1.1. D835V2 Dipole Calibration Certificate

ngineering AG ghausstrasse 43, 8004 Zurich, 5		Madalahin Mach S	wiss Calibration Service
edited by the Swiss Accreditation Swiss Accreditation Service is tilateral Agreement for the rec	s one of the signatories of ognition of calibration ce	to the EA ertificates	D835V2-4d238_Feb18
ALIBRATION C			
oject	D835V2 - SN:4d23	38	
alibration procedure(s)	QA CAL-05.v9 Calibration procee	dure for dipole validation kits abov	ve 700 MHz
alibration date:	February 19, 201	8	
he measurements and the unce	rtainties with confidence pl	onal standards, which realize the physical unit robability are given on the following pages and ry facility: environment temperature (22 ± 3)°C	
he measurements and the unce Il calibrations have been conduc alibration Equipment used (M&	rtainties with confidence pl	ry facility: environment temperature (22 ± 3)°C Cal Date (Certificate No.)	c and humidity < 70%. Scheduled Calibration
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Calibration Laboratory of Schmid & Partner **Engineering AG** Zeughausstrasse 43, 8004 Zurich, Switzerland



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

Accreditation No.: SCS 0108

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

Cloceary

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%.

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Measurement Conditions D

DASY5	V52.10.0
Advanced Extrapolation	
Modular Flat Phantom	
15 mm	with Spacer
dx, dy, dz = 5 mm	
835 MHz ± 1 MHz	
	DASY5 Advanced Extrapolation Modular Flat Phantom 15 mm dx, dy, dz = 5 mm

Head TSL parameters

e following parameters and calculations were appli	Temperature	Permittivity	Conductivity
	22.0 °C	41.5	0.90 mho/m
Nominal Head TSL parameters	(00.0.0.0) %	41.2 ± 6 %	0.92 mho/m ± 6 %
Measured Head TSL parameters	(22.0 ± 0.2) °C	41.2 10 /0	
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	
	250 mW input power	2.42 W/kg
SAR measured	normalized to 1W	9.51 W/kg ± 17.0 % (k=2)
SAR for nominal Head TSL parameters	Hormanzed to The	
24D sugged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL		1.56 W/kg
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured SAR for nominal Head TSL parameters	condition 250 mW input power normalized to 1W	1.56 W/kg 6.15 W/kg ± 16.5 % (k=2)

Body TSL parameters

ouv	I OL PUI	amouste		the set of the set of the set of the		the state
			and	calculations	were	applied.
Tho	following	narameters	anu	Calculations	11010	and the second s

e following parameters and calculations were appri-	Temperature	Permittivity	Conductivity
	22.0 °C	55.2	0.97 mho/m
Nominal Body TSL parameters	(22.0 ± 0.2) °C	55.0 ± 6 %	0.99 mho/m ± 6 %
Measured Body TSL parameters	< 0.5 °C		
Body TSL temperature change during test	- 0.0 0		

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
	250 mW input power	2.45 W/kg
SAR measured	normalized to 1W	9.64 W/kg ± 17.0 % (k=2)
SAR for nominal Body TSL parameters	Hormanzed to TT	Contraction of the second second
and aver 10 cm ³ (10 a) of Body TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Body TSL		1.60 W/kg
SAR averaged over 10 cm ³ (10 g) of Body TSL SAR measured SAR for nominal Body TSL parameters	condition 250 mW input power normalized to 1W	1.60 W/kg 6.32 W/kg ± 16.5 % (k=2)

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

the standard to feed point	50.8 Ω - 4.0 jΩ
Impedance, transformed to feed point	- 27.8 dB
Beturn Loss	- 27.0 00

Antenna Parameters with Body TSL

the second to feed point	47.6 Ω - 6.0 jΩ
Impedance, transformed to feed point	- 23.6 dB
Return Loss	- 20.0 00

General Antenna Parameters and Design

	1.391 ns
Electrical Delay (one direction)	

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

10	SPEAG
Manufactured by	June 02, 2017
Manufactured on	

Certificate No: D835V2-4d238_Feb18

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DASY5 Validation Report for Head TSL

Date: 19.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d238

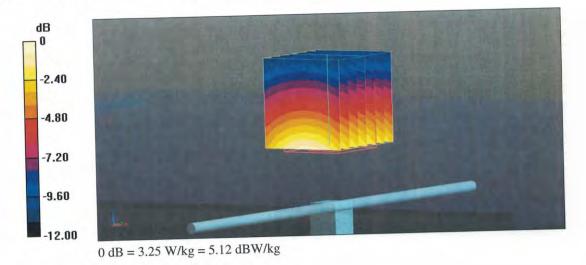
Communication System: UID 0 - CW; Frequency: 835 MHz Medium parameters used: f = 835 MHz; σ = 0.92 S/m; ϵ_r = 41.2; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(9.9, 9.9, 9.9); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

