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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D1900V2-5d149\_Sep21**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d149**

Calibration procedure(s) **QA CAL-05.v11  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

*PN 8-21-23*

Calibration date: **September 21, 2021**

*BN 09-01-22*

*BN 10-07-2021*

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

	<b>Name</b>	<b>Function</b>	<b>Signature</b>
Calibrated by:	Leif Klysner	Laboratory Technician	<i>[Signature]</i>
Approved by:	Katja Pokovic	Technical Manager	<i>[Signature]</i>

Issued: September 21, 2021

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



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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.

<b>DASY Version</b>	DASY52	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	1900 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	40.0	1.40 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	40.4 $\pm$ 6 %	1.40 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	10.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>40.5 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	5.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>21.2 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	53.3	1.52 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	53.9 $\pm$ 6 %	1.50 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	10.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>40.4 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	5.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>21.1 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.6 $\Omega$ + 6.6 j $\Omega$
Return Loss	- 23.3 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.2 $\Omega$ + 6.9 j $\Omega$
Return Loss	- 22.8 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.197 ns
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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
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# DASY5 Validation Report for Head TSL

Date: 21.09.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149**

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.4$  S/m;  $\epsilon_r = 40.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.43, 8.43, 8.43) @ 1900 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- 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 = 110.8 V/m; Power Drift = 0.02 dB

