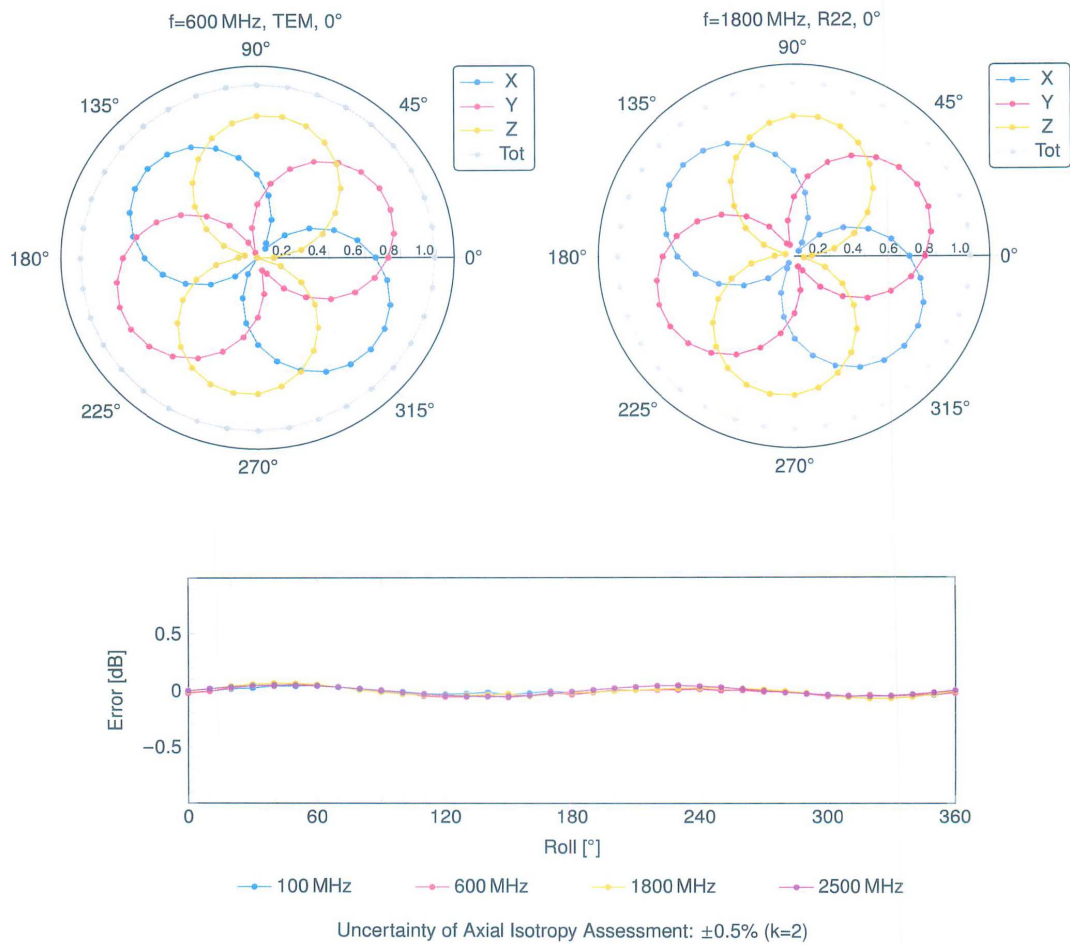


ES3DV2 - SN:3019

January 30, 2025

Receiving Pattern (ϕ), $\vartheta = 0^\circ$

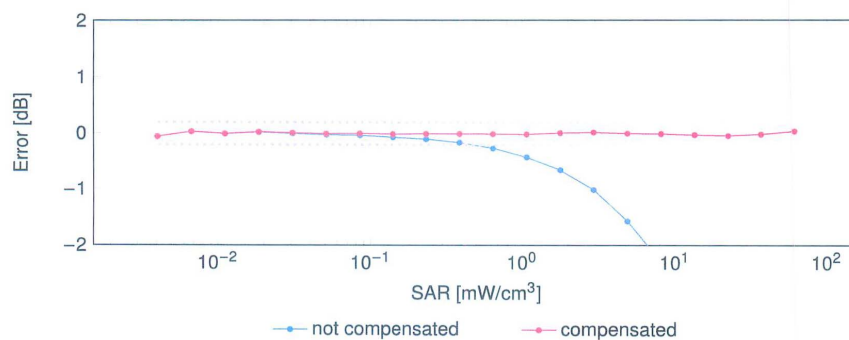
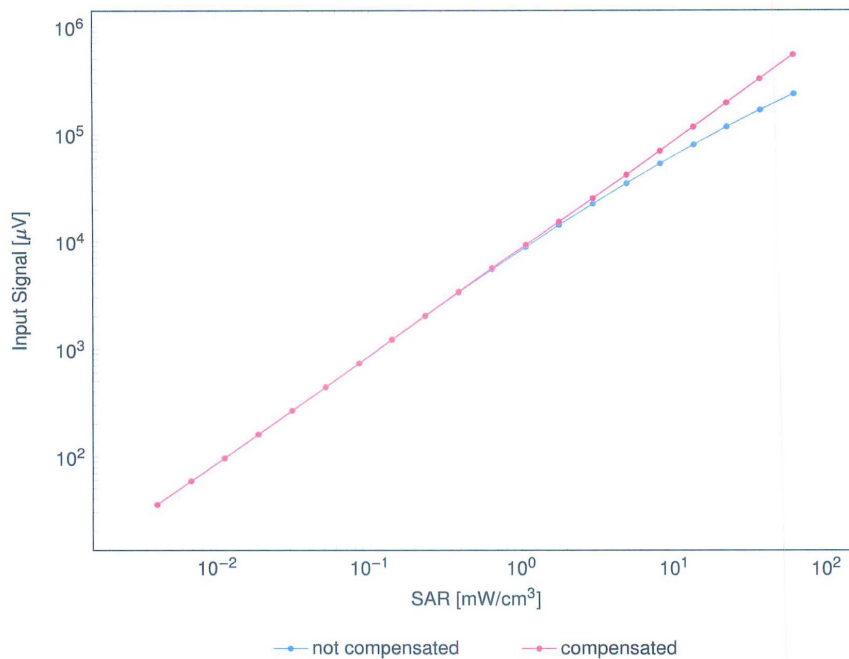


ES3DV2 - SN:3019

January 30, 2025

Dynamic Range f(SAR_{head})

(TEM cell, f_{eval} = 1900 MHz)

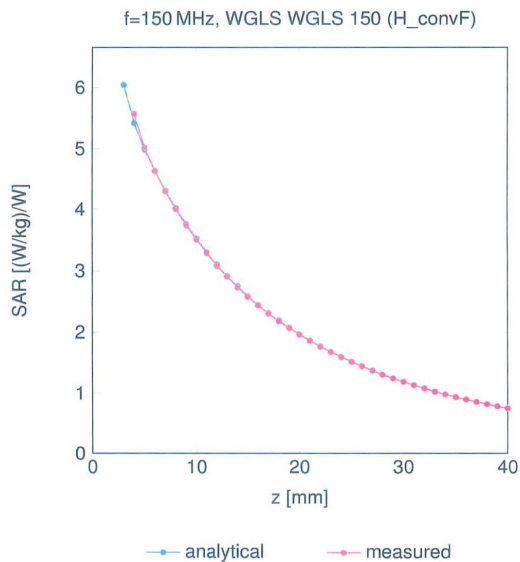