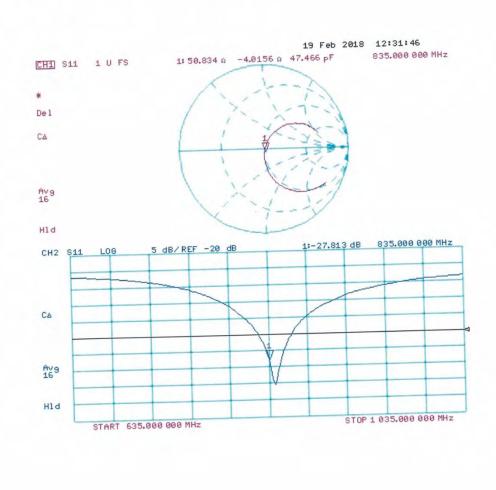
Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 62.44 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 3.69 W/kg SAR(1 g) = 2.42 W/kg; SAR(10 g) = 1.56 W/kg Maximum value of SAR (measured) = 3.25 W/kg



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Impedance Measurement Plot for Head TSL

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DASY5 Validation Report for Body TSL

Date: 19.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d238

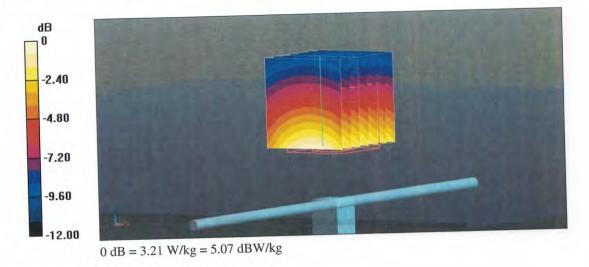
Communication System: UID 0 - CW; Frequency: 835 MHz Medium parameters used: f = 835 MHz; σ = 0.99 S/m; ϵ_r = 55; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.05, 10.05, 10.05); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

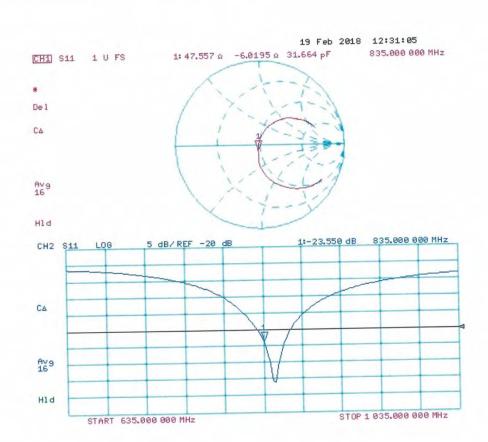
Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 60.24 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 3.70 W/kg SAR(1 g) = 2.45 W/kg; SAR(10 g) = 1.6 W/kg Maximum value of SAR (measured) = 3.21 W/kg



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Impedance Measurement Plot for Body TSL

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Extended Dipole Calibrations

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

			Head-835			
Date of	Poturn loop (dP)		Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Delta (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/19	-27.8		50.8		-4.0	
2019/2/3	-27.1	2.52%	49.9	0.9	-3.6	0.4
2020/1/22	-26.9	3.24%	50.2	0.6	-3.7	0.3

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.

1.2. D1750V2 Dipole Calibration Certificate

	tion Service (SAS)	Ac	creditation No.: SCS 0108
credited by the Swiss Accredite e Swiss Accreditation Servic ultilateral Agreement for the r	e is one of the signatories	s to the EA	
ient CCIC-HTW (Au			D1750V2-1164_Feb18
ALIBRATION	CERTIFICATE		
Dbject	D1750V2 - SN:11	164	
Calibration procedure(s)	QA CAL-05.v9 Calibration proce	dure for dipole validation kits ab	ove 700 MHz
Calibration date:	February 06, 201	8	
All calibrations have been condu	ucted in the closed laborato	robability are given on the following pages a ry facility: environment temperature $(22 \pm 3)^{\circ}$	
Il calibrations have been conducation Equipment used (M&	ucted in the closed laborato		°C and humidity < 70%. Scheduled Calibration
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Il calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP	LICE critical for calibration) ID # SN: 104778 SN: 103244	ry facility: environment temperature (22 ± 3) Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521)	² C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18
All calibrations have been condent Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	LID # SN: 104778 SN: 103244 SN: 103245	ry facility: environment temperature (22 ± 3) <u>Cal Date (Certificate No.)</u> 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been conducted Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination	ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	ry facility: environment temperature (22 ± 3) Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been conducted Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination Reference Probe EX3DV4	ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been conducted Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination Reference Probe EX3DV4 DAE4	ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17)	² C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18
All calibrations have been condi- Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17)	² C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18
All calibrations have been conde Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A	ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID #	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 <u>Scheduled Check</u> In house check: Oct-18 In house check: Oct-18
All calibrations have been conde Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	Arte critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 <u>Scheduled Check</u> In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
All calibrations have been conder Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	Licted in the closed laborato ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 <u>Scheduled Check</u> In house check: Oct-18 In house check: Oct-18
All calibrations have been conder Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	Lacted in the closed laborato ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 <u>Scheduled Check</u> In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
All calibrations have been conder Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	Licted in the closed laborato ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585 Name	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 <u>Scheduled Check</u> In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
All calibrations have been conducted Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	Licted in the closed laborato ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02523) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17)	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 <u>Scheduled Check</u> In house check: Oct-18 In house check: Oct-18
All calibrations have been conde Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	Licted in the closed laborato ATE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: US37390585 Name	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function	² C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 <u>Scheduled Check</u> In house check: Oct-18 In house check: Oct-18

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





S Schweizerischer Kalibrierdienst

C Service suisse d'étalonnage

Accreditation No.: SCS 0108

Servizio svizzero di taratura

S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)

The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

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%.