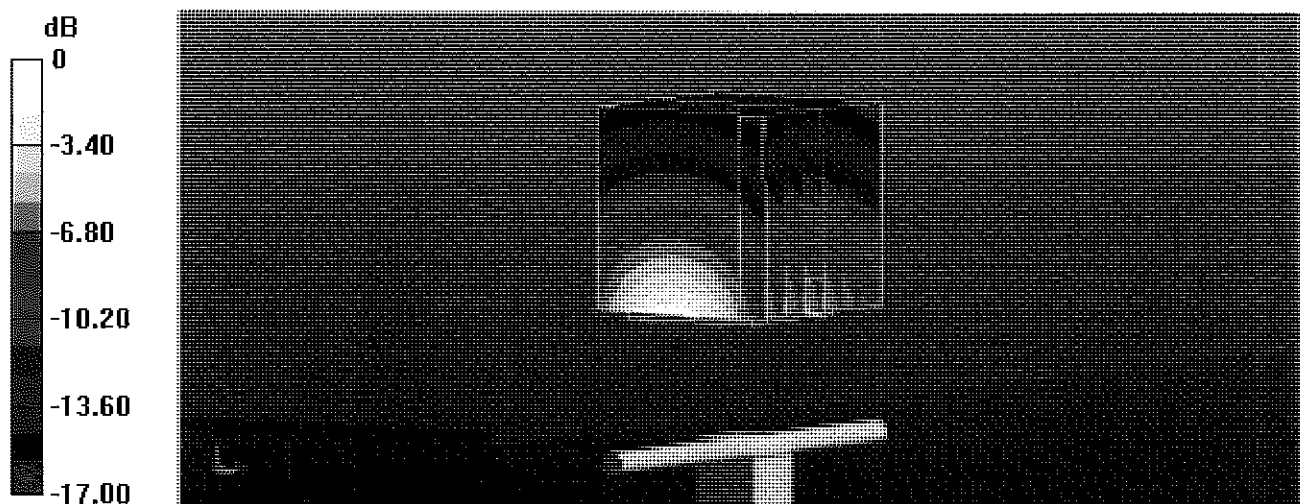
Peak SAR (extrapolated) = 18.7 W/kg

**SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.29 W/kg**

Smallest distance from peaks to all points 3 dB below = 10 mm

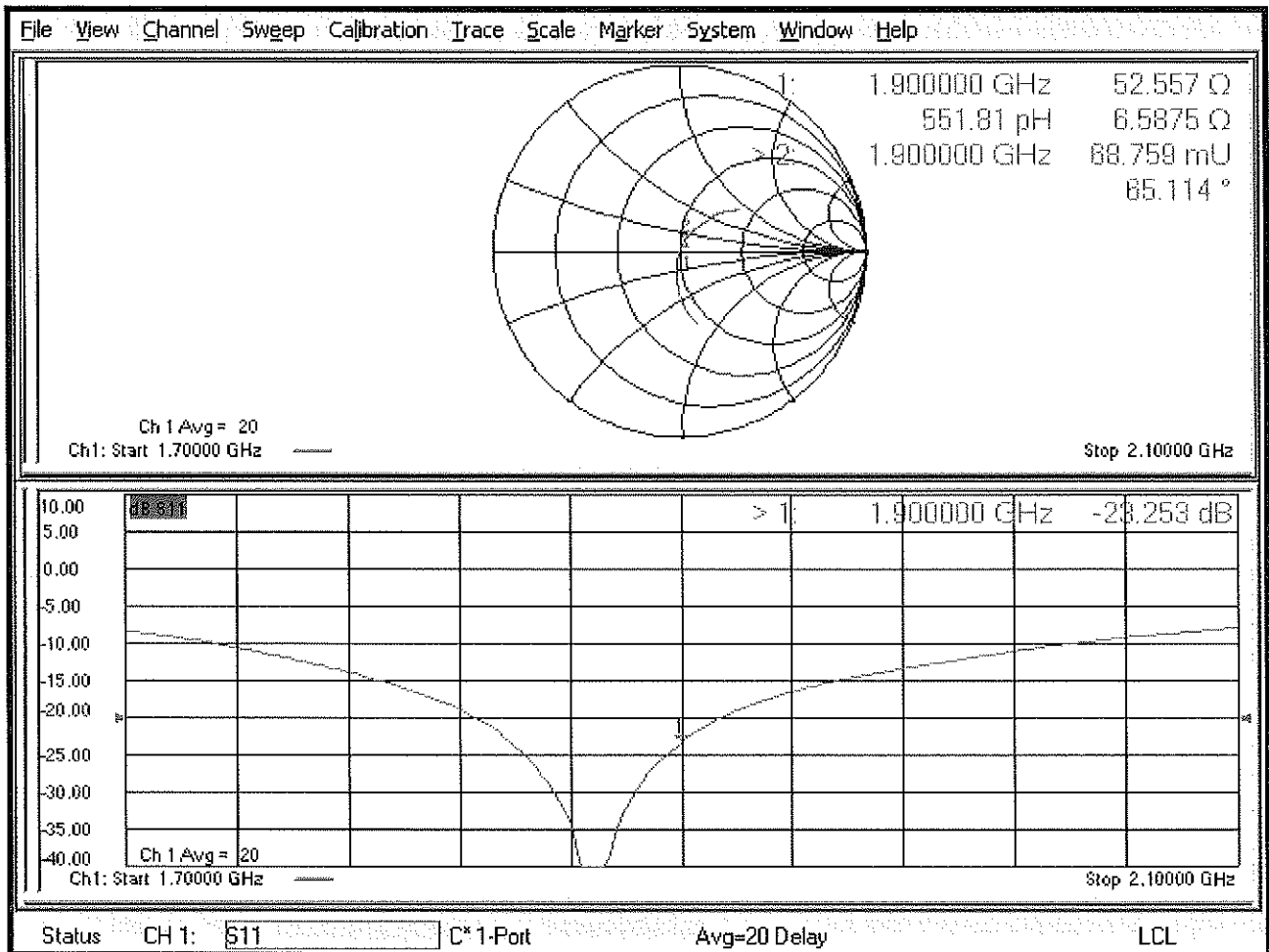
Ratio of SAR at M2 to SAR at M1 = 55.1%

Maximum value of SAR (measured) = 15.5 W/kg



0 dB = 15.5 W/kg = 11.90 dBW/kg

# Impedance Measurement Plot for Head TSL



# DASY5 Validation Report for Body TSL

Date: 21.09.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149**

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.5$  S/m;  $\epsilon_r = 53.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.42, 8.42, 8.42) @ 1900 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 105.7 V/m; Power Drift = -0.03 dB

