Justification for Extended SAR Dipole Calibrations

Instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements

KDB 865664 D01v01r04 requirements

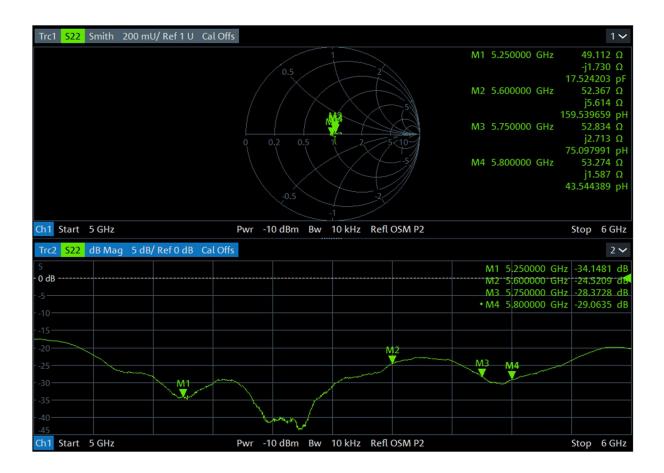
a) return loss : < - 20 dB, within 20% of previous measurement

b) impedance : within 5 $\boldsymbol{\Omega}$ from previous measurement

Dipole Antenna	Head/Body	Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ
D5GHzV2-SN : 1325	Head	2023.04.21	-25.600	4.2	53.052	0.685
D3GH2V2-SN . 1325	пеай	2024.04.02	-24.520	4.2	52.367	0.085

c) peak SAR (1g) : within 10% of that reported in the calibration data

Dipole Antenna	Head/Body	Date of Measurement	peak SAR (1g) (W/kg)	Δ%
	Llood	2023.04.21	8.07	0.07
D5GHzV2-SN : 1325	Head	2024.04.04	8.00	0.87



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

UL Korea

Client



Schweizerischer Kalibrierdienst

Service suisse d'étalonnage

С Servizio svizzero di taratura

S **Swiss Calibration Service**

Accreditation No.: SCS 0108

S

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

Certificate No: D5GHzV2-1209_Feb23

CALIBRATION CERTIFICATE

Object	D5GHzV2 - SN:1	209			
Calibration procedure(s)	QA CAL-22.v7				
	Calibration Proce	dure for SAR Validation Sources	s between 3-10 GHz		
Calibration date:	February 28, 202	3			
This calibration cortificate documen	to the treeschility to notic	not standards, which realize the physical up	ite of monour entry (OI)		
		nal standards, which realize the physical un	NOT ALL THE REPORT OF A CONTRACT		
The measurements and the uncerta	anues with confidence pr	obability are given on the following pages a	id are part of the certificate.		
All calibrations have been conducte	d in the closed laborator	y facility: environment temperature (22 ± 3)°	C and humidity < 70%.		
Calibration Equipment used (M&TE	critical for calibration)				
	1				
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration		
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23		
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23		
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23		
Reference 20 dB Attenuator	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23		
Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23		
Reference Probe EX3DV4	SN: 3503	08-Mar-22 (No. EX3-3503_Mar22)	Mar-23		
DAE4	SN: 601	19-Dec-22 (No. DAE4-601_Dec22)	Dec-23		
Secondary Standards	ID #	Check Date (in house)	Scheduled Check		
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-22)	In house check: Oct-24		
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-22)	In house check: Oct-24		
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-22)	In house check: Oct-24		
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-22)	In house check: Oct-24		
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24		
AlfaD index					
	Name	Function	Signature		
Calibrated by:	Jeton Kastrati	Laboratory Technician	11-		
		\bigcirc	- 112		
Approved by:	Sven Kühn	Technical Manager	/ /		
			6.5		
		C			
			Issued: February 28, 2023		
This calibration cortificate shall not	he reproduced exection	full without writton approval of the lobarate	•		
rins canoration certificate shall not	ne reproduced except in	full without written approval of the laborator	у.		