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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	1750 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.4 ± 6 %	1.35 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	9.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.6 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 c) of Head TSI	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured SAR for nominal Head TSL parameters	condition 250 mW input power	4.83 W/kg

Body TSL parameters The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.5 ± 6 %	1.46 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	9.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	36.7 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSI	condition	
SAR averaged over 10 cm ³ (10 g) of Body TSL SAR measured	condition 250 mW input power	4.84 W/kg

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.1 Ω - 0.1 jΩ
Return Loss	- 39.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.2 Ω - 1.3 jΩ	
Return Loss	- 27.6 dB	

General Antenna Parameters and Design

Electrical Delay (one direction)	1.216 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	March 07, 2016	

Certificate No: D1750V2-1164_Feb18

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DASY5 Validation Report for Head TSL

Date: 06.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

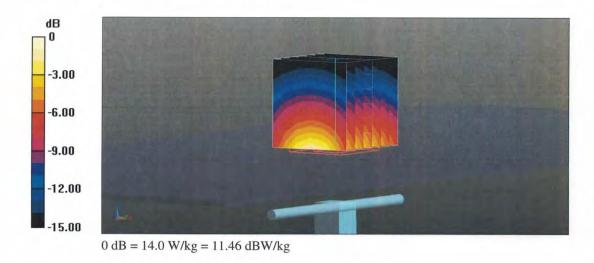
DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1164

Communication System: UID 0 - CW; Frequency: 1750 MHz Medium parameters used: f = 1750 MHz; σ = 1.35 S/m; ε_r = 39.4; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

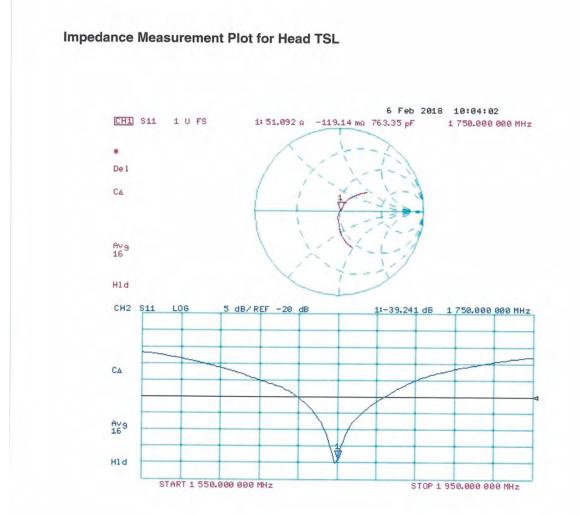
- Probe: EX3DV4 SN7349; ConvF(8.5, 8.5, 8.5); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 106.4 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 16.8 W/kg SAR(1 g) = 9.11 W/kg; SAR(10 g) = 4.83 W/kg Maximum value of SAR (measured) = 14.0 W/kg



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Certificate No: D1750V2-1164_Feb18

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DASY5 Validation Report for Body TSL

Date: 06.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1164

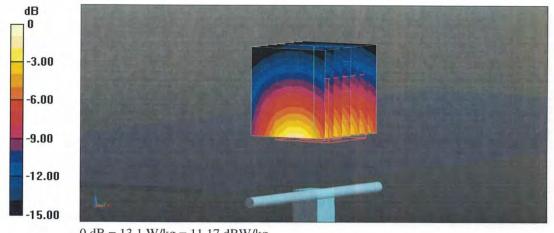
Communication System: UID 0 - CW; Frequency: 1750 MHz Medium parameters used: f = 1750 MHz; $\sigma = 1.46$ S/m; $\varepsilon_r = 53.5$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.35, 8.35, 8.35); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- 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=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

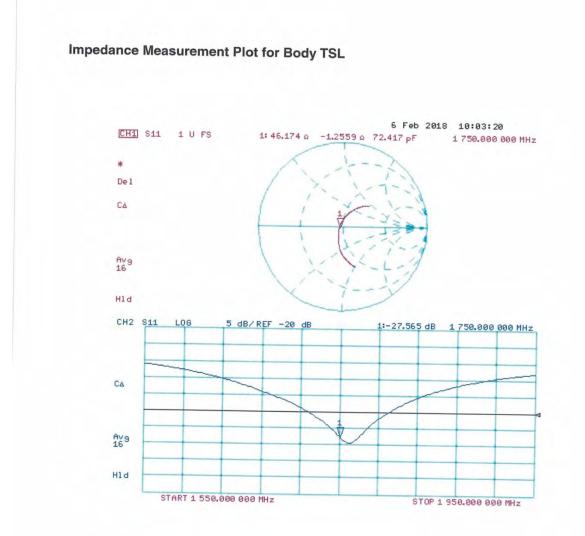
Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 99.62 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 16.0 W/kg SAR(1 g) = 9.06 W/kg; SAR(10 g) = 4.84 W/kgMaximum value of SAR (measured) = 13.1 W/kg