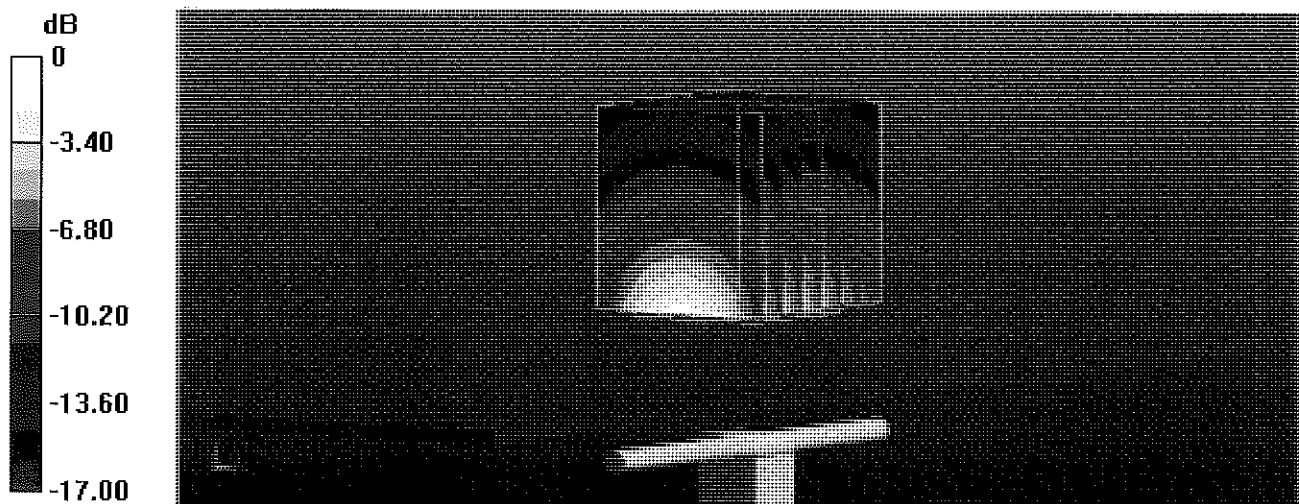
Peak SAR (extrapolated) = 18.5 W/kg

**SAR(1 g) = 10 W/kg; SAR(10 g) = 5.25 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

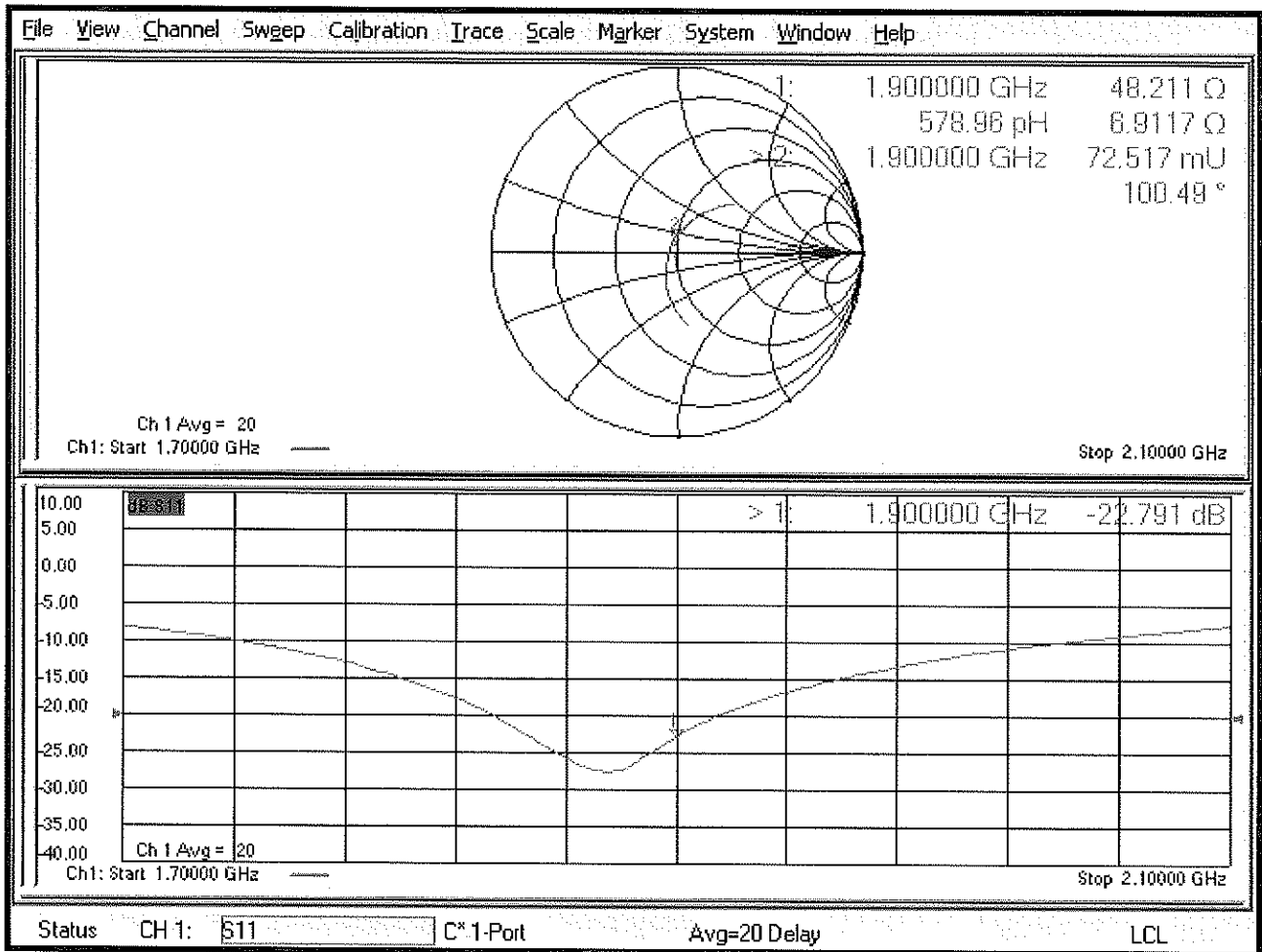
Ratio of SAR at M2 to SAR at M1 = 55.1%

Maximum value of SAR (measured) = 15.5 W/kg



0 dB = 15.5 W/kg = 11.90 dBW/kg

# Impedance Measurement Plot for Body TSL





# Certification of Calibration

Object: D1900V2 – SN: 5d149

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 08/31/2022

Description: SAR Validation Dipole at 1900 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	6/21/2022	Annual	6/21/2023	MY47420651
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	3/28/2022	Annual	3/8/2023	1339007
Anritsu	MA2411B	Pulse Power Sensor	10/21/2021	Annual	10/21/2022	1339027
Anritsu	ML2496A	Power Meter	11/29/2021	Annual	11/29/2022	1840005
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/12/2021	Biennial	3/12/2023	210202100
Control Company	4352	Ultra Long Stem Thermometer	10/25/2021	Annual	10/25/2022	200645916
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670653
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	NC-100	Torque Wrench	3/19/2022	Annual	3/19/2023	N/A
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/20/2021	Annual	10/20/2022	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	4/11/2022	Annual	4/11/2023	1323
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	9/27/2021	Annual	9/27/2022	MY53401181
SPEAG	EX3DV4	SAR Probe	7/18/2022	Annual	7/18/2023	7406
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/18/2022	Annual	7/18/2023	1677
SPEAG	EX3DV4	SAR Probe	2/22/2022	Annual	2/22/2023	7417
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/22/2022	Annual	2/22/2023	665

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Bizunesh Baldinazzo	Test Engineer	BB
Approved By:	Kaitlin O’Keefe	Senior Technical Manager	KOK

# DIPOLE CALIBRATION EXTENSION

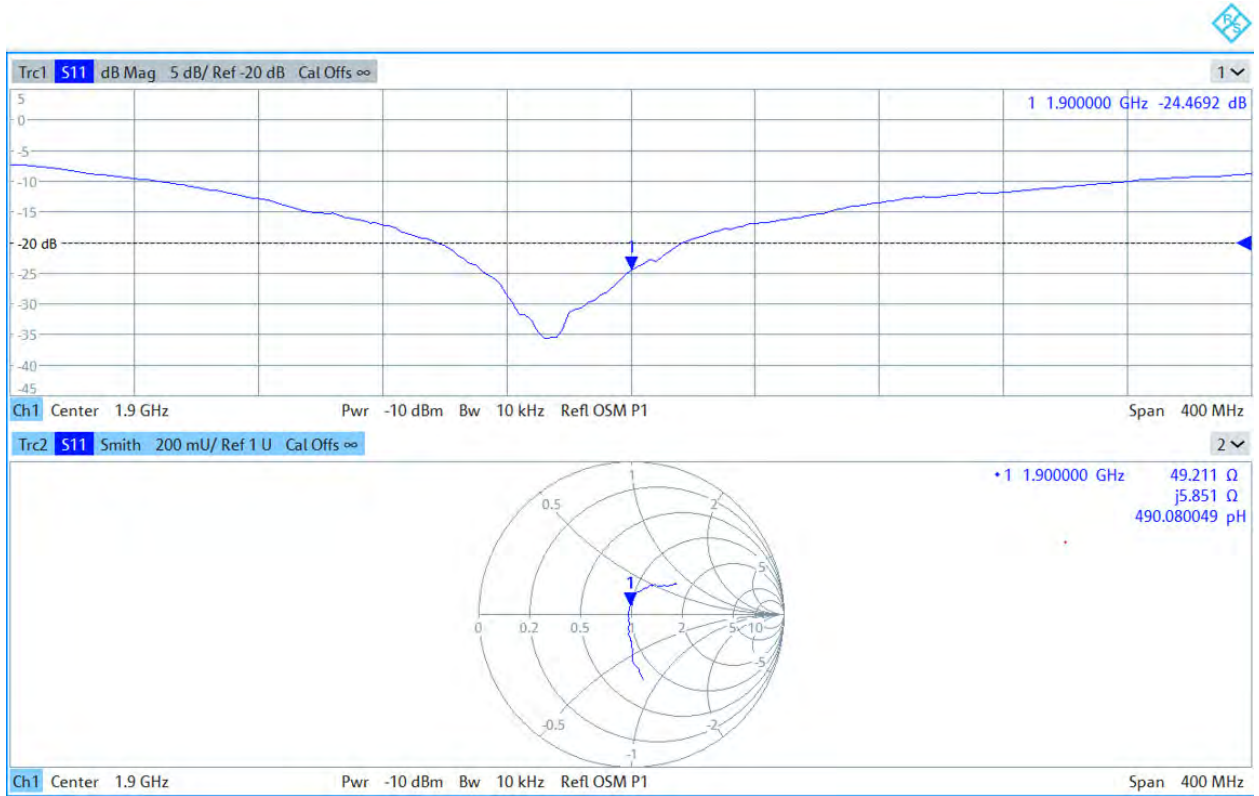
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