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) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

c) DASY System Handbook

Methods Applied and Interpretation of Parameters:

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

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Accreditation No.: SCS 0108

Measurement Conditions

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom 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	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.0 ± 6 %	4.67 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition		
SAR measured	100 mW input power	8.04 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	80.4 W/kg ± 19.9 % (k=2)	

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.9 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	35.9 ± 6 %	5.06 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	8.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	, <u>, ,, ,,,,</u> ,,,,,,,,,,,,,,,,,,,,,,,,,,
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.6 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.7 ± 6 %	5.17 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.88 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.9 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 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	35.6 ± 6 %	5.21 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	8.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	······································
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.9 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	46.3 Ω - 1.2 jΩ
Return Loss	- 27.9 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	51.2 Ω + 3.7 jΩ
Return Loss	- 28.2 dB

Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	53.5 Ω + 3.3 jΩ
Return Loss	- 26.6 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	53.5 Ω + 3.3 jΩ
Return Loss	- 26.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1 100
	1.192 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
	SPEAG

DASY5 Validation Report for Head TSL

Date: 28.02.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1209

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5800 MHz Medium parameters used: f = 5250 MHz; $\sigma = 4.67$ S/m; $\varepsilon_r = 36$; $\rho = 1000$ kg/m³, Medium parameters used: f = 5600 MHz; $\sigma = 5.06$ S/m; $\varepsilon_r = 35.9$; $\rho = 1000$ kg/m³, Medium parameters used: f = 5750 MHz; $\sigma = 5.17$ S/m; $\varepsilon_r = 35.7$; $\rho = 1000$ kg/m³, Medium parameters used: f = 5800 MHz; $\sigma = 5.21$ S/m; $\varepsilon_r = 35.6$; $\rho = 1000$ kg/m³ Medium parameters used: f = 5800 MHz; $\sigma = 5.21$ S/m; $\varepsilon_r = 35.6$; $\rho = 1000$ kg/m³ Medium parameters used: f = 5800 MHz; $\sigma = 5.21$ S/m; $\varepsilon_r = 35.6$; $\rho = 1000$ kg/m³

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.81 V/m; Power Drift = -0.00 dB Peak SAR (extrapolated) = 27.5 W/kg SAR(1 g) = 8.04 W/kg; SAR(10 g) = 2.29 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 71.2% Maximum value of SAR (measured) = 18.0 W/kg

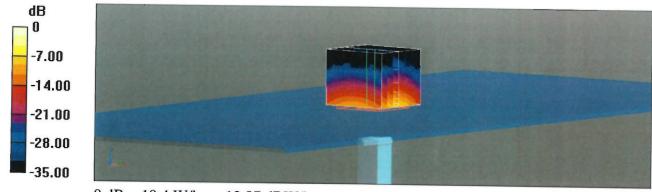
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.05 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 30.6 W/kg SAR(1 g) = 8.29 W/kg; SAR(10 g) = 2.35 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 67.8% Maximum value of SAR (measured) = 19.2 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 72.78 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 30.5 W/kg SAR(1 g) = 7.88 W/kg; SAR(10 g) = 2.22 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 66.5% Maximum value of SAR (measured) = 18.5 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 = 73.16 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 31.6 W/kg SAR(1 g) = 8.11 W/kg; SAR(10 g) = 2.28 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 66.9% Maximum value of SAR (measured) = 19.4 W/kg