Uncertainty of Linearity Assessment: ±0.6% (k=2)

ES3DV2 - SN:3019

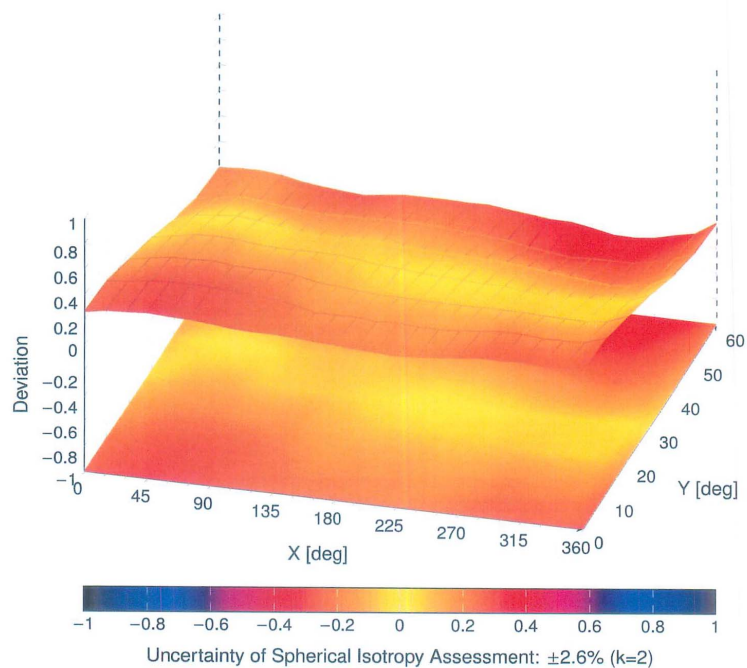
January 30, 2025

Conversion Factor Assessment



Deviation from Isotropy in Liquid

Error (ϕ, θ), f = 900 MHz



Certificate No: ES-3019_Jan25

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DIPOLE CALIBRATION CERTIFICATES