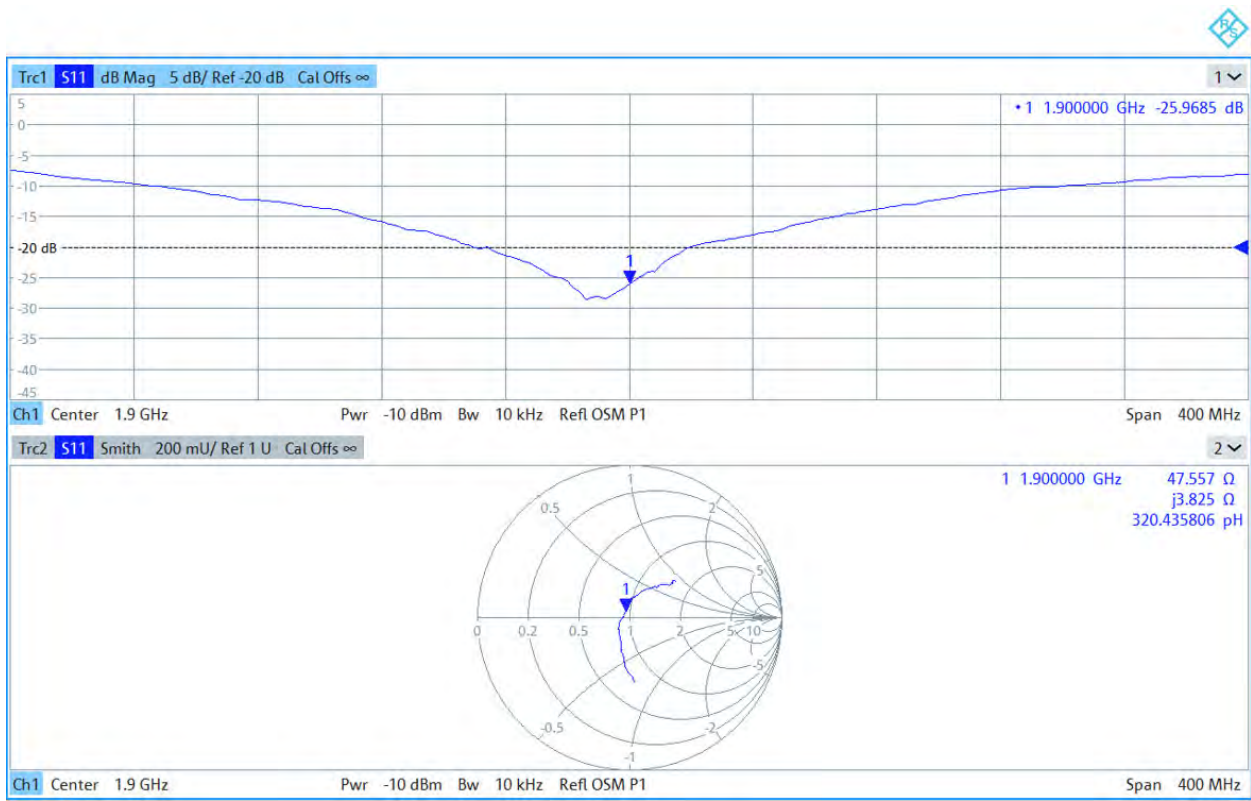
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/21/2021	8/31/2022	1.197	4.05	4.11	1.48%	2.12	2.11	-0.47%	52.6	49.2	3.4	6.6	5.9	0.7	-23.3	-24.5	-5.00%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
9/21/2021	8/31/2022	1.197	4.04	4.25	5.20%	2.11	2.2	4.27%	48.2	47.6	0.6	6.9	3.8	3.1	-22.8	-26.0	-13.90%	PASS

# Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL



# Certification of Calibration

Object: D1900V2 – SN: 5d149

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 08/21/2023

Description: SAR Validation Dipole at 1900 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	11/30/2022	Annual	11/30/2023	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA24106A	USB Power Sensor	1/9/2023	Annual	1/9/2024	1344545
Anritsu	MA24106A	USB Power Sensor	1/9/2023	Annual	1/9/2024	1349511
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/27/2023	Biennial	3/27/2025	230208060
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774675
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/21/2022	Annual	10/21/2023	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/14/2022	Annual	11/14/2023	1277
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	11/11/2022	Annual	11/11/2023	MY53401181
SPEAG	EX3DV4	SAR Probe	1/11/2022	Annual	1/11/2023	7570
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/17/2023	Annual	1/17/2024	1558

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halfoster	Test Engineer	<i>Brodie Halfoster</i>
Approved By:	Greg Snyder	Executive VP of Operations	<i>Greg Snyder</i>