0 dB = 13.1 W/kg = 11.17 dBW/kg

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Extended Dipole Calibrations

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head-1750						
Date of	Datura lass (dD) Data (%	Dolto (9/)	Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Delta (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/6	-39.2		51.1		-0.1	
2019/2/3	-38.6	1.53%	50.7	0.4	-0.8	0.7
2020/1/22	-38.4	2.04%	50.5	0.6	-0.6	0.5

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.

1.3. D1900V2 Dipole Calibration Certificate

Calibration procedure(s)	s one of the signatori ognition of calibration en) ERTIFICAT D1900V2 - SN:5 QA CAL-05.v9 Calibration proce February 22, 20 ⁻ s the traceability to nat inties with confidence p d in the closed laborato	ies to the EA n certificates Certificate I E 5d226 edure for dipole validation kits ab	nits of measurements (SI). Ind are part of the certificate.
CALIBRATION CE	ERTIFICAT D1900V2 - SN:5 QA CAL-05.v9 Calibration proce February 22, 20 s the traceability to nat inties with confidence p d in the closed laborato	E 5d226 edure for dipole validation kits ab 18 tional standards, which realize the physical u probability are given on the following pages a	nits of measurements (SI).
Dbject I Calibration procedure(s) I Calibration date: I This calibration certificate documents I The measurements and the uncertain III calibrations have been conducted Calibration Equipment used (M&TE conducted) Calibration certificate	D1900V2 - SN:5 QA CAL-05.v9 Calibration proce February 22, 20 s the traceability to nat inties with confidence p d in the closed laborato	5d226 edure for dipole validation kits at 18 tional standards, which realize the physical u probability are given on the following pages a	nits of measurements (SI). Ind are part of the certificate.
Calibration procedure(s)	QA CAL-05.v9 Calibration proce February 22, 20 s the traceability to nat inties with confidence p d in the closed laborate	edure for dipole validation kits ab 18 tional standards, which realize the physical u probability are given on the following pages a	nits of measurements (SI). Ind are part of the certificate.
Calibration date:	Calibration proce February 22, 20 s the traceability to nat inties with confidence p d in the closed laborato	18 tional standards, which realize the physical u probability are given on the following pages a	nits of measurements (SI). Ind are part of the certificate.
This calibration certificate documents The measurements and the uncertain All calibrations have been conducted Calibration Equipment used (M&TE c Primary Standards	s the traceability to nat inties with confidence p d in the closed laborate	tional standards, which realize the physical u probability are given on the following pages a	and are part of the certificate.
The measurements and the uncertain All calibrations have been conducted Calibration Equipment used (M&TE c	inties with confidence p	probability are given on the following pages a	and are part of the certificate.
Power meter NRP	ID #	Cal Date (Certificate No.)	Scheduled Calibration
	SN: 104778	04-Apr-17 (No. 217-02521/02522)	Apr-18
	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
and the filler of the state of the second se	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
	SN: 7349 SN: 601	30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17)	Dec-18 Oct-18
econdary Standards	ID #	Check Date (in house)	Scheduled Check
and the second se	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
letwork Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18
and and a start a later of the start of the	Name Michael Weber	Function	Signature
		Laboratory Technician	1285

Certificate No: D1900V2-5d226_Feb18

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



S Schweizerischer Kalibrierdienst

- C Service suisse d'étalonnage
- Servizio svizzero di taratura Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)

The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

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%.

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Accreditation No.: SCS 0108

Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	V02.10.0
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	and option
Frequency	1900 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.7 ± 6 %	1.39 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	10.0 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.3 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured	condition 250 mW input power	5.25 W/kg

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.2 ± 6 %	1.48 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	9.71 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.8 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Body TSL SAR measured	condition 250 mW input power	5.16 W/kg

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	F2 2 0 + 2 0 10
Return Loss	52.2 Ω + 6.0 jΩ
	- 24.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.9 Ω + 7.5 jΩ
Return Loss	47.5 52 + 7.5 52
	- 22.0 dB

General Antenna Parameters and Design

J.	Electrical Delay (one direction)	1.195 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 No programmer 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	
	April 16, 2015

Certificate No: D1900V2-5d226_Feb18

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DASY5 Validation Report for Head TSL

Test Laboratory: SPEAG, Zurich, Switzerland

Date: 22.02.2018

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d226

Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; σ = 1.39 S/m; ϵ_r = 40.7; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.18, 8.18, 8.18); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection) .
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017 .
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417) .