0 dB = 19.4 W/kg = 12.87 dBW/kg

Impedance Measurement Plot for Head TSL

Eile	View	Channel	Sw <u>e</u> ep	Calibration	Trace	<u>S</u> cale	M <u>a</u> rker	System	<u>W</u> indow	Help			
						$\overline{\langle}$		P	A	1:		250000 GHz 24.428 pF 600000 GHz	46.340 Ω -1.2410 Ω 51.248 Ω
					,		Χ,	1-	11-4			106.09 pH	3.7330 Q
					-	~/	\sim	\times	K	3:	5.1	750000 GHz 90.904 pH	53.530 Ω 3.2842 Ω
					1	T		<u>7-</u> X	NA	> 4;	5.4	800000 GHz	53.478 Ω
					- I					1		89.187 pH	3.2502 Q
					۱.		4-	5-X	74	R:	0.3	500000 GHz	32.934 mU 118.30 *
					F	- A	1	\sim	7—-M				
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10.0	0								-			50000 GHz	-27.935 dB 28.212 dB
10.0 5.0										1: 2: 3: > 4:	5.	50000 GHz	-27.935 dB
10.0										3:	5.	50000 GHz 00000 GHz 50000 GHz	-27.935 dB 28.212 dB -26.642 dB
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10.0 5.0 -5.0 -10. -15. -20. -25. -30.		JB S11					~			2+ 3: > 4.	5.	50000 GHz 00000 GHz 50000 GHz	-27.935 dB 28.212 dB -26.642 dB
- 5.0 -5.0 -10. -15. -20. -25. -30. -35.			20				~			2+ 3: > 4.	5.	\$50000 GHz 50000 GHz 50000 GHz 200000 GHz	-27, 935 dB 28,212 dB -26,642 dB -26,749 dB
- 5.0 -5.0 -10. -15. -20. -25. -30. -35.		HE S11	20				~~~			2+ 3: > 4.	5.	\$50000 GHz 50000 GHz 50000 GHz 200000 GHz	-27.935 dB 28.212 dB -26.642 dB

Justification for Extended SAR Dipole Calibrations

Instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements

KDB 865664 D01v01r04 requirements

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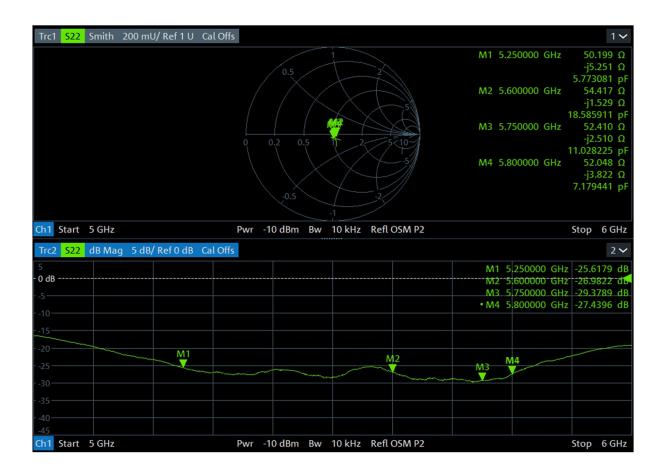
a) return loss : < - 20 dB, within 20% of previous measurement

b) impedance : within 5 $\boldsymbol{\Omega}$ from previous measurement

Dipole Antenna	Head/Body	Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ
D5GHzV2-SN : 1209	Head	2023.02.28	-28.212	4.36	51.248	-3.17
D3GH2V2-SN . 1209	пеай	2024.04.02	-26.982	4.50	54.417	-5.17

c) peak SAR (1g) : within 10% of that reported in the calibration data

Dipole Antenna	Head/Body	Date of Measurement	Peak SAR (1g) (W/kg)	Δ%
	Llood	2023.02.28	8.29	2 77
D5GHzV2-SN : 1209	Head	2024.03.20	8.52	2.77



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

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Accreditation No.: SCS 0108

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Certificate No: D1750V2-1180_Sep22

CALIBRATION CERTIFICATE

UL Korea (Dymstec)

