18.53%
	SAR averaged over 10g	2.08 W/Kg	**20.8 W/Kg**	± 18.61%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	46.92 Ω 4.017 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	25.70	± 1.48 dB

Frequency: 5750 MHz

Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	5750	22.0 °C	21.0 °C	21.0°C	21.0°C	εr	48.3	46.523	± 5%
						σ	5.94	5.968	± 5%

SAR Results – Body Simulating Liquid (MSL)

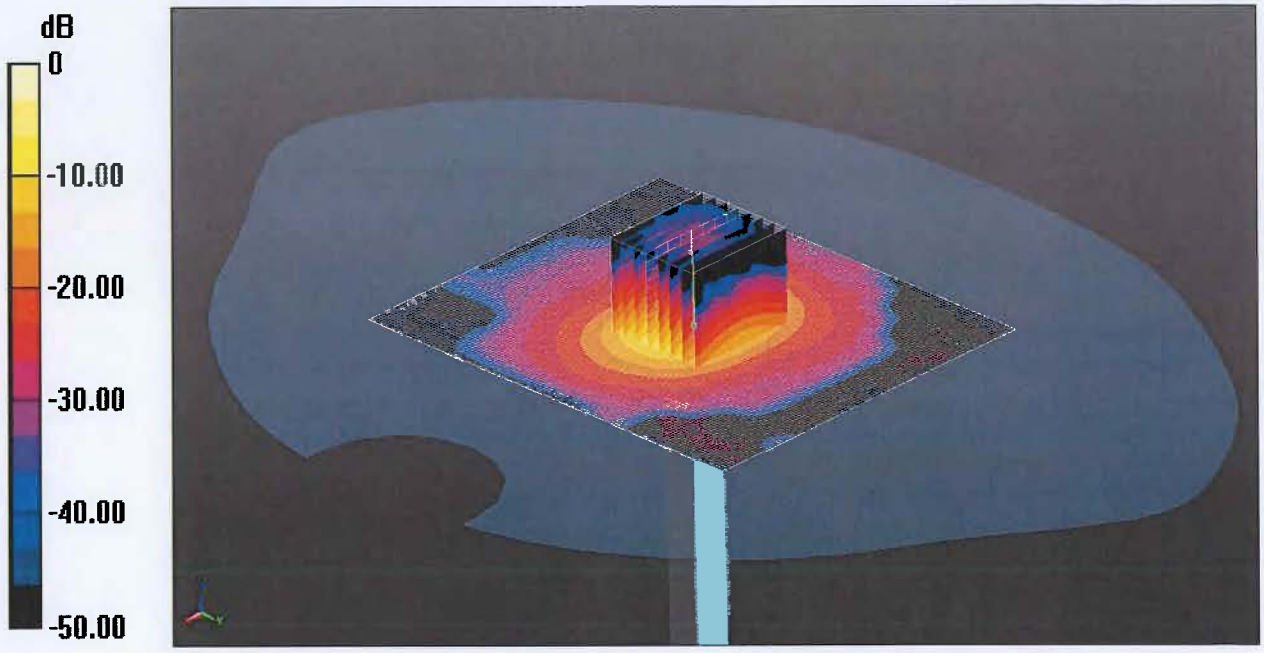
Simulant Liquid	**SAR Measured**	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	6.53 W/Kg	**65.3 W/Kg**	± 18.53%
	SAR averaged over 10g	1.82 W/Kg	**18.2 W/Kg**	± 18.61%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	59.977 Ω -2.829 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	20.34	± 1.48 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2 - SN1168; Type: D5GHzV2; Serial: SN1168



