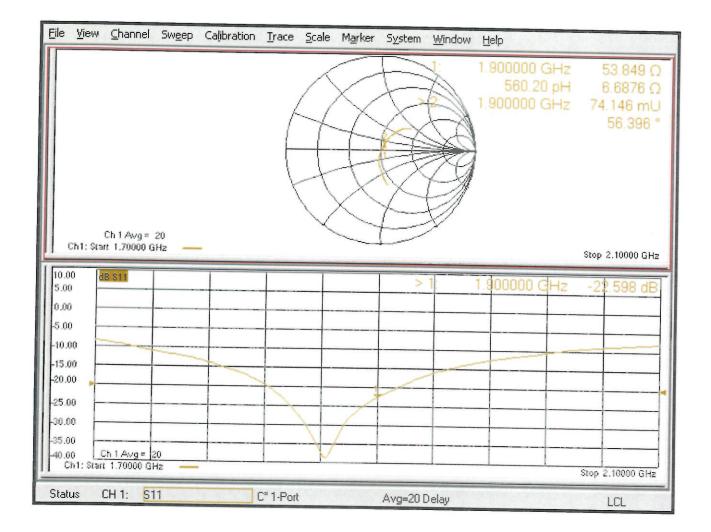
Impedance Measurement Plot for Head TSL



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

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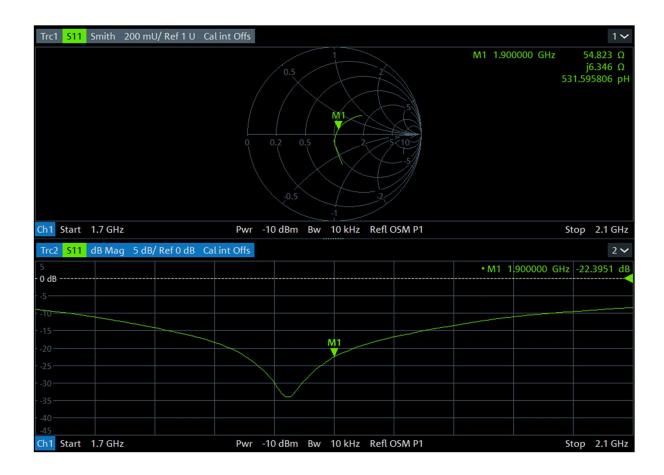
a) return loss : < - 20 dB, within 20% of previous measurement

b) impedance : within 5 Ω from previous measurement

Dipole Antenna	Head/Body	Date of Measurement	Return Loss (dB)	Δ%	Impedance (Ω)	ΔΩ	
D1900V2-SN : 5d190	Head	2022.11.16	-22.598	0.89	53.849	0.074	
D1900V2-SN . 50190	пеай	2023.11.09	-22.395	0.89	54.823	-0.974	

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%
	Llood	2022.11.16	18.3	-5.46
D1900V2-SN : 5d190	Head	2023.11.13	3.11.13 19.3	



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

Client UL

Gyeonggi-do, Republic of Korea

Calibration Equipment used (M&TE critical for calibration) ID # Cal Date (Certificate No.) Scheduled Calibration Primary Standards ID # Cal Date (Certificate No.) Scheduled Calibration Power meter NRP2 SN: 104778 30-Mar-23 (No. 217-03804/03805) Mar-24 Power sensor NRP-Z91 SN: 103244 30-Mar-23 (No. 217-03805) Mar-24 Power sensor NRP-Z91 SN: 103245 30-Mar-23 (No. 217-03805) Mar-24 Reference 20 dB Attenuator SN: BH9394 (20k) 30-Mar-23 (No. 217-03809) Mar-24 System SN: 310982 / 06327 30-Mar-23 (No. 217-03810) Mar-24 SN: 601 30-Jan-24 (No. DAE4-601_Jan24) Jan-25 Secondary Standards ID # Check Date (in house) Scheduled Check Power sensor HP 8481A SN: GB39512475 30-Oct-14 (in house check Oct-22) In house check: Oct-20 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-22) In house check: Oct-20 Power sensor HP 8481A SN: W141093315 07-Oct-15 (in house check Oct-22) In house check: Oct-20 Power sensor HP 8481A SN: US41080477 31-Mar-14 (in house check Oct-22) In house check: Oct-20	Object	D835V2 - SN:4d	1194	
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz Calibration date: March 11, 2024 This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. All calibration shave been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%. Calibration Equipment used (M&TE critical for calibration) Primary Standards ID # Cal Date (Certificate No.) Scheduled Calibration Power meter NRP2 SN: 104778 30-Mar-23 (No. 217-03804/03805) Mar-24 Power sensor NRP-Z91 SN: 103245 30-Mar-23 (No. 217-03804) Mar-24 Power sensor NRP-Z91 SN: 103245 30-Mar-23 (No. 217-03805) Mar-24 Reference 20 dB Attenuator SN: 8149394 (20k) 30-Mar-23 (No. 217-03809) Mar-24 Reference Probe EX3DV4 SN: 3749 03-Mar-23 (No. 217-03809) Mar-24 Secondary Standards ID # Check Date (in house) Scheduled Check Power sensor HP 8481A SN: US37282783 07-Oct-15 (in house check Oct-22) In house check: Oct- Power sens	Calibration procedure(s)			
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Calibrated by: Leif Klysner Laboratory Technician				In house check: Oct-24
Calibrated by: Leif Klysner Laboratory Technician	RF generator R&S SMT-06	SN: US41080477	(
	RF generator R&S SMT-06			Signatura
Approved by: Sven Kühn Technical Manager	RF generator R&S SMT-06 Network Analyzer Agilent E8358A	Name	Function	Signature
	RF generator R&S SMT-06 Network Analyzer Agilent E8358A	Name	Function	0.1 100
	RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	Name Leif Klysner	Function Laboratory Technician	0:0 100
	RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	Name Leif Klysner	Function Laboratory Technician	0.1.10
Issued: March 12, 202 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.	RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	Name Leif Klysner	Function Laboratory Technician	0.1.10