Object	D1750V2 - SN:1	1180	
Calibration procedure(s)	QA CAL-05.v11 Calibration Proc	edure for SAR Validation Source	s between 0.7-3 GHz
Calibration date:	September 21, 2	2022	
The measurements and the uncert	nts the traceability to nati tainties with confidence p	ional standards, which realize the physical ur probability are given on the following pages ar	nits of measurements (SI).
All calibrations have been conduct	ed in the closed laborato	ry facility: environment temperature (22 ± 3)°	C and humidity < 70%.
Calibration Equipment used (M&TE	E critical for calibration)		
Primary Standards	ID #	Cal Date (Certificate No.)	Schedulad Calibration
Power meter NRP	ID # SN: 104778	Cal Date (Certificate No.) 04-Apr-22 (No. 217-03525/03524)	Scheduled Calibration
Power meter NRP Power sensor NRP-Z91		04-Apr-22 (No. 217-03525/03524)	Apr-23
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	SN: 104778	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524)	Apr-23 Apr-23
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	SN: 104778 SN: 103244	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525)	Apr-23 Apr-23 Apr-23
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	SN: 104778 SN: 103244 SN: 103245	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527)	Apr-23 Apr-23 Apr-23 Apr-23
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k)	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527)	Apr-23 Apr-23 Apr-23 Apr-23
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	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23
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 E4419B	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23 Scheduled Check
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 E4419B Power sensor HP 8481A	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house) 30-Oct-14 (in house check Oct-20)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23 Scheduled Check In house check: Oct-22
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 E4419B Power sensor HP 8481A Power sensor HP 8481A	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house) 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23 Scheduled Check In house check: Oct-22 In house check: Oct-22
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 E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house) 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23 Scheduled Check In house check: Oct-22 In house check: Oct-22 In house check: Oct-22
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 E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: US37292783	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house) 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23 Scheduled Check In house check: Oct-22 In house check: Oct-22 In house check: Oct-22 In house check: Oct-22 In house check: Oct-22
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 E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: 100972	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house) 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 15-Jun-15 (in house check Oct-20)	Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23 Scheduled Check In house check: Oct-22 In house check: Oct-22 In house check: Oct-22 In house check: Oct-22 In house check: Oct-22
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 E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: 100972 SN: US41080477	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house) 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 15-Jun-15 (in house check Oct-20) 31-Mar-14 (in house check Oct-20)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23
	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: 100972 SN: US41080477 Name	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 31-Dec-21 (No. EX3-7349_Dec21) 31-Aug-22 (No. DAE4-601_Aug22) Check Date (in house) 30-Oct-14 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 07-Oct-15 (in house check Oct-20) 15-Jun-15 (in house check Oct-20) 31-Mar-14 (in house check Oct-20) Function	Apr-23 Apr-23 Apr-23 Apr-23 Dec-22 Aug-23 Scheduled Check In house check: Oct-22 In house check: Oct-22 In house check: Oct-22 In house check: Oct-22 In house check: Oct-22

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



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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

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) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

c) DASY System Handbook

Methods Applied and Interpretation of Parameters:

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

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	···
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	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	38.7 ± 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	8.90 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.90 W/kg 35.6 W/kg ± 17.0 % (k=
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	4.72 W/kg

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.9 Ω - 0.6 jΩ
Return Loss	- 39.2 dB

General Antenna Parameters and Design

Electrical Delay (and direction)	
Electrical Delay (one direction)	1.214 ns
	1.2 14115

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

Monufootured by	
Manufactured by	0054.0
	SPEAG

DASY5 Validation Report for Head TSL

Date: 21.09.2022

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1180

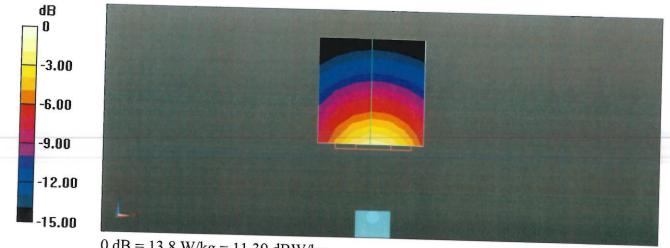
Communication System: UID 0 - CW; Frequency: 1750 MHz Medium parameters used: f = 1750 MHz; σ = 1.35 S/m; ϵ_r = 38.7; ρ = 1000 kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.67, 8.67, 8.67) @ 1750 MHz; Calibrated: 31.12.2021 •
- Sensor-Surface: 1.4mm (Mechanical Surface Detection) •
- Electronics: DAE4 Sn601; Calibrated: 31.08.2022 •
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001 .
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501) •