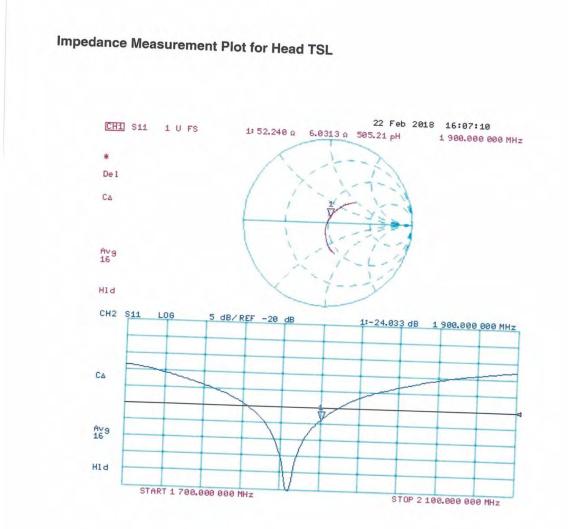
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 109.6 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 18.5 W/kgSAR(1 g) = 10 W/kg; SAR(10 g) = 5.25 W/kg

Maximum value of SAR (measured) = 15.3 W/kg



0 dB = 15.3 W/kg = 11.85 dBW/kg

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Certificate No: D1900V2-5d226_Feb18

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Date: 22.02.2018

DASY5 Validation Report for Body TSL

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d226

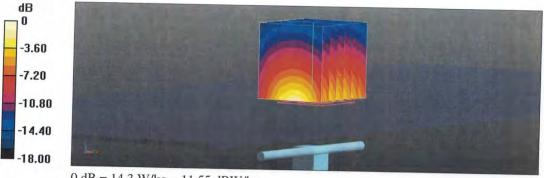
Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.48$ S/m; $\varepsilon_r = 55.2$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.15, 8.15, 8.15); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- 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=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

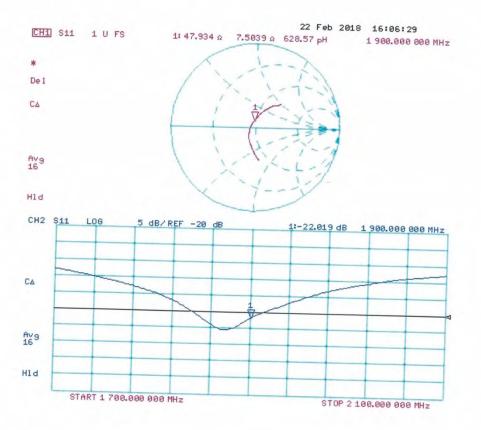
Reference Value = 102.8 V/m; Power Drift = -0.09 dBPeak SAR (extrapolated) = 17.2 W/kgSAR(1 g) = 9.71 W/kg; SAR(10 g) = 5.16 W/kgMaximum value of SAR (measured) = 14.3 W/kg



0 dB = 14.3 W/kg = 11.55 dBW/kg

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Extended Dipole Calibrations

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head-1900						
Date of	Poturn loop (dP)	Dolto (9/)	Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Delta (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/22	-24.0		52.2		6.0	
2019/2/20	-24.5	-2.08%	52.6	0.4	6.5	0.5
2020/01/22	-24.7	-2.92%	52.5	0.3	6.1	0.1

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.

1.4. D2450V2 Dipole Calibration Certificate

Calibration Labora Schmid & Partner Engineering AG ^{Zeughausstrasse} 43, 8004 z		CONTRACTOR SCORE	 S Schweizerischer Kalibrierdien Service suisse d'étalonnage Servizio svizzero di taratura Swiss Calibration Service
Accredited by the Swiss Accre The Swiss Accreditation Ser Multilateral Agreement for th	vice is one of the signat	ories to the EA tion certificates	Accreditation No.: SCS 0108
Client CCIC-HTW (Certific	ate No: D2450V2-1009_Feb18
CALIBRATION	CERTIFICA	TE	States and the
Object	D2450V2 - SN	:1009	
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz		
Calibration date:	February 05, 20	018	
All calibrations have been cond	ucted in the closed laborat	ational standards, which realize the physica probability are given on the following page tory facility: environment temperature (22 ±	es and are part of the certificate.
	ucted in the closed laborat TE critical for calibration)	tory facility: environment temperature (22 \pm	es and are part of the certificate.
All calibrations have been cond Calibration Equipment used (M& Primary Standards Power meter NRP	ucted in the closed laborat	tory facility: environment temperature (22 ±	es and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration
All calibrations have been cond Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91	ucted in the closed laborat &TE critical for calibration)	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522)	es and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18
All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521)	es and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18
All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521/	ss and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529)	ss and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17)	ss and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529)	ss and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been condi Calibration Equipment used (M& <u>Primary Standards</u> Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17)	ss and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Dec-18 Oct-18
All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A	ucted in the closed laborat 3TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16)	ss and are part of the certificate. 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Dec-18 Oct-18 Scheduled Check
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All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A	ucted in the closed laborat STE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	ss and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
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All calibrations have been condi Calibration Equipment used (M& Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer HP 8753E	ucted in the closed laborat &TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 5047.2 / 06327 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317 SN: 100972 SN: 100972 SN: US37390585 Name	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 18-Oct-01 (in house check Oct-17) Function	ss and are part of the certificate. : 3)°C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18
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Certificate No: D2450V2-1009_Feb18

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Calibration Laboratory of Schmid & Partner

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



Schweizerischer Kalibrierdienst S

- Service suisse d'étalonnage С
- Servizio svizzero di taratura S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)

The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Glossary:

ISL	tissue simulating liquid
ConvF	sopoitivity in TOL (NIG
N/A	sensitivity in TSL / NORM x,y,z
IN/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%.