S

Swiss Calibration Service

Certificate No. D835V2-4d194_Mar24

Accreditation No.: SCS 0108

Schweizerischer Kalibrierdienst



Schweizerischer Kalibrierdienst S

Service suisse d'étalonnage

С 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

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	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity	
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m	
Measured Head TSL parameters	(22.0 ± 0.2) °C	42.8 ± 6 %	0.92 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	2.49 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.86 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.63 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.45 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.4 Ω - 3.7 jΩ
Return Loss	- 28.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	
Electrical Delay (one direction)	1.393 ns
	1.000115

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: 11.03.2024

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d194

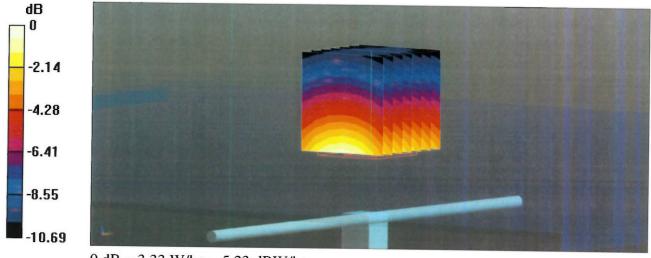
Communication System: UID 0 - CW; Frequency: 835 MHz Medium parameters used: f = 835 MHz; $\sigma = 0.92$ S/m; $\epsilon_r = 42.8$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(9.69, 9.69, 9.69) @ 835 MHz; Calibrated: 03.11.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.01.2024
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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 = 64.69 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 3.73 W/kg**SAR(1 g) = 2.49 W/kg; SAR(10 g) = 1.63 W/kg** Smallest distance from peaks to all points 3 dB below = 19.8 mm Ratio of SAR at M2 to SAR at M1 = 66.4% Maximum value of SAR (measured) = 3.33 W/kg



0 dB = 3.33 W/kg = 5.23 dBW/kg

Impedance Measurement Plot for Head TSL

File	View	<u>C</u> hannel	Sweep	Calibration	Trace	<u>S</u> cale	Marker	System	<u>W</u> indow	Help	1.246		
		Ch 1 Avg = rt 635.000 M			Ę				A	5	100 MHz 1.705 pF 100 MHz	36.886 m -82.195	ΩU
		-	1H2									Stop 1.03500 GF	Hz
10.00 5.00 -5.00 -10.0 -15.0 -20.0 -25.0 -25.0 -30.0 -35.0 -40.0 C		E S11 Ch 1 Avg = 1 t 635.000 M	20 Hz					>	1: 835	5.0000		-28.663 d	
Statu	l sı	CH 1: 51	11		C* 1-Port			Avg=20 D	elau			LCL	_