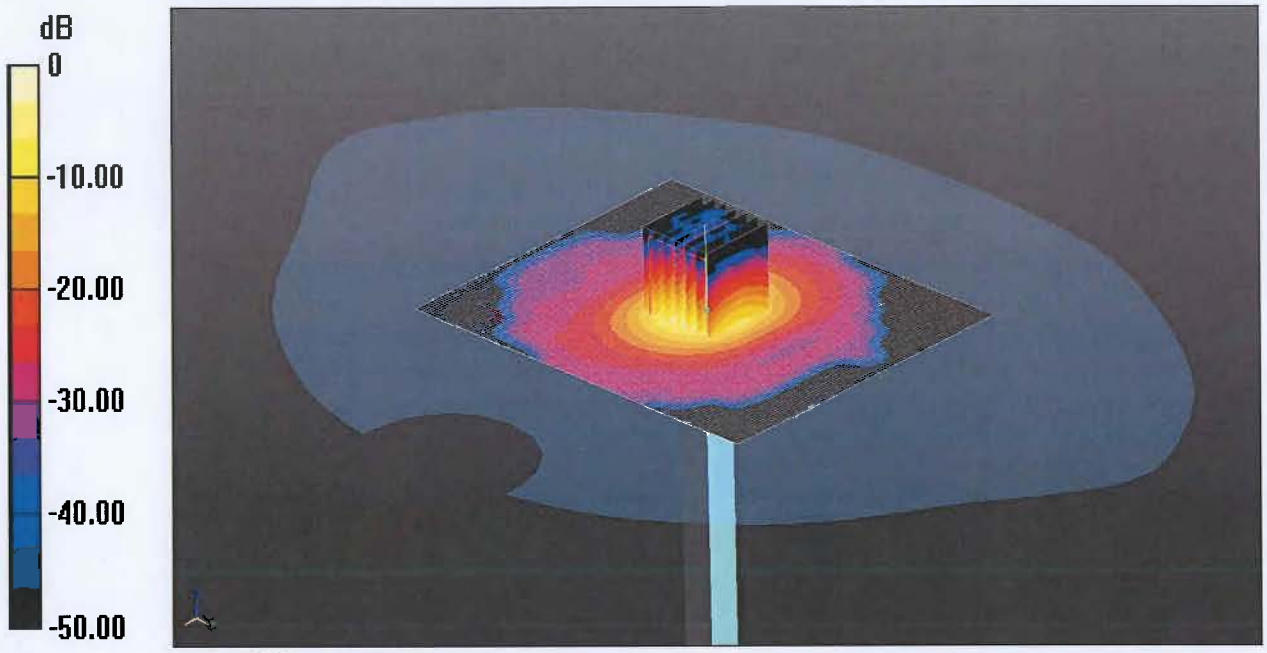
0 dB = 16.9 W/kg = 12.28 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5250 MHz;Duty Cycle: 1:1
Medium: 5GHz MSL Medium parameters used: f = 5250 MHz; σ = 4.578 S/m; ε_r = 36.445; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(5.38, 5.38, 5.38); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection), Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW 2 2/Area Scan (101x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 12.4 W/kg
Configuration/d=10mm, Pin=250mW 2 2/Zoom Scan 2 (9x8x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 53.68 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 33.8 W/kg
SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.28 W/kg
Maximum value of SAR (measured) = 16.9 W/kg

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2 - SN1168; Type: D5GHzV2; Serial: SN1168



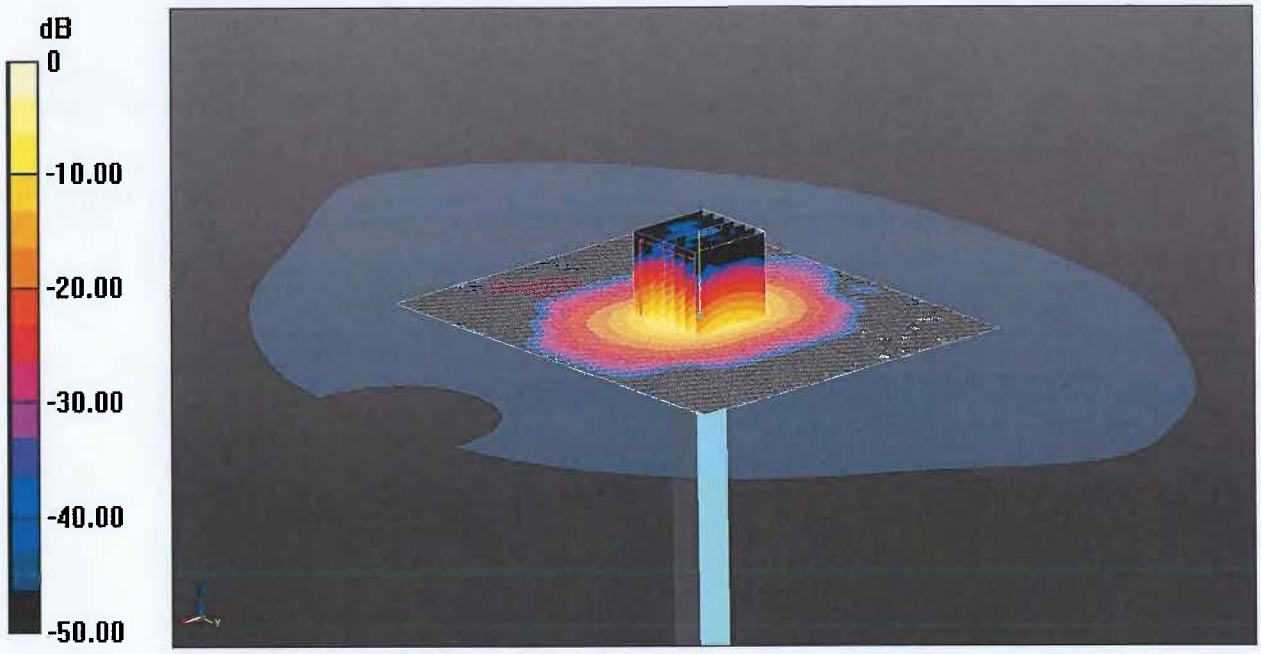
0 dB = 18.6 W/kg = 12.70 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5600 MHz;Duty Cycle: 1:1
Medium: 5GHz MSL Medium parameters used: f = 5600 MHz; σ = 5.011 S/m; ε_r = 36.195; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(5.02, 5.02, 5.02); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection), Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW/Area Scan (101x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 13.2 W/kg
Configuration/d=10mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 53.28 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 38.9 W/kg
SAR(1 g) = 8.72 W/kg; SAR(10 g) = 2.44 W/kg
Maximum value of SAR (measured) = 18.6 W/kg