Certificate No: D2450V2-1009_Feb18

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Accreditation No.: SCS 0108

Measurement Conditions

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

DASY Version	DASY5	7.00
Extrapolation		V52.10.0
man at 1	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with O
Zoom Scan Resolution	dx, dy, dz = 5 mm	with Spacer
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

Temperature	Permittivity	Conductivity
22.0 °C		1.80 mho/m
(22.0 ± 0.2) °C		
< 0.5 °C		1.87 mho/m ± 6 %
	22.0 °C (22.0 ± 0.2) °C	22.0 °C 39.2 (22.0 ± 0.2) °C 37.9 ± 6 %

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	12.0 \////
SAR for nominal Head TSL parameters	normalized to 1W	13.2 W/kg 51.5 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured	condition 250 mW input power	6.13 W/kg

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	51.4 ± 6 %	2.04 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	12.7 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.4 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.92 W/kg

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	
Return Loss	53.8 Ω + 2.2 jΩ
Hotani 2000	- 27.4 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	
Return Loss	49.9 Ω + 4.6 jΩ
	- 26.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)		
	1.152 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 No excessive force much here.

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	SPEAC
Manufactured on	SPEAG
Manufactured off	October 17, 2017

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Date: 05.02.2018

DASY5 Validation Report for Head TSL

Test Laboratory: SPEAG, Zurich, Switzerland

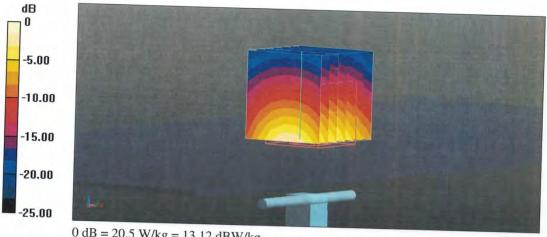
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:1009

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; σ = 1.87 S/m; ϵ_r = 37.9; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.88, 7.88, 7.88); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- 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=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 111.8 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 26.6 W/kg SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.13 W/kg Maximum value of SAR (measured) = 20.5 W/kg

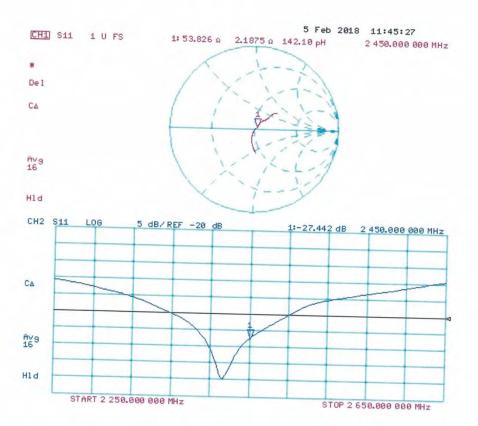


0 dB = 20.5 W/kg = 13.12 dBW/kg

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Certificate No: D2450V2-1009_Feb18

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DASY5 Validation Report for Body TSL

Test Laboratory: SPEAG, Zurich, Switzerland

Date: 05.02.2018

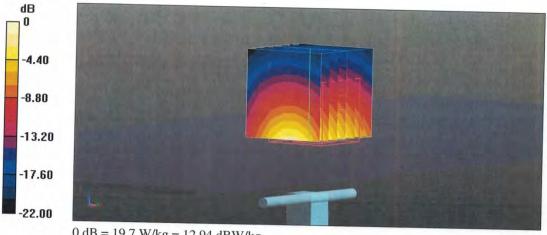
DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:1009

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; $\sigma = 2.04$ S/m; $\varepsilon_r = 51.4$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.01, 8.01, 8.01); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- 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=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 104.2 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 25.5 W/kg SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.92 W/kg Maximum value of SAR (measured) = 19.7 W/kg

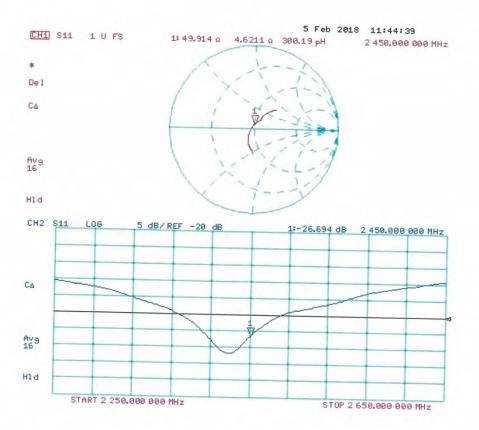


0 dB = 19.7 W/kg = 12.94 dBW/kg

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Extended Dipole Calibrations

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head-2450						
Date of	Poturn loop (dP)		Real Impedance	Delta	Imaginary	Delta
measurement	Return-loss (dB)	Delta (%)	(ohm)	(ohm)	impedance (ohm)	(ohm)
2018-02-05	-27.4		53.8		2.2	
2019-02-03	-26.8	2.19%	52.9	0.9	1.9	0.3
2020-01-22	-27.1	1.09%	53.1	0.7	1.8	0.4

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.