# DIPOLE CALIBRATION EXTENSION

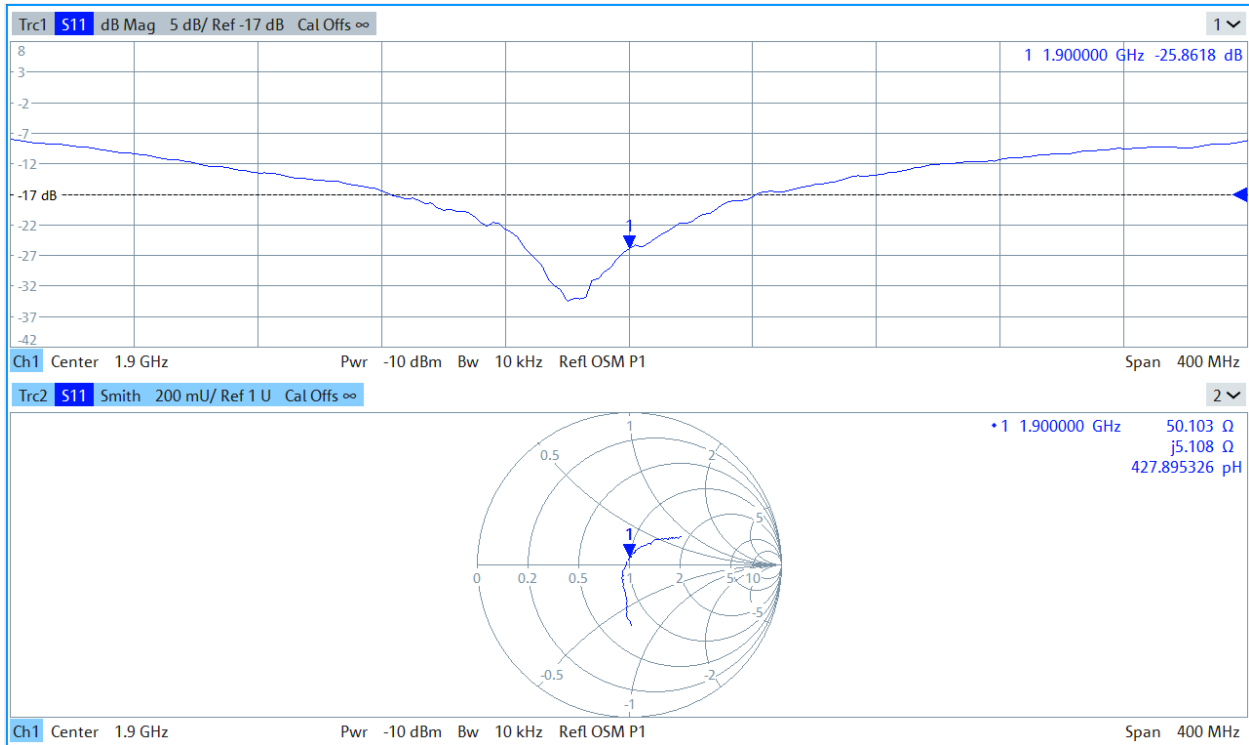
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/21/2021	8/21/2023	1.197	4.05	4.12	1.73%	2.12	2.13	0.47%	52.6	50.1	2.5	6.6	5.1	1.5	-23.3	-25.9	-11.00%	PASS

### Impedance & Return-Loss Measurement Plot for Head TSL





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Accreditation No.: **SCS 0108**

Client **Element**

Certificate No: **D2300V2-1073\_Aug22**

**CALIBRATION CERTIFICATE**

Object **D2300V2 - SN:1073** BN<sup>✓</sup><sub>09-01-22</sub>

Calibration procedure(s) **QA CAL-05.v11  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz** PN<sup>✓</sup><sub>8-21-23</sub>

Calibration date: **August 25, 2022**

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%.

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Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23
Reference Probe EX3DV4	SN: 7349	31-Dec-21 (No. EX3-7349_Dec21)	Dec-22
DAE4	SN: 601	02-May-22 (No. DAE4-601_May22)	May-23

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
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Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

Calibrated by:	Name <b>Aidonia Georgiadou</b>	Function Laboratory Technician	Signature 
Approved by:	Name <b>Sven Kühn</b>	Function Technical Manager	Signature 

Issued: August 25, 2022

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**Glossary:**

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
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- 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.
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- *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.

<b>DASY Version</b>	DASY52	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2300 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.5	1.67 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	38.5 $\pm$ 6 %	1.69 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	12.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>48.6 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	5.98 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>23.7 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.9	1.81 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	51.6 $\pm$ 6 %	1.86 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	12.3 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>48.1 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	5.96 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.6 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$48.5 \Omega + 2.5 j\Omega$
Return Loss	- 30.5 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	$43.7 \Omega + 1.4 j\Omega$
Return Loss	- 23.3 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.164 ns
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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
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## DASY5 Validation Report for Head TSL

Date: 24.08.2022

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1073**

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used:  $f = 2300$  MHz;  $\sigma = 1.69$  S/m;  $\epsilon_r = 38.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.98, 7.98, 7.98) @ 2300 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- 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 = 115.8 V/m; Power Drift = 0.05 dB