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2 - SN1168; Type: D5GHzV2; Serial: SN1168

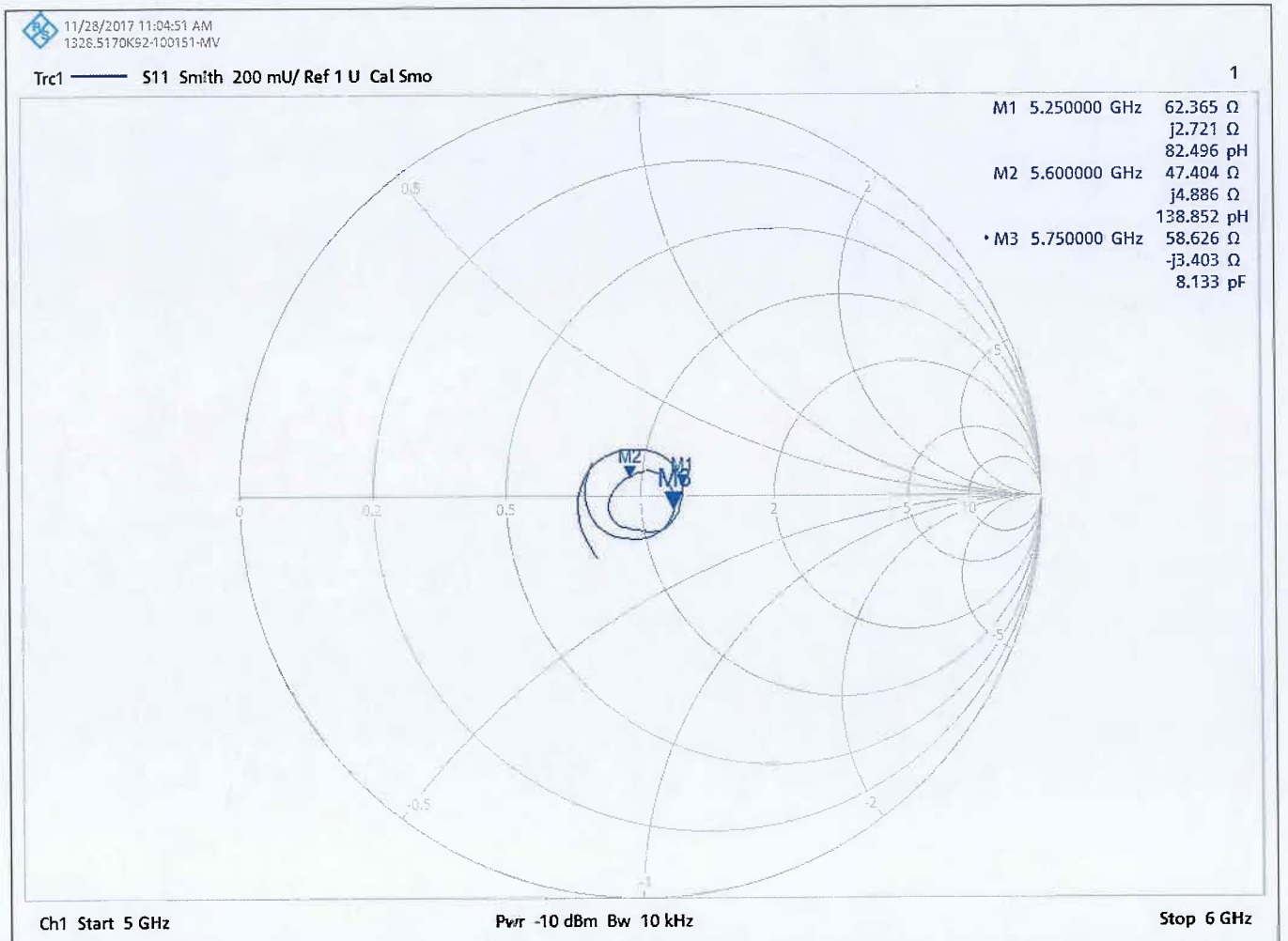


0 dB = 16.9 W/kg = 12.28 dBW/kg

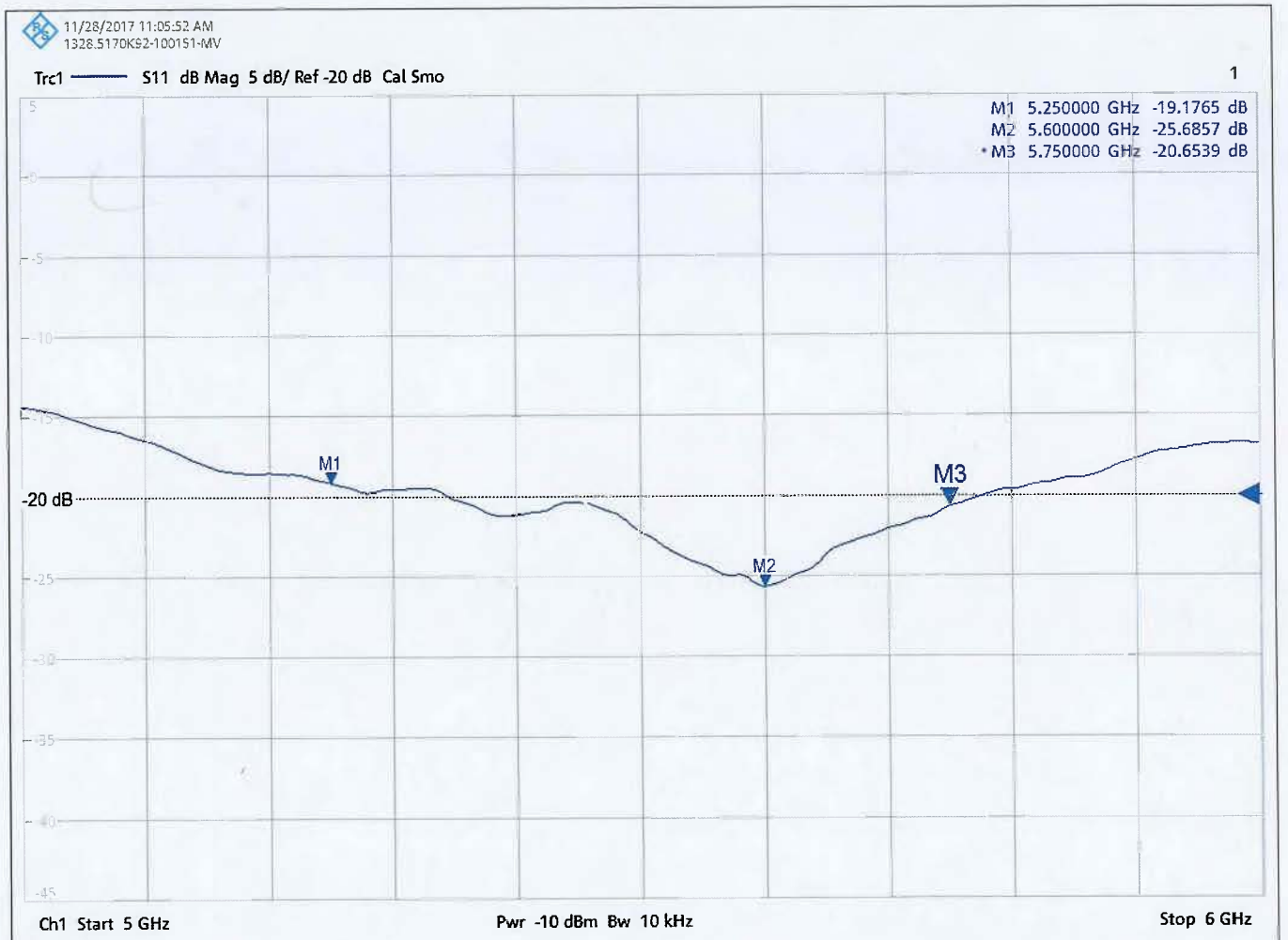
Communication System: UID 0, CW (0); Frequency: 5750 MHz;Duty Cycle: 1:1
Medium: 5GHz MSL Medium parameters used: f = 5750 MHz; σ = 5.214 S/m; ε_r = 35.945; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY 5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(5.3, 5.3, 5.3); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection), Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW/Area Scan (101x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 11.8 W/kg
Configuration/d=10mm, Pin=250mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 49.29 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 36.5 W/kg
SAR(1 g) = 7.91 W/kg; SAR(10 g) = 2.21 W/kg
Maximum value of SAR (measured) = 16.9 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