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



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S 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

Accreditation No.: SCS 0108

Client **BACL USA**

Certificate No: **D450V3-1096_Nov22**

CALIBRATION CERTIFICATE

Object	D450V3 - SN:1096																																																																			
Calibration procedure(s)	QA CAL-15.v9 Calibration Procedure for SAR Validation Sources below 700 MHz																																																																			
Calibration date:	November 17, 2022																																																																			
<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.</p> <p>Calibration Equipment used (M&TE critical for calibration)</p> <table><thead><tr><th>Primary Standards</th><th>ID #</th><th>Cal Date (Certificate No.)</th><th>Scheduled Calibration</th></tr></thead><tbody><tr><td>Power meter NRP</td><td>SN: 104778</td><td>04-Apr-22 (No. 217-03525/03524)</td><td>Apr-23</td></tr><tr><td>Power sensor NRP-Z91</td><td>SN: 103244</td><td>04-Apr-22 (No. 217-03524)</td><td>Apr-23</td></tr><tr><td>Power sensor NRP-Z91</td><td>SN: 103245</td><td>04-Apr-22 (No. 217-03525)</td><td>Apr-23</td></tr><tr><td>Reference 20 dB Attenuator</td><td>SN: CC2552 (20k)</td><td>04-Apr-22 (No. 217-03527)</td><td>Apr-23</td></tr><tr><td>Type-N mismatch combination</td><td>SN: 310982 / 06327</td><td>04-Apr-22 (No. 217-03528)</td><td>Apr-23</td></tr><tr><td>Reference Probe EX3DV4</td><td>SN: 3877</td><td>31-Dec-21 (No. EX3-3877_Dec21)</td><td>Dec-22</td></tr><tr><td>DAE4</td><td>SN: 854</td><td>26-Jan-22 (No. DAE4-854_Jan22)</td><td>Jan-23</td></tr></tbody></table> <table><thead><tr><th>Secondary Standards</th><th>ID #</th><th>Check Date (in house)</th><th>Scheduled Check</th></tr></thead><tbody><tr><td>Power meter E4419D</td><td>SN: GB41293874</td><td>06-Apr-16 (in house check Jun-22)</td><td>In house check: Jun-24</td></tr><tr><td>Power sensor E4412A</td><td>SN: NY41468087</td><td>06-Apr-16 (in house check Jun-22)</td><td>In house check: Jun-24</td></tr><tr><td>Power sensor E4412A</td><td>SN: 000110210</td><td>06-Apr-16 (in house check Jun-22)</td><td>In house check: Jun-24</td></tr><tr><td>RF generator HP 8648C</td><td>SN: US3642U01700</td><td>04-Aug-99 (in house check Oct-22)</td><td>In house check: Jun-24</td></tr><tr><td>Network Analyzer Agilent E8358A</td><td>SN: US41080477</td><td>31-Mar-14 (in house check Oct-22)</td><td>In house check: Oct-24</td></tr></tbody></table> <table><thead><tr><th>Name</th><th>Function</th><th>Signature</th></tr></thead><tbody><tr><td>Calibrated by: Aldonia Georgiadou</td><td>Laboratory Technician</td><td></td></tr><tr><td>Approved by: Sven Kühn</td><td>Technical Manager</td><td></td></tr></tbody></table> <p>This calibration certificate shall not be reproduced except in full without written approval of the laboratory.</p> <p>Issued: November 17, 2022</p>				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: CC2552 (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: 3877	31-Dec-21 (No. EX3-3877_Dec21)	Dec-22	DAE4	SN: 854	26-Jan-22 (No. DAE4-854_Jan22)	Jan-23	Secondary Standards	ID #	Check Date (in house)	Scheduled Check	Power meter E4419D	SN: GB41293874	06-Apr-16 (in house check Jun-22)	In house check: Jun-24	Power sensor E4412A	SN: NY41468087	06-Apr-16 (in house check Jun-22)	In house check: Jun-24	Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-22)	In house check: Jun-24	RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Oct-22)	In house check: Jun-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: Aldonia Georgiadou	Laboratory Technician		Approved by: Sven Kühn	Technical Manager	
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Certificate No: D450V3-1096_Nov22