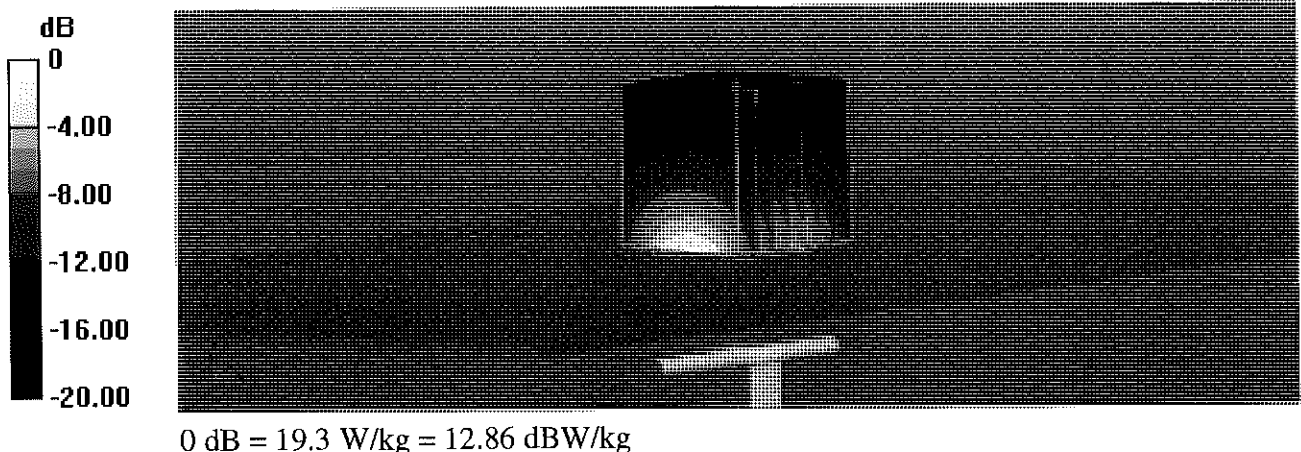
Peak SAR (extrapolated) = 22.6 W/kg

**SAR(1 g) = 12.3 W/kg; SAR(10 g) = 5.98 W/kg**

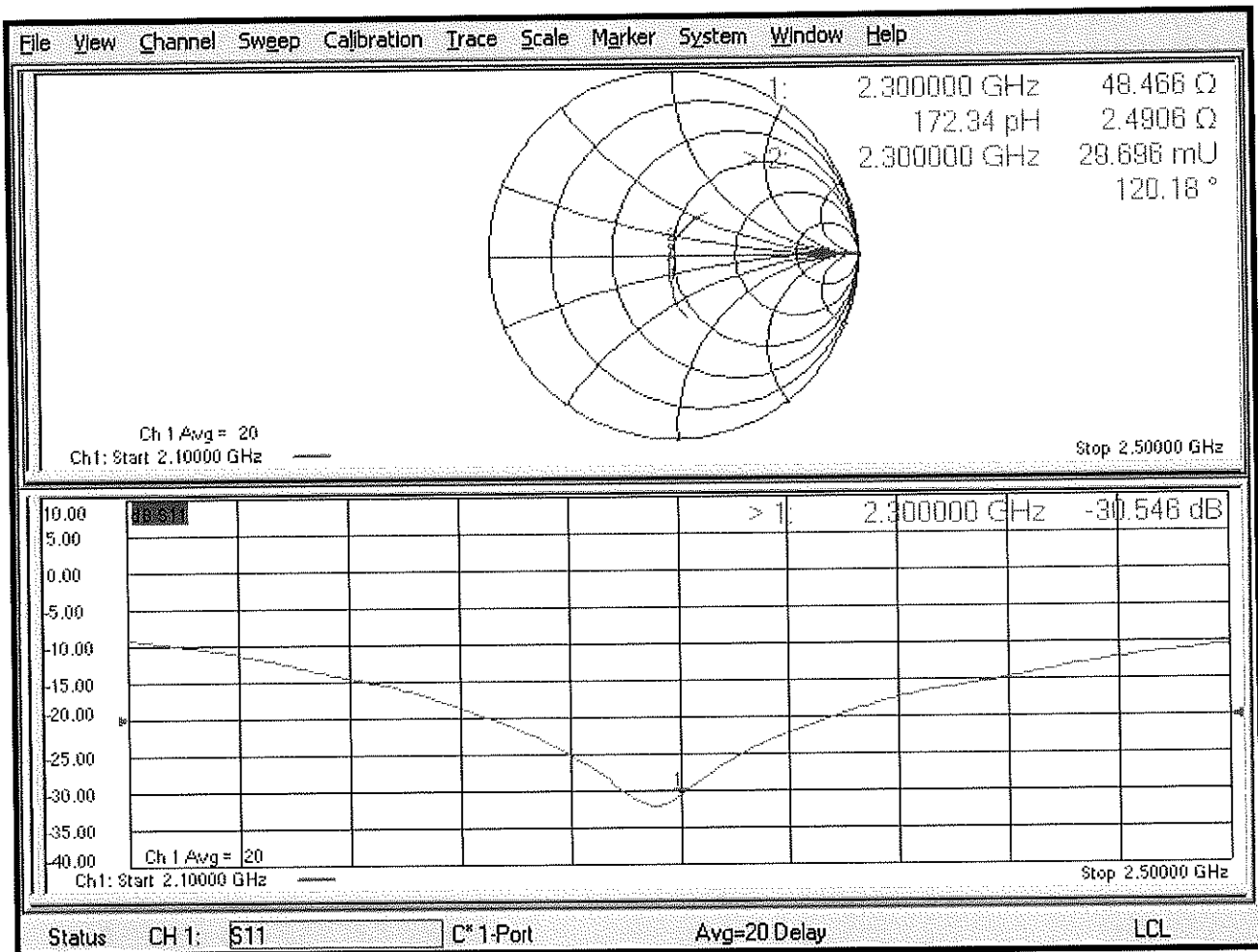
Smallest distance from peaks to all points 3 dB below = 9 mm

Ratio of SAR at M2 to SAR at M1 = 55%

Maximum value of SAR (measured) = 19.3 W/kg



# Impedance Measurement Plot for Head TSL



# DASY5 Validation Report for Body TSL

Date: 25.08.2022

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1073**

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used:  $f = 2300$  MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 51.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.13, 8.13, 8.13) @ 2300 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 107.2 V/m; Power Drift = -0.03 dB