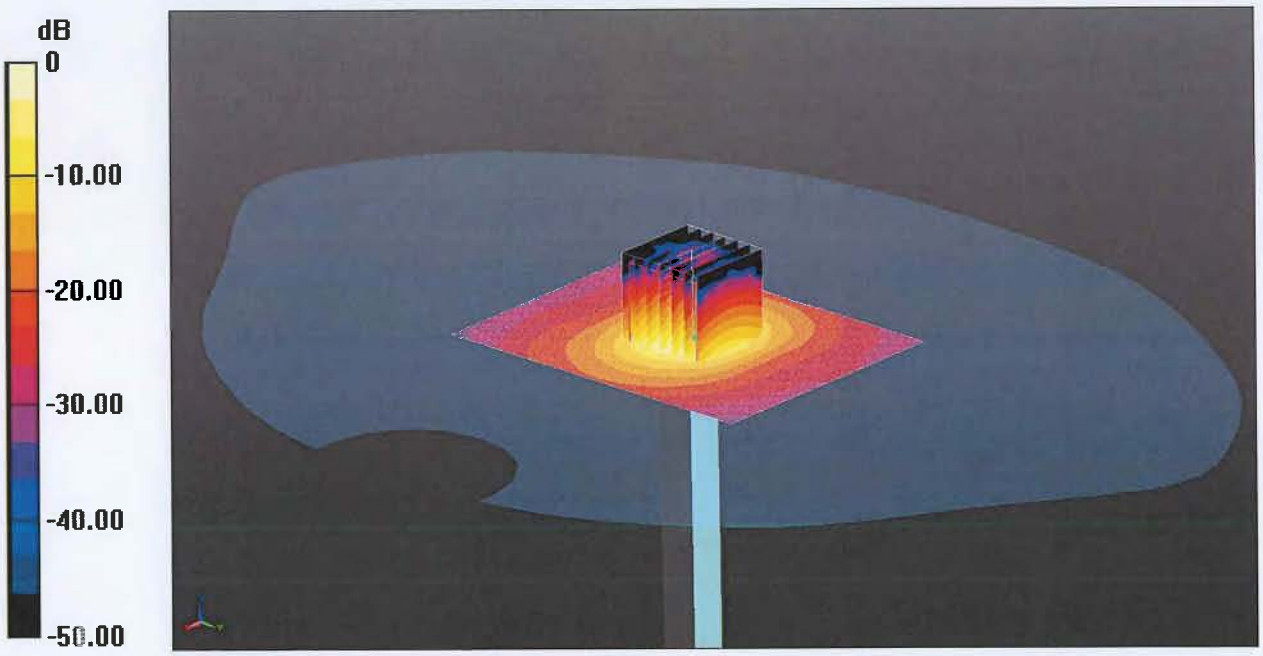


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: 5GHz Dipole SN:1016; Type: D5GHzV2; Serial: SN 1016