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



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S 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

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

- 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	ELI4 Flat Phantom	Shell thickness: 2 ± 0.2 mm
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	450 MHz \pm 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	43.5	0.87 mho/m
Measured Head TSL parameters	(22.0 \pm 0.2) °C	43.4 \pm 6 %	0.88 mho/m \pm 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.15 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	4.56 W/kg \pm 18.1 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	0.766 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	3.04 W/kg \pm 17.6 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	56.7	0.94 mho/m
Measured Body TSL parameters	(22.0 \pm 0.2) °C	56.2 \pm 6 %	0.93 mho/m \pm 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	4.59 W/kg \pm 18.1 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	0.768 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	3.09 W/kg \pm 17.6 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	56.1 Ω - 5.9 j Ω
Return Loss	- 22.0 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	53.2 Ω - 9.7 j Ω
Return Loss	- 20.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.347 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: 17.11.2022

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN:1096

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.88$ S/m; $\epsilon_r = 43.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3877; ConvF(10.64, 10.64, 10.64) @ 450 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 26.01.2022
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 38.88 V/m; Power Drift = 0.00 dB

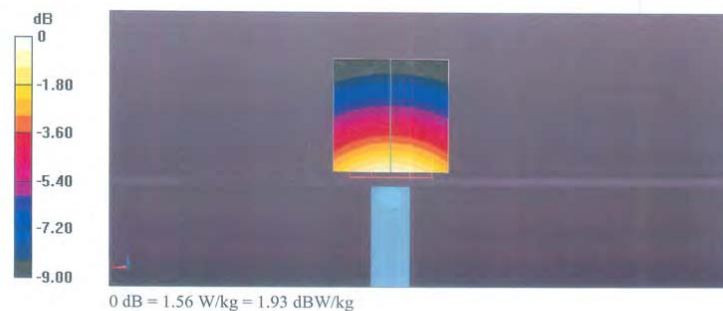
Peak SAR (extrapolated) = 1.79 W/kg

SAR(1 g) = 1.15 W/kg; SAR(10 g) = 0.766 W/kg

Smallest distance from peaks to all points 3 dB below: Larger than measurement grid (> 15 mm)

Ratio of SAR at M2 to SAR at M1 = 64.3%

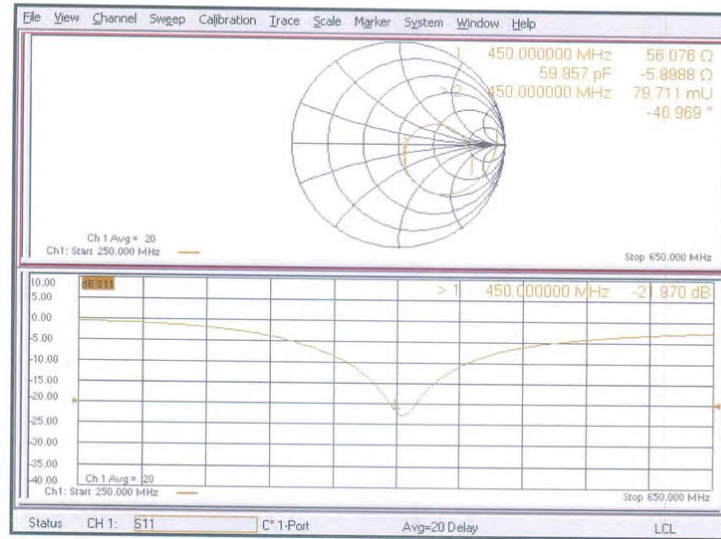
Maximum value of SAR (measured) = 1.56 W/kg



Certificate No: D450V3-1096_Nov22

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Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 17.11.2022

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN:1096

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.93$ S/m; $\epsilon_r = 56.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3877; ConvF(10.64, 10.64, 10.64) @ 450 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 26.01.2022
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 42.04 V/m; Power Drift = -0.04 dB