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S Swiss Calibration Service

Certificate No. D2450V2-960_Mar24

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

Client UL

Gyeonggi-do, Republic of Korea

CALIBRATION CERTIFICATE			
Object	D2450V2 - SN:96	60	
Calibration procedure(s)	OA CAL-05 v12		
Calibration procedure(s)	QA CAL-05.v12 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz		
Calibration date:	March 14, 2024		
This calibration certificate documen	ts the traceability to natio	onal standards, which realize the physical un	its of measurements (SI).
The measurements and the uncerta	ainties with confidence pr	robability are given on the following pages ar	nd are part of the certificate.
All calibrations have been conducte	ed in the closed laborator	y facility: environment temperature (22 \pm 3)°	C and humidity < 70%.
Calibration Equipment used (M&TE	critical for calibration)		
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP2	SN: 104778	30-Mar-23 (No. 217-03804/03805)	Mar-24
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
Reference 20 dB Attenuator	SN: BH9394 (20k)	30-Mar-23 (No. 217-03809)	Mar-24
Type-N mismatch combination	SN: 310982 / 06327	30-Mar-23 (No. 217-03810)	Mar-24
Reference Probe EX3DV4	SN: 7349	03-Nov-23 (No. EX3-7349_Nov23)	Nov-24
DAE4	SN: 601	30-Jan-24 (No. DAE4-601_Jan24)	Jan-25
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
	Name	Function	Signature
Calibrated by:	Krešimir Franjić	Laboratory Technician	X
Approved by:	Sven Kühn	Technical Manager	Sil
			Issued: March 15, 2024

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Glossarv:

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	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.5 ± 6 %	1.83 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.8 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	6.07 W/kg

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.9 Ω + 2.5 jΩ
Return Loss	- 25.6 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.160 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: 14.03.2024

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:960

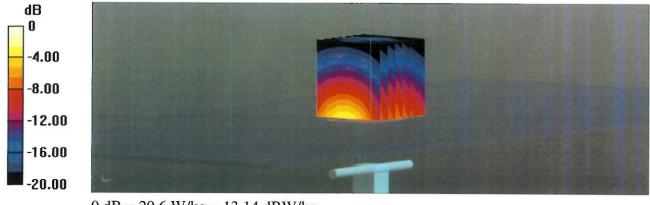
Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz; $\sigma = 1.83$ S/m; $\epsilon_r = 38.5$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 03.11.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.01.2024
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

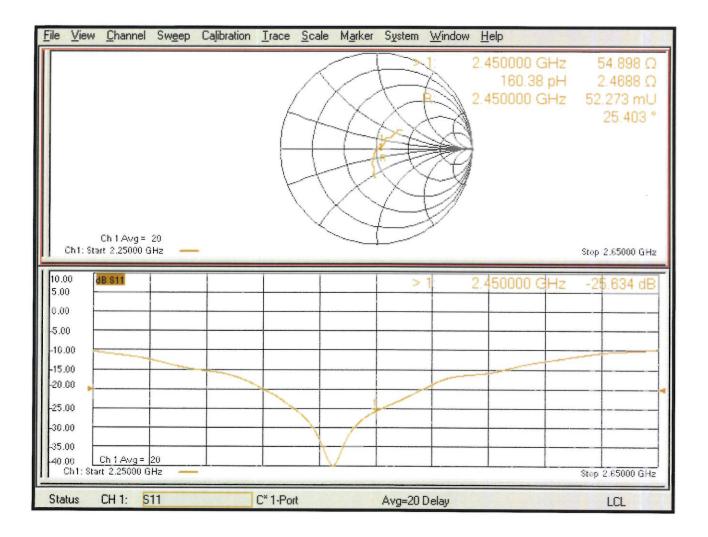
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 114.0 V/m; Power Drift = 0.07 dB Peak SAR (extrapolated) = 26.2 W/kg SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.07 W/kg Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 50.8% Maximum value of SAR (measured) = 20.6 W/kg



0 dB = 20.6 W/kg = 13.14 dBW/kg

Impedance Measurement Plot for Head TSL





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Swiss Calibration Service

Certificate No. D2600V2-1097_Sep23

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

Client UL

Gyeonggi-do, Republic of Korea

CALIBRATION CERTIFICATE Object D2600V2 - SN:1097 Calibration procedure(s) QA CAL-05.v12 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz Calibration date: September 26, 2023 This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate. All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%. Calibration Equipment used (M&TE critical for calibration) **Primary Standards** ID # Cal Date (Certificate No.) Scheduled Calibration Power meter NRP2 SN: 104778 30-Mar-23 (No. 217-03804/03805) Mar-24 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 Reference 20 dB Attenuator SN: BH9394 (20k) 30-Mar-23 (No. 217-03809) Mar-24 Type-N mismatch combination SN: 310982 / 06327 30-Mar-23 (No. 217-03810) Mar-24 Reference Probe EX3DV4 SN: 7349 10-Jan-23 (No. EX3-7349_Jan23) Jan-24 DAE4 SN: 654 27-Jan-23 (No. DAE4-654_Jan23) Jan-24 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 Name Function Signature Calibrated by: Krešimir Franjić Laboratory Technician Approved by: Sven Kühn Technical Manager Issued: September 26, 2023 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.