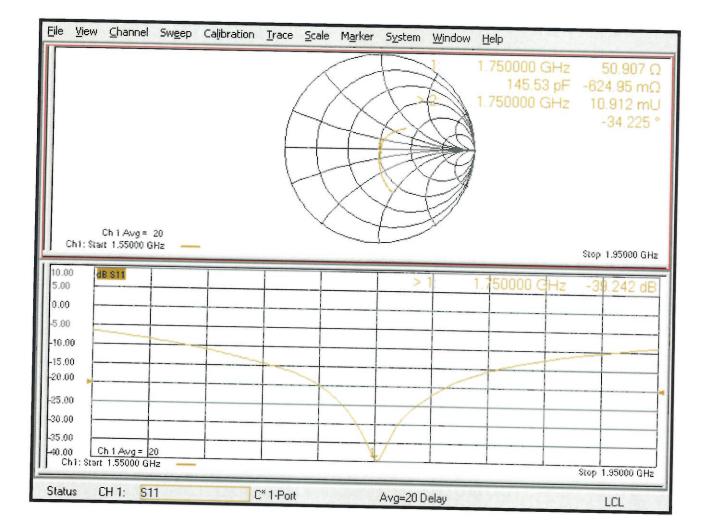
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 106.1 V/m; Power Drift = -0.09 dBPeak SAR (extrapolated) = 16.3 W/kgSAR(1 g) = 8.9 W/kg; SAR(10 g) = 4.72 W/kgSmallest distance from peaks to all points 3 dB below = 10 mm Ratio of SAR at M2 to SAR at M1 = 54.7% Maximum value of SAR (measured) = 13.8 W/kg



0 dB = 13.8 W/kg = 11.39 dBW/kg

Impedance Measurement Plot for Head TSL



Justification for Extended SAR Dipole Calibrations

Instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements

KDB 865664 D01v01r04 requirements

a) return loss : < - 20 dB, within 20% of previous measurement

b) impedance : within 5 Ω from previous measurement

Dipole Antenna	Head/Body	Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ
D1750V2-SN : 1180	Head	2022.09.21	-39.242	-1.08	50.907	1.908
D1/50V2-5N . 1180	пеай	2023.09.14	-39.667	-1.08	48.999	1.908

c) 1g SAR : within 10% of that reported in the calibration data

Dipole Antenna	Head/Body	Date of Measurement	1g SAR (W/kg)	Δ%
D17E0V/2 CN - 1190	Llood	2022.09.21	3.56	0.04
D1750V2-SN : 1180	Head	2023.09.20	3.53	0.84



Calibration Laboratory of Schmid & Partner Engineering AG

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Certificate No. D2600V2-1178_Apr23

Accreditation No.: SCS 0108

Gyeonggi-do, Republic of Korea

Client UL

CALIBRATION C	ERTIFICAT	E	
Object	D2600V2 - SN:1	178	
Calibration procedure(s)	QA CAL-05.v12 Calibration Proc	edure for SAR Validation Sources	s between 0.7-3 GHz
Calibration date:	April 25, 2023		
The measurements and the uncert	ainties with confidence p ed in the closed laborato	ional standards, which realize the physical uni robability are given on the following pages an ry facility: environment temperature (22 \pm 3)°C	d are part of the certificate.
Primary Standards	ID #	Cal Date (Certificate No.)	
Power meter NRP2	SN: 104778	30-Mar-23 (No. 217-03804/03805)	Scheduled Calibration
Power sensor NRP-Z91	SN: 103244	30-Mar-23 (No. 217-03804)	Mar-24
Power sensor NRP-Z91	SN: 103245	30-Mar-23 (No. 217-03805)	Mar-24 Mar-24
Reference 20 dB Attenuator	SN: BH9394 (20k)	30-Mar-23 (No. 217-03809)	Mar-24 Mar-24
ype-N mismatch combination	SN: 310982 / 06327	30-Mar-23 (No. 217-03810)	Mar-24 Mar-24
Reference Probe EX3DV4	SN: 7349	10-Jan-23 (No. EX3-7349_Jan23)	Jan-24
DAE4	SN: 601	19-Dec-22 (No. DAE4-601_Dec22)	Dec-23
econdary Standards	ID #	Check Date (in house)	Scheduled Check
ower meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-22)	In house check: Oct-24
ower sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
ower sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-22)	In house check: Oct-24
letwork Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24
	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	N.Illes
pproved by:	Sven Kühn	Technical Manager	A. Koll
			Issued: April 26, 2023

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

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



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- 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

Glossary:

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

Calibration is Performed According to the Following Standards:

- a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

c) DASY System Handbook

Methods Applied and Interpretation of Parameters:

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

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz ± 1 MHz	

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	37.1 ± 6 %	2.02 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	14.7 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	57.4 W/kg ± 17.0 % (k=2)	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition		
SAR measured	250 mW input power	6.53 W/kg	

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.8 Ω - 1.7 jΩ
Return Loss	- 33.5 dB

General Antenna Parameters and Design

	Electrical Delay (one direction)	
1		1.153 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
,	

DASY5 Validation Report for Head TSL

Date: 25.04.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1178

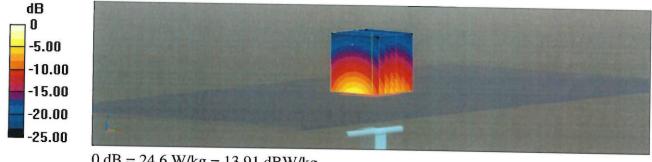
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; $\sigma = 2.02 \text{ S/m}$; $\varepsilon_r = 37.1$; $\rho = 1000 \text{ kg/m}^3$ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.68, 7.68, 7.68) @ 2600 MHz; Calibrated: 10.01.2023 •
- Sensor-Surface: 1.4mm (Mechanical Surface Detection) •
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022 .
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001 •
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

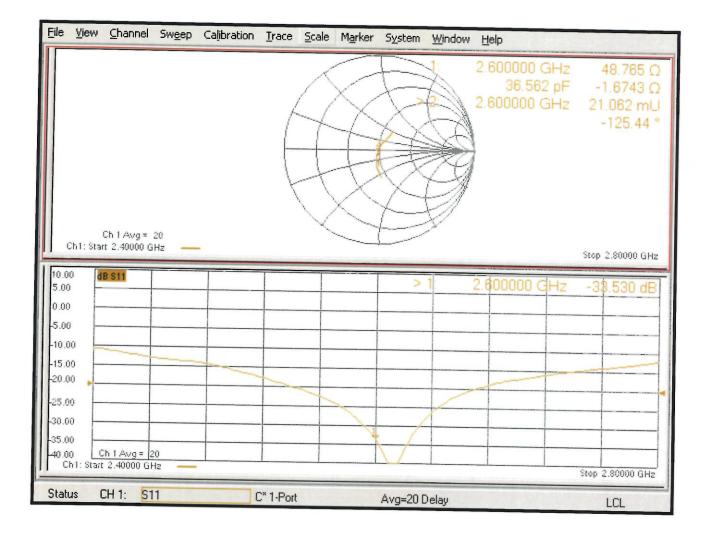
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 120.8 V/m; Power Drift = 0.05 dB Peak SAR (extrapolated) = 29.3 W/kgSAR(1 g) = 14.7 W/kg; SAR(10 g) = 6.53 W/kgSmallest distance from peaks to all points 3 dB below = 8.9 mm Ratio of SAR at M2 to SAR at M1 = 50.1%Maximum value of SAR (measured) = 24.6 W/kg



0 dB = 24.6 W/kg = 13.91 dBW/kg

Impedance Measurement Plot for Head TSL



Justification for Extended SAR Dipole Calibrations

Instead of the typical annual calibration recommended by measurement standards, longer calibration intervals of up to three years may be considered when it is demonstrated that the SAR target, impedance and return loss of a dipole have remain stable according to the following requirements

KDB 865664 D01v01r04 requirements

a) return loss : < - 20 dB, within 20% of previous measurement

b) impedance : within 5 Ω from previous measurement

Dipole Antenna	Head/Body	Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ
D2600V2-SN : 1178	Head	2023.04.25	-33.530	11.2	48.765	1.241
	пеай	2024.04.02	-29.760	11.2	47.524	1.241

c) extrapolated peak SAR : within 10% of that reported in the calibration data

Dipole Antenna	Head/Body	Date of Measurement	extrapolated peak SAR (W/kg)	Δ%
D2C00V2 CN - 1170	Head	2023.04.25	11.72	0.55
D2600V2-SN : 1178		2024.04.22	10.6	9.55