1.5. D2600V2 Dipole Calibration Certificate

			and the second sec
credited by the Swiss Accreditati e Swiss Accreditation Service ultilateral Agreement for the red	is one of the signatories	to the EA	creditation No.: SCS 0108
ient CCIC-HTW (Auc			: D2600V2-1150_Feb18
ALIBRATION C	ERTIFICATE		
Dbject	D2600V2 - SN:11	50	
Calibration procedure(s)	QA CAL-05.v9	the textinete velidation bits abs	W0 700 MHz
	Calibration proces	dure for dipole validation kits abo	500 Min2
Calibration date:	February 05, 201	8	
All calibrations have been conduc	ted in the closed laborator	robability are given on the following pages ar ry facility: environment temperature (22 \pm 3)°	
All calibrations have been conduc	ted in the closed laborator E critical for calibration)	ry facility: environment temperature (22 \pm 3)°	
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards	ted in the closed laborator E critical for calibration)	ry facility: environment temperature (22 ± 3)° Cal Date (Certificate No.)	C and humidity < 70%.
All calibrations have been conduc Calibration Equipment used (M&1 Primary Standards Power meter NRP	ted in the closed laborator E critical for calibration)	ry facility: environment temperature (22 \pm 3)°	C and humidity < 70%. Scheduled Calibration
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91	ted in the closed laborator TE critical for calibration) ID # SN: 104778	ry facility: environment temperature (22 ± 3)° Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522)	C and humidity < 70%. Scheduled Calibration Apr-18
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	ted in the closed laborator TE critical for calibration) ID # SN: 104778 SN: 103244	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521)	C and humidity < 70%. <u>Scheduled Calibration</u> Apr-18 Apr-18
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	ted in the closed laborator TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522)	C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18
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All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	ted in the closed laborator TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529)	C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	ted in the closed laborator TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17)	C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	ted in the closed laborator TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID #	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house)	C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A	ted in the closed laborator TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16)	C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Dec-18 Oct-18 Scheduled Check
All calibrations have been conduc Calibration Equipment used (M&T Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	ted in the closed laborator TE critical for calibration) ID # SN: 104778 SN: 103244 SN: 103244 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783	Cal Date (Certificate No.) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521/02522) 04-Apr-17 (No. 217-02521) 04-Apr-17 (No. 217-02522) 07-Apr-17 (No. 217-02528) 07-Apr-17 (No. 217-02529) 30-Dec-17 (No. EX3-7349_Dec17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	C and humidity < 70%. Scheduled Calibration Apr-18 Apr-18 Apr-18 Apr-18 Apr-18 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
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Calibration Laboratory of Schmid & Partner Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland

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

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

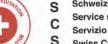
Methods Applied and Interpretation of Parameters:

- 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%.

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Schweizerischer Kalibrierdienst Service suisse d'étalonnage

- Servizio svizzero di taratura
- Swiss Calibration Service

Accreditation No.: SCS 0108

Measurement Conditions

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

DASY5	V52.10.0
Advanced Extrapolation	
Modular Flat Phantom	
10 mm	with Spacer
dx, dy, dz = 5 mm	
2600 MHz ± 1 MHz	
	Advanced Extrapolation Modular Flat Phantom 10 mm dx, dy, dz = 5 mm

Head TSL parameters The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.3 ± 6 %	2.04 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		
SAB measured	250 mW input power	14.3 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	55.6 W/kg ± 17.0 % (k=2)	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition		
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition 250 mW input power	6.36 W/kg	

Body TSL parameters The following parameters and calculations were applied.

le following parameters and balearance were appro-	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	51.0 ± 6 %	2.22 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	13.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	54.6 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
		6.16 W/kg

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.4 Ω - 7.1 jΩ
Return Loss	- 22.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.9 Ω - 4.4 jΩ
Return Loss	- 25.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.141 ns
Electrical Boldy (one checker)	

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	August 29, 2017	

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DASY5 Validation Report for Head TSL

Date: 05.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1150

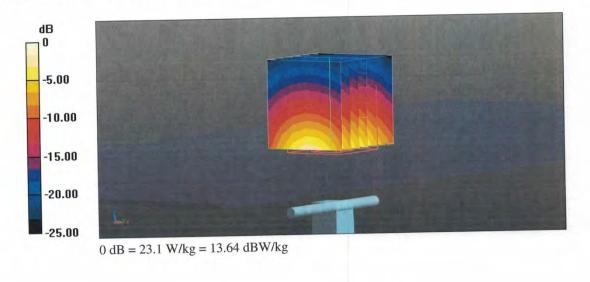
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; σ = 2.04 S/m; ϵ_r = 37.3; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.7, 7.7, 7.7); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