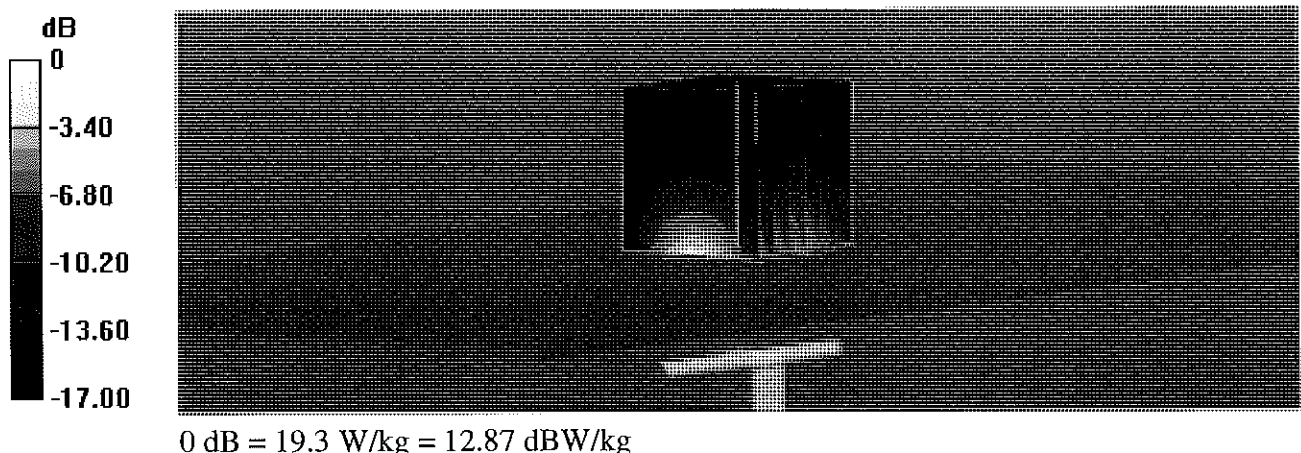
Peak SAR (extrapolated) = 23.0 W/kg

**SAR(1 g) = 12.3 W/kg; SAR(10 g) = 5.96 W/kg**

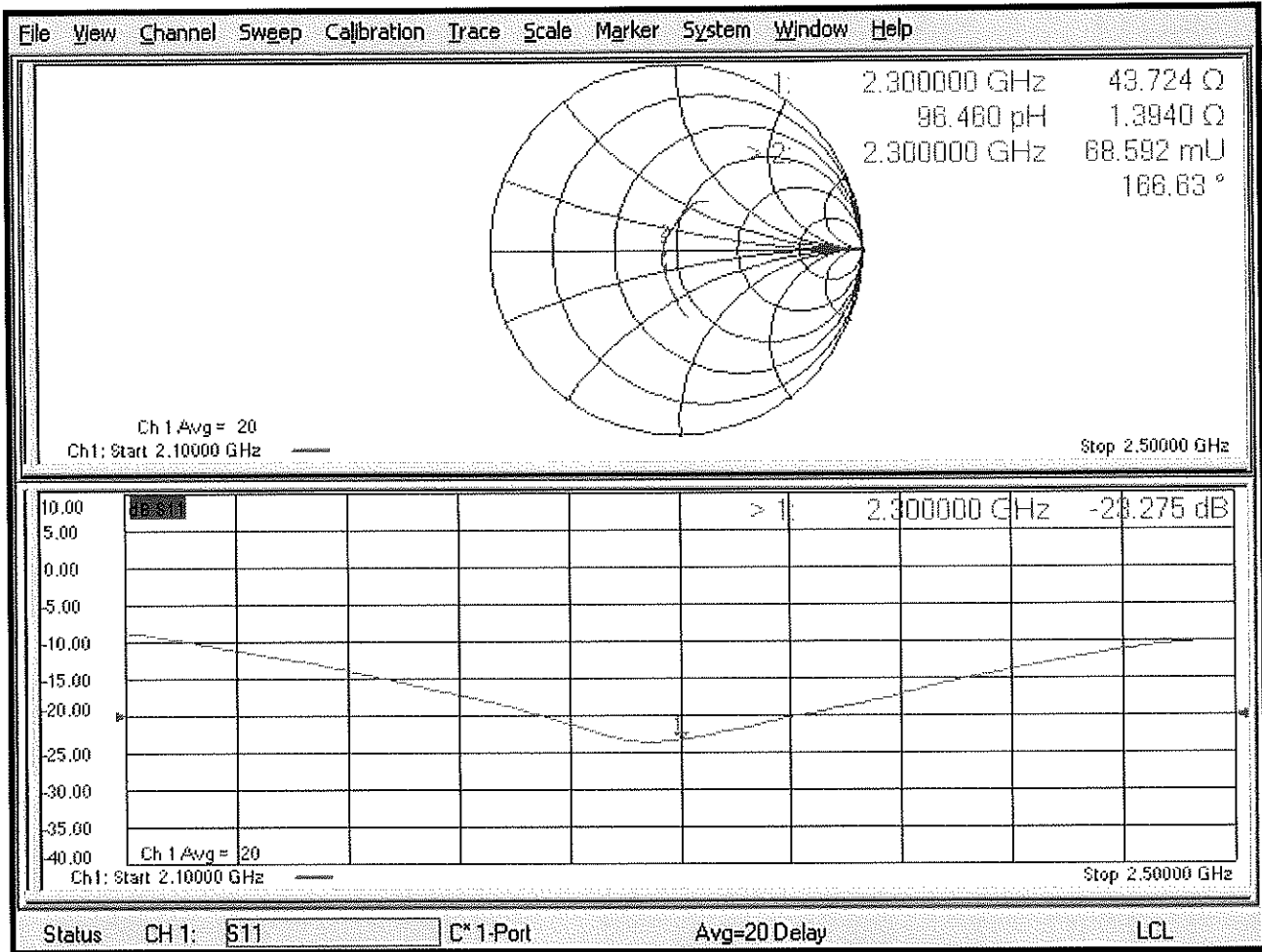
Smallest distance from peaks to all points 3 dB below = 9 mm

Ratio of SAR at M2 to SAR at M1 = 54.7%

Maximum value of SAR (measured) = 19.3 W/kg



# Impedance Measurement Plot for Body TSL



# Certification of Calibration

Object: D2300V2 – SN: 1073  
 Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.  
 Extension Calibration date: 08/21/2023  
 Description: SAR Validation Dipole at 2300 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	11/30/2022	Annual	11/30/2023	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA24106A	USB Power Sensor	1/9/2023	Annual	1/9/2024	1344545
Anritsu	MA24106A	USB Power Sensor	1/9/2023	Annual	1/9/2024	1349511
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/27/2023	Biennial	3/27/2025	230208060
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774675
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/21/2022	Annual	10/21/2023	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/14/2022	Annual	11/14/2023	1277
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	11/11/2022	Annual	11/11/2023	MY53401181
SPEAG	EX3DV4	SAR Probe	1/11/2023	Annual	1/11/2024	7570
SPEAG	DAE4	Dasy Data Acquisition Electronics	1/17/2023	Annual	1/17/2024	1558

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Brodie Halfoster	Test Engineer	<i>BRODIE HALBFOSTER</i>
Approved By:	Greg Snyder	Executive VP of Operations	<i>Greg Snyder</i>