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Accreditation No.: SCS 0108

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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	<u>, , , , , , , , , , , , , , , , , , , </u>
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	37.2 ± 6 %	2.00 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	14.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	57.3 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.52 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.7 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.2 Ω - 4.6 jΩ
Return Loss	- 25.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	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: 26.09.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1097

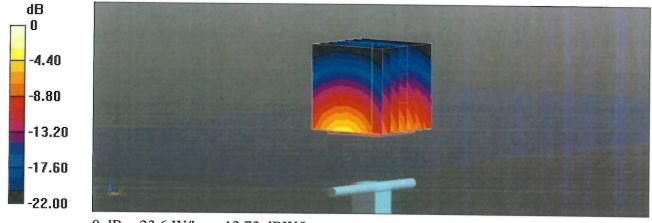
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz; $\sigma = 2$ S/m; $\varepsilon_r = 37.2$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

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 Sn654; Calibrated: 27.01.2023
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

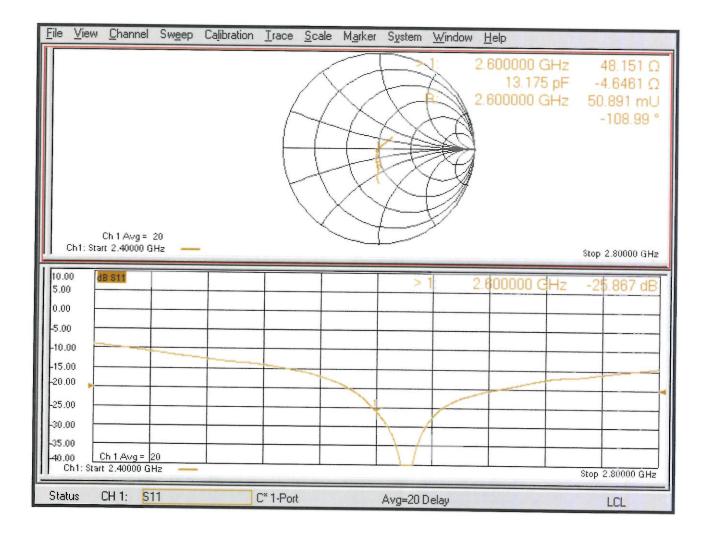
Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 121.0 V/m; Power Drift = 0.05 dB Peak SAR (extrapolated) = 28.5 W/kg SAR(1 g) = 14.6 W/kg; SAR(10 g) = 6.52 W/kg Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 51% Maximum value of SAR (measured) = 23.6 W/kg



0 dB = 23.6 W/kg = 13.73 dBW/kg

Impedance Measurement Plot for Head TSL



UL Korea

Client



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Accreditation No.: SCS 0108

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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 monoursents (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 calibration 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



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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

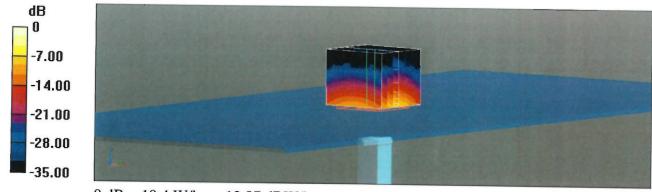
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.05 V/m; Power Drift = 0.01 dB Peak SAR (extrapolated) = 30.6 W/kg SAR(1 g) = 8.29 W/kg; SAR(10 g) = 2.35 W/kg Smallest distance from 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

File	⊻iew	Channel	Sw <u>e</u> ep	Calibration	Trace	<u>S</u> cale	M <u>a</u> rker	System	<u>W</u> indow	Help		
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						\wedge		1	Δ	2:	5.600000 GHz	51.248 Q
					/	- /	\sim	\sim	12-7	3:	106.09 pH 5.750000 GHz	3.7330 Q 53.530 Q
					\sim		\sim	\sim	K-Y	0.	90.904 pH	3.2842 Q
					(A-A	St	> 4:	5.800000 GHz	53.478 Q
									R	R:	89.187 pH 5.500000 GHz	3.2502 Ω 32.934 mU
					/	4	-	$\mathcal{X}\mathcal{Y}$	$\Box $			118.30 *
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0.0			1		1					> 4;	5.800000 GHz	-26.749 dB
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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
	zV2-SN : 1209 Head	2023.02.28	-28.212	4.36	51.248	-3.17
D5GH2V2-5N . 1209		2024.02.15	-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%	
D5GHzV2-SN : 1209	Head	2023.02.28	8.29	2.77	
		2024.02.16	8.52	2.77	