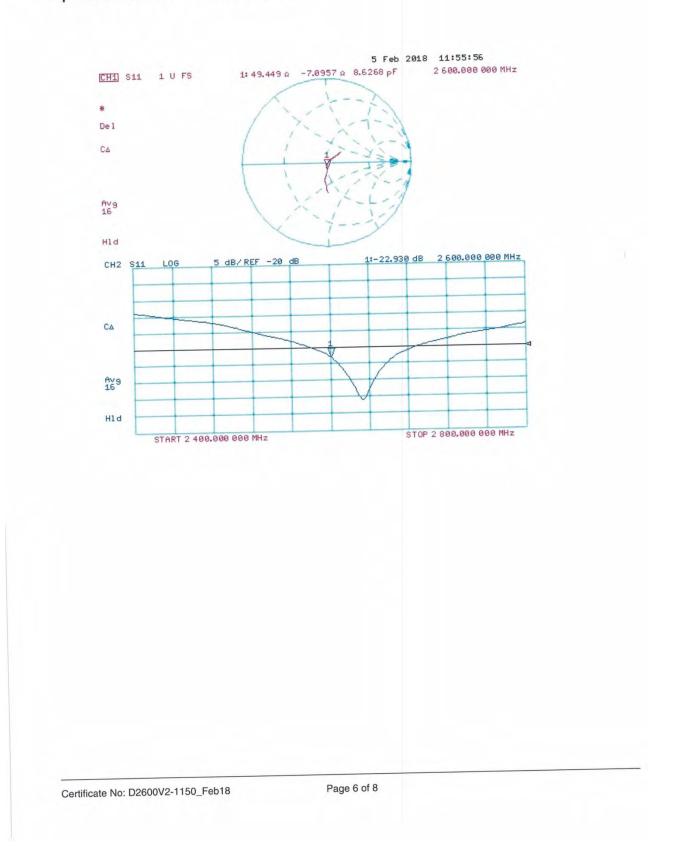
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 116.4 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 28.9 W/kg SAR(1 g) = 14.3 W/kg; SAR(10 g) = 6.36 W/kg Maximum value of SAR (measured) = 23.1 W/kg



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Impedance Measurement Plot for Head TSL

DASY5 Validation Report for Body TSL

Date: 05.02.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1150

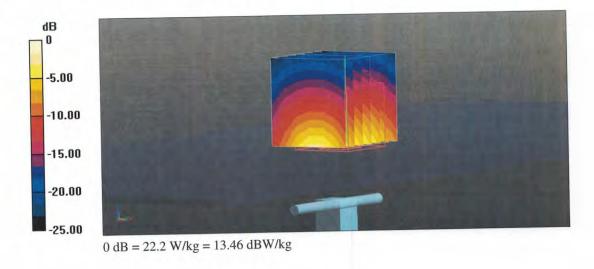
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; σ = 2.22 S/m; ϵ_r = 51; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.81, 7.81, 7.81); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- 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=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

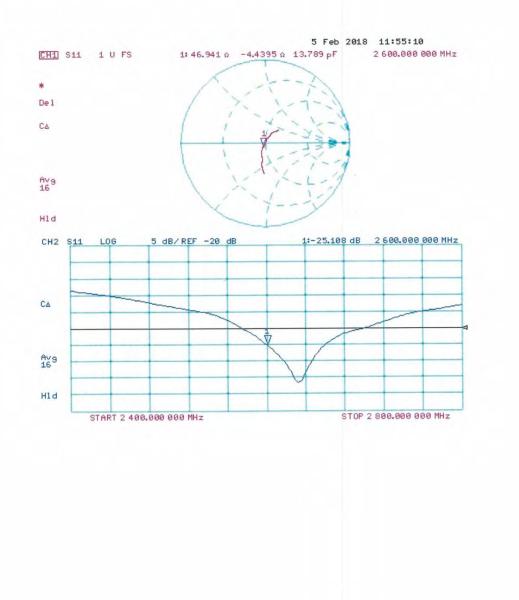
Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 105.5 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 29.0 W/kg SAR(1 g) = 13.9 W/kg; SAR(10 g) = 6.16 W/kg Maximum value of SAR (measured) = 22.2 W/kg



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Extended Dipole Calibrations

Referring to KDB865664 D01, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

Head-750						
Date of	Return-loss (dB)	Delta (%)	Real Impedance	Delta	Imaginary	Delta
measurement			(ohm)	(ohm)	impedance (ohm)	(ohm)
2018/2/5	-22.9		49.4		-7.1	
2019/2/3	-23.4	-2.18%	48.8	0.6	-6.7	0.4
2020/1/22	-23.1	-0.87%	48.6	0.8	-6.5	0.6

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 50hm of prior calibration. Therefore the verification result should support extended calibration.