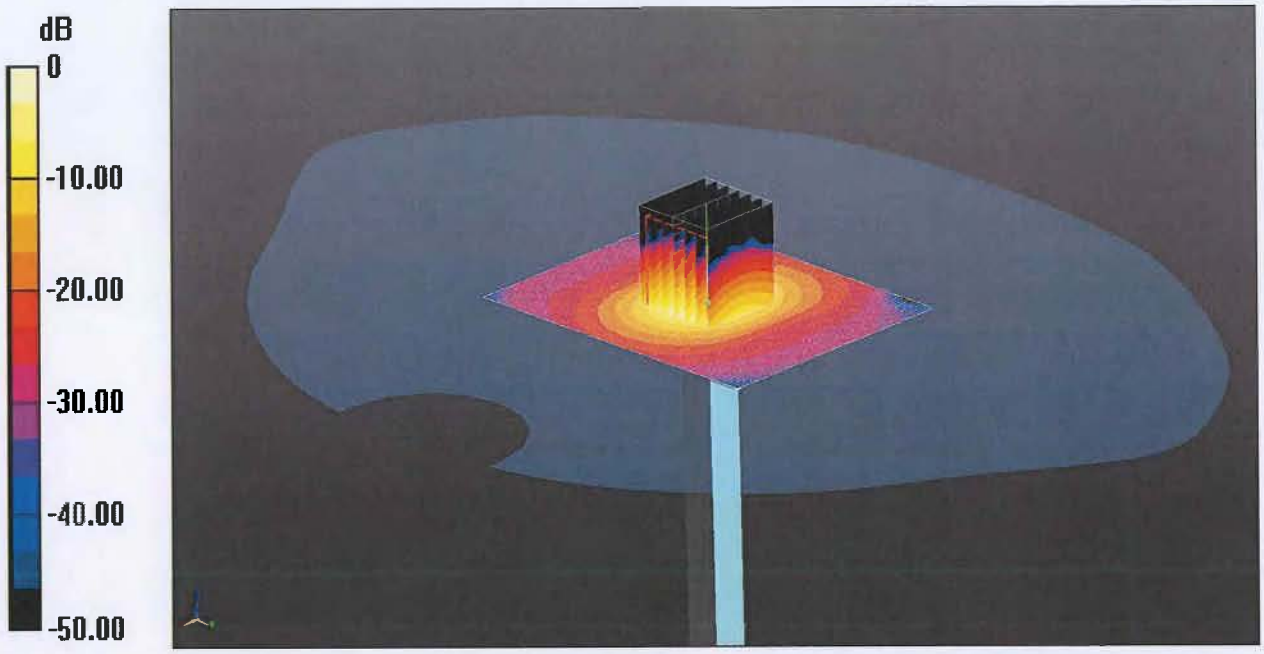
0 dB = 14.8 W/kg = 11.70 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5250 MHz;Duty Cycle: 1:1
Medium: MSL 5G Medium parameters used: f = 5250 MHz; σ = 5.312 S/m; ε_r = 47.644; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(4.97, 4.97, 4.97); Calibrated: 04/05/2017;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=100mW 2 2/Area Scan (71x91x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 15.3 W/kg
Configuration/d=10mm, Pin=100mW 2 2/Zoom Scan (7x7x12) (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 40.03 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 29.5 W/kg
SAR(1 g) = 7.07 W/kg; SAR(10 g) = 1.97 W/kg
Maximum value of SAR (measured) = 14.8 W/kg

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: 5GHz Dipole SN:1168; Type: D5GHzV2; Serial: SN 1168



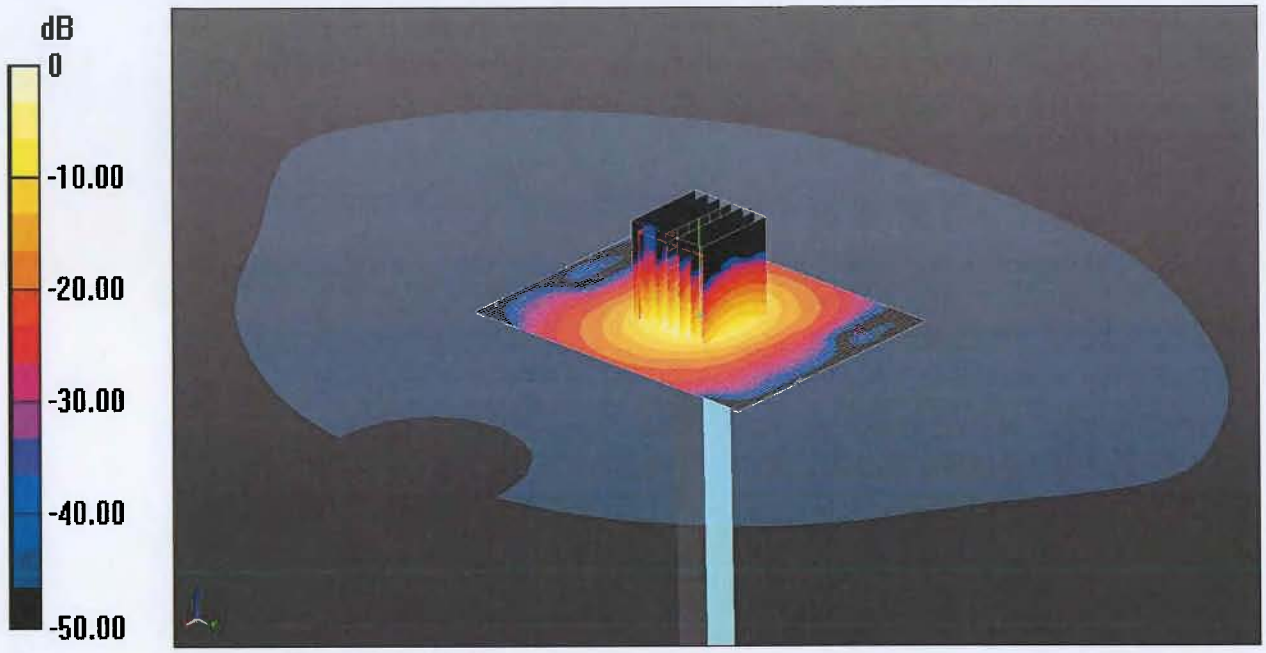
0 dB = 16.2 W/kg = 12.10 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5600 MHz;Duty Cycle: 1:1
Medium: MSL 5G Medium parameters used: f = 5600 MHz; σ = 5.777 S/m; ε_r = 46.782; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY 5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(4.4, 4.4, 4.4); Calibrated: 04/05/2017;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=100mW 2/Area Scan (71x91x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 17.1 W/kg
Configuration/d=10mm, Pin=100mW 2/Zoom Scan (7x7x12) (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 39.49 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 33.7 W/kg
SAR(1 g) = 7.56 W/kg; SAR(10 g) = 2.08 W/kg
Maximum value of SAR (measured) = 16.2 W/kg