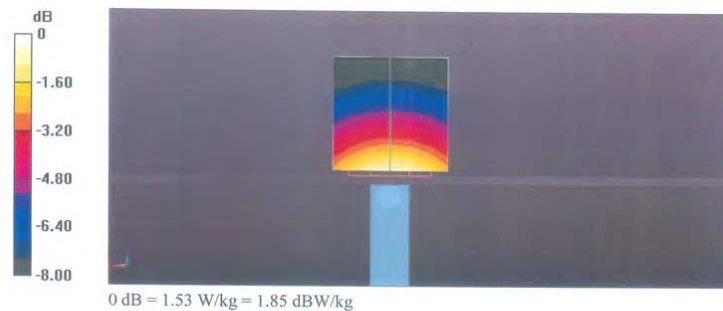
Peak SAR (extrapolated) = 1.74 W/kg

SAR(1 g) = 1.14 W/kg; SAR(10 g) = 0.768 W/kg

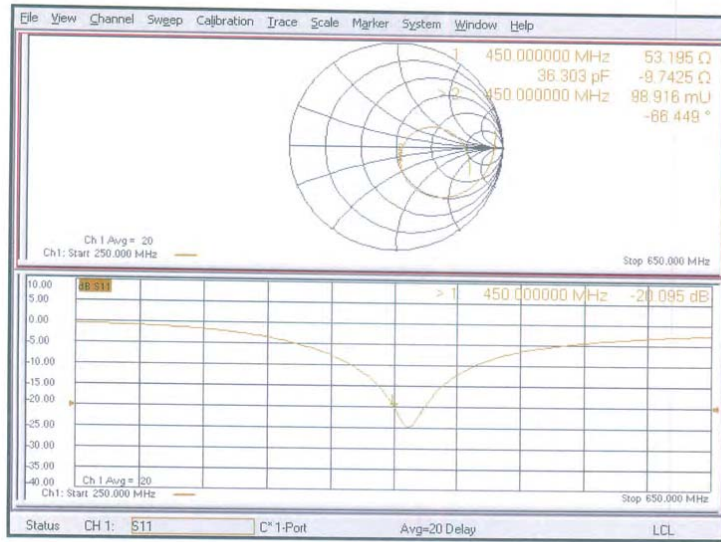
Smallest distance from peaks to all points 3 dB below: Larger than measurement grid (> 15 mm)

Ratio of SAR at M2 to SAR at M1 = 65.8%

Maximum value of SAR (measured) = 1.53 W/kg



Impedance Measurement Plot for Body TSL



APPENDIX E - RETURN LOSS AND IMPEDANCE MEASUREMENT**D450V3 - SN:1096 Extended Dipole Calibrations**

Referring to KDB 865664 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.

Test Equipment Information:

Equipment	Model	S/N	Calibration Date	Calibration Due Date
Simulated Tissue 450 MHz Head	TS-450H	2409045001	Each Time	/
Oval Flat Phantom	ELI V8.0	2051	NCR	NCR
Network Analyzer	E5071C	MY46519680	2023/07/16	2024/07/15
Network Analyzer Calibration Kit	50 Ω	51026	NCR	NCR

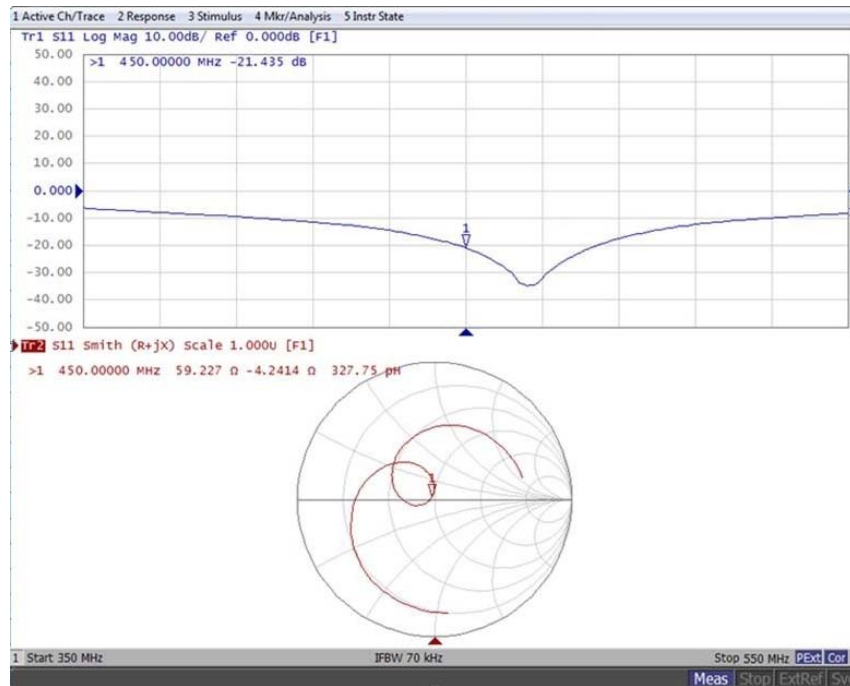
Justification of the extended calibration