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: 5GHz Dipole SN:1168; Type: D5GHzV2; Serial: SN 1168

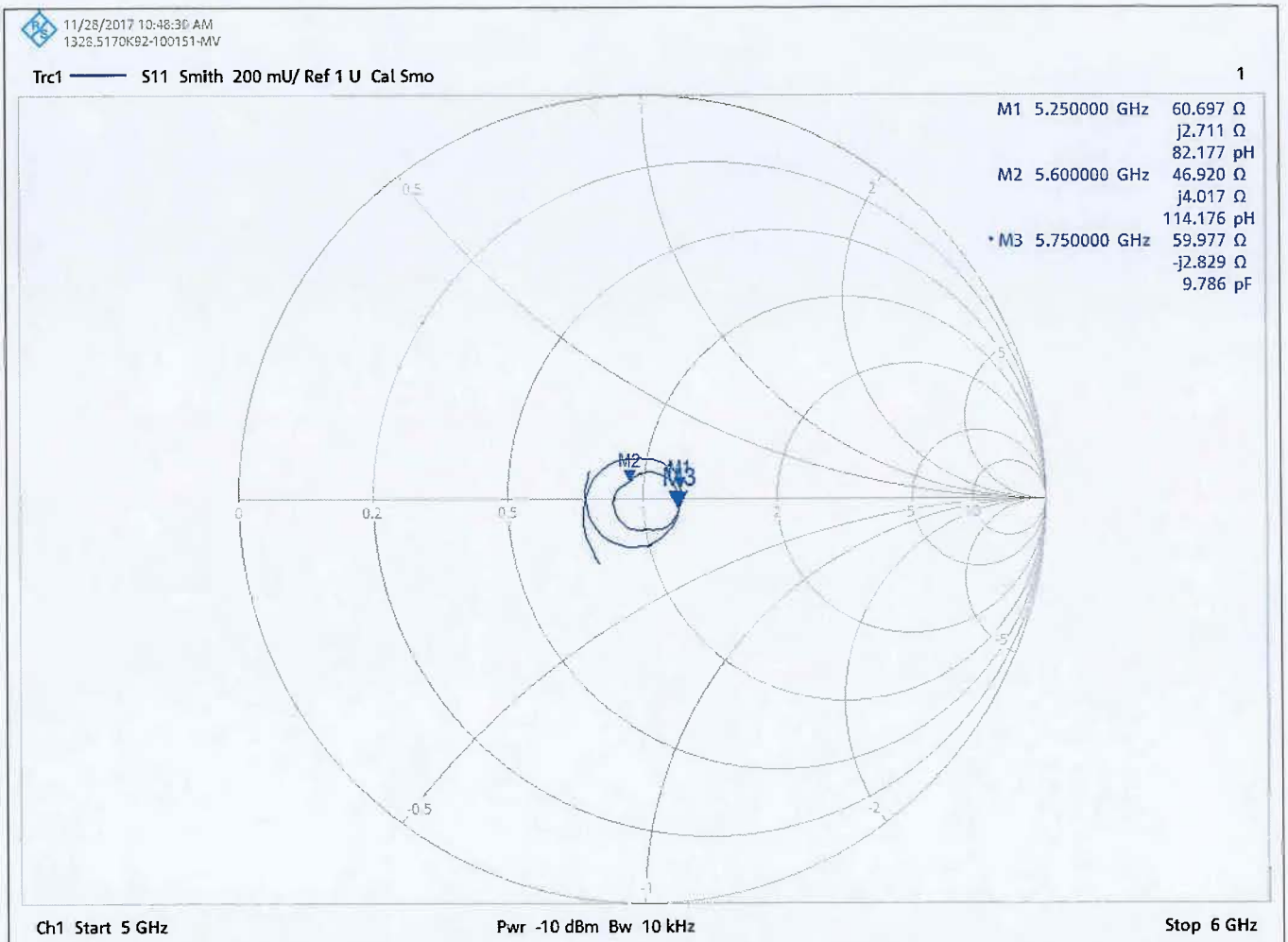


0 dB = 14.1 W/kg = 11.49 dBW/kg

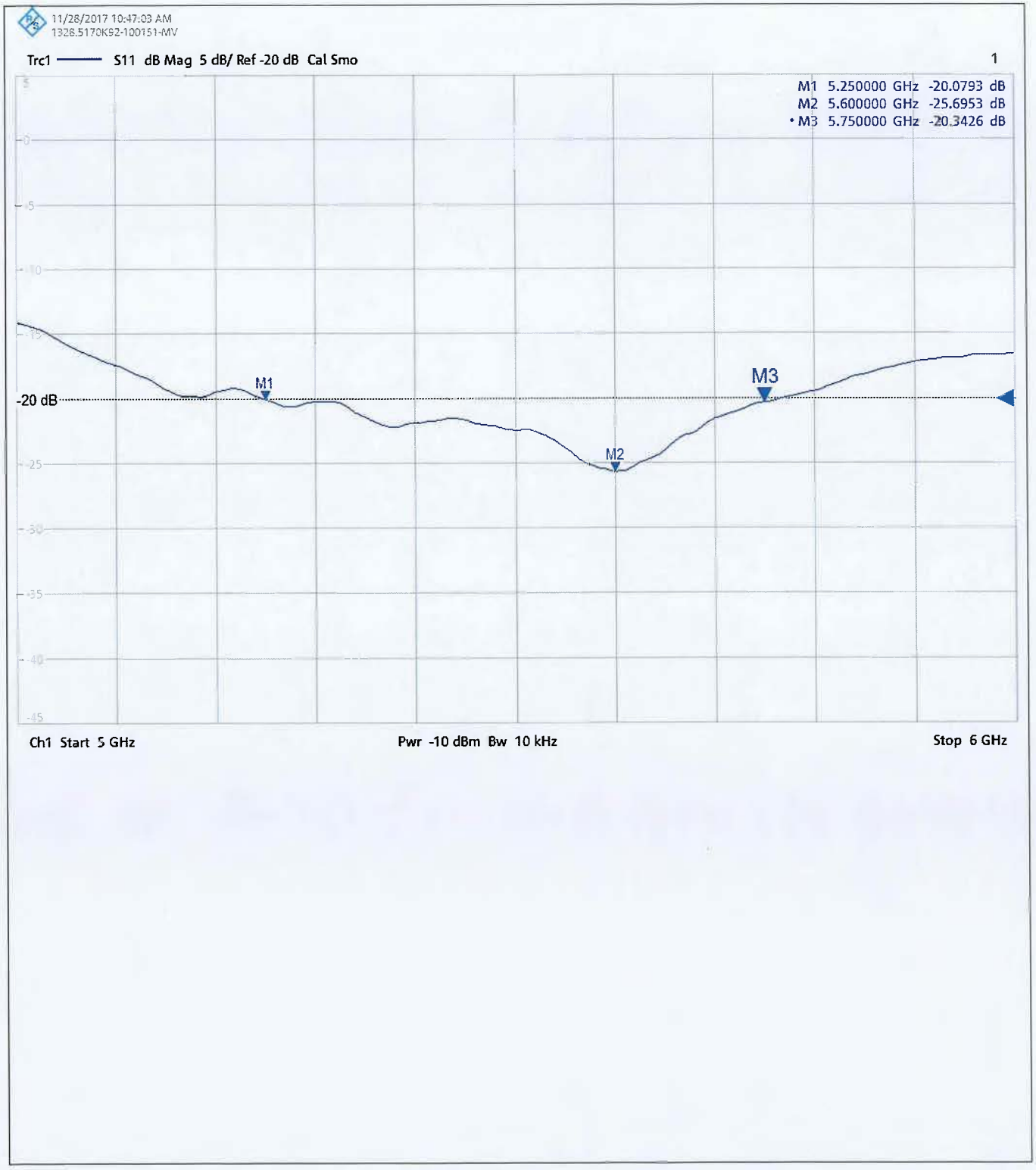
Communication System: UID 0, CW (0); Frequency: 5750 MHz;Duty Cycle: 1:1
Medium: MS 5G Medium parameters used: f = 5750 MHz; σ = 5.968 S/m; ε_r = 46.523; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY 5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(4.59, 4.59, 4.59); Calibrated: 04/05/2017;
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=100mW 2 2 2/Area Scan (71x91x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 14.4 W/kg
Configuration/d=10mm, Pin=100mW 2 2 2/Zoom Scan (7x7x12) (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 36.07 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 29.2 W/kg
SAR(1 g) = 6.53 W/kg; SAR(10 g) = 1.82 W/kg
Maximum value of SAR (measured) = 14.1 W/kg

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903932JD01F Instrument ID: 1168 Calibration Date: 23/Nov/2017 Calibration Due Date:

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