D450V3 - SN:1096						
450MHz Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
2022/11/17 (Cal. Report)	-21.97	/	56.076	/	-5.8988	/
2023/11/15 (Extended)	-21.435	2.44%	59.227	-3.151	-4.2414	-1.6574

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data> D450V3 - SN:1096 (Date of Measurement: 2023/11/15)

450MHz - Head



	Name	Tilt	Signature
Calibrated By:	Mark Dong	SAR Engineer	<i>Mark Dong</i>
Approved By:	Brave Lu	SAR Supervisor	<i>Brave Lu</i>

D450V3 - SN:1096 Extended Dipole Calibrations

Referring to KDB 865664 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.

Test Equipment Information:

Equipment	Model	S/N	Calibration Date	Calibration Due Date
Simulated Tissue 450 MHz Head	TS-450H	2409045001	Each Time	/
Oval Flat Phantom	ELI V8.0	2051	NCR	NCR
Network Analyzer	E5071C	MY46519680	2024/07/11	2025/07/10
Network Analyzer Calibration Kit	50 Ω	51026	NCR	NCR

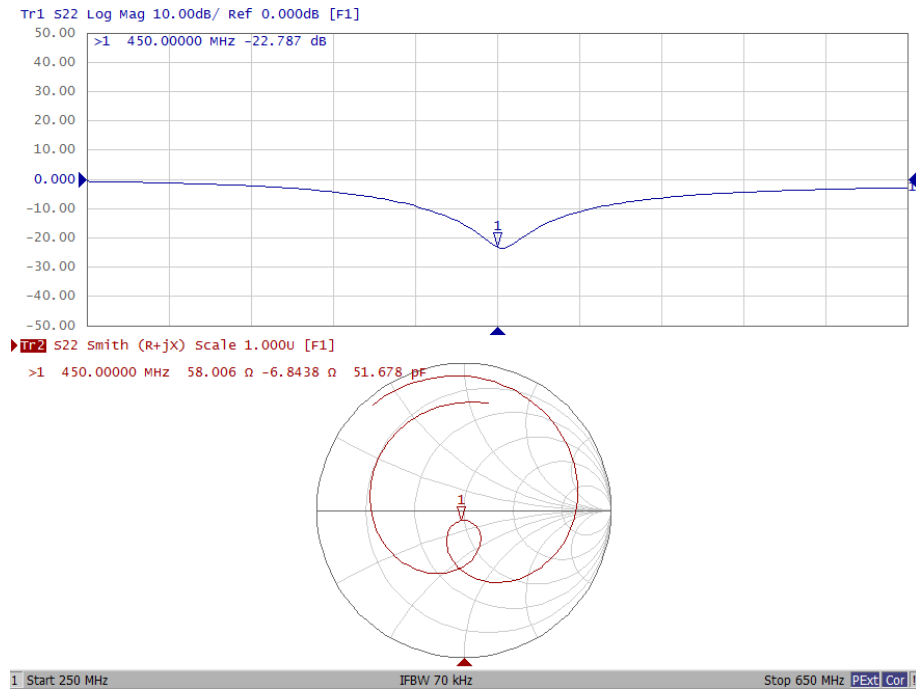
Justification of the extended calibration

D450V3 - SN:1096						
450MHz Head						
Date of Measurement	Return-Loss (dB)	Delta (%)	Real Impedance (ohm)	Delta (ohm)	Imaginary Impedance (ohm)	Delta (ohm)
2022/11/17 (Cal. Report)	-21.97	/	56.076	/	-5.8988	/
2024/11/15 (Extended)	-22.787	-3.72%	58.006	-1.93	-6.8438	0.945

The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

Dipole Verification Data> D450V3 - SN:1096 (Date of Measurement: 2024/11/15)

450MHz - Head



	Name	Tilt	Signature
Calibrated By:	Mark Dong	SAR Engineer	<i>Mark Dong</i>
Approved By:	Brave Lu	SAR Supervisor	<i>Brave Lu</i>

******* END OF REPORT *******