# DIPOLE CALIBRATION EXTENSION

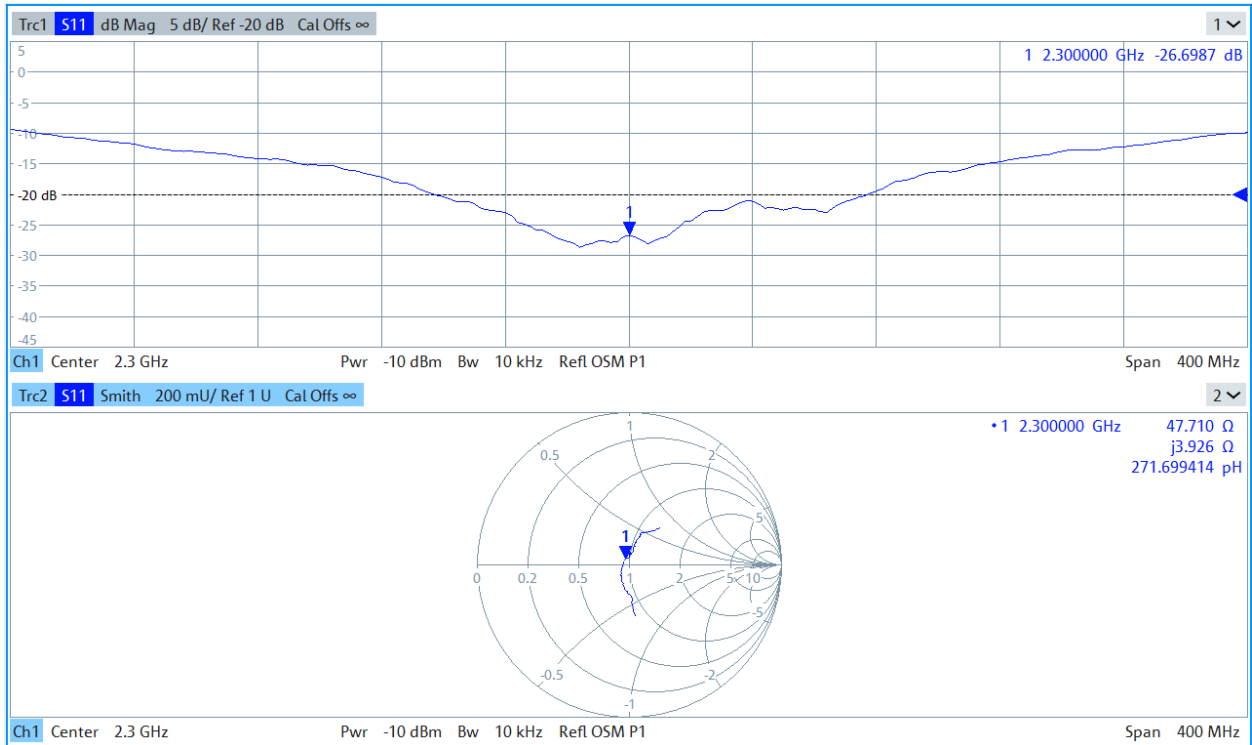
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
9/1/2022	8/21/2023	1.164	4.86	4.87	0.21%	2.37	2.33	-1.69%	48.5	47.7	0.8	2.5	3.9	1.4	-30.5	-26.7	12.50%	PASS

### Impedance & Return-Loss Measurement Plot for Head TSL





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Multilateral Agreement for the recognition of calibration certificates

Client **Element**  
Yongin, Republic of Korea

Certificate No. **D2300V2-1117\_Jun23**

**CALIBRATION CERTIFICATE**

Object **D2300V2 - SN:1117**

Calibration procedure(s) **QA CAL-05.v12  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **June 12, 2023**

실무자	기재자
<i>[Signature]</i>	<i>[Signature]</i>

6-28-2023

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: 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

Calibrated by:	Name	Function	Signature
	<b>Paulo Pina</b>	<b>Laboratory Technician</b>	<i>[Signature]</i>
Approved by:	Name	Function	Signature
	<b>Sven Kühn</b>	<b>Technical Manager</b>	<i>[Signature]</i>

Issued: June 12, 2023

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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:

- 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.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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.

<b>DASY Version</b>	DASY52	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2300 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.5	1.67 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	39.4 $\pm$ 6 %	1.65 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	---	---

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	12.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	49.9 W/kg $\pm$ 17.0 % (k=2)

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.06 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg $\pm$ 16.5 % (k=2)

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.9	1.81 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	52.8 $\pm$ 6 %	1.81 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	---	---

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	11.8 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	47.2 W/kg $\pm$ 17.0 % (k=2)

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	5.78 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.1 W/kg $\pm$ 16.5 % (k=2)

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$47.8 \Omega + 3.5 j\Omega$
Return Loss	- 27.5 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	$44.9 \Omega + 2.6 j\Omega$
Return Loss	- 24.4 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.164 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
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## DASY5 Validation Report for Head TSL

Date: 09.06.2023

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1117**

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used:  $f = 2300$  MHz;  $\sigma = 1.65$  S/m;  $\epsilon_r = 39.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.98, 7.98, 7.98) @ 2300 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: 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=5mm

Reference Value = 116.7 V/m; Power Drift = 0.05 dB

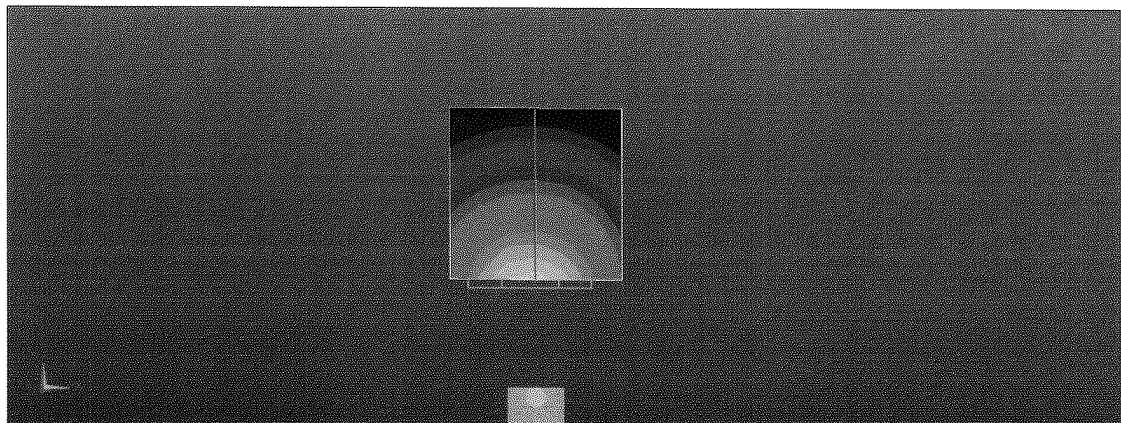
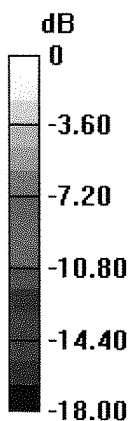
Peak SAR (extrapolated) = 22.2 W/kg

**SAR(1 g) = 12.4 W/kg; SAR(10 g) = 6.06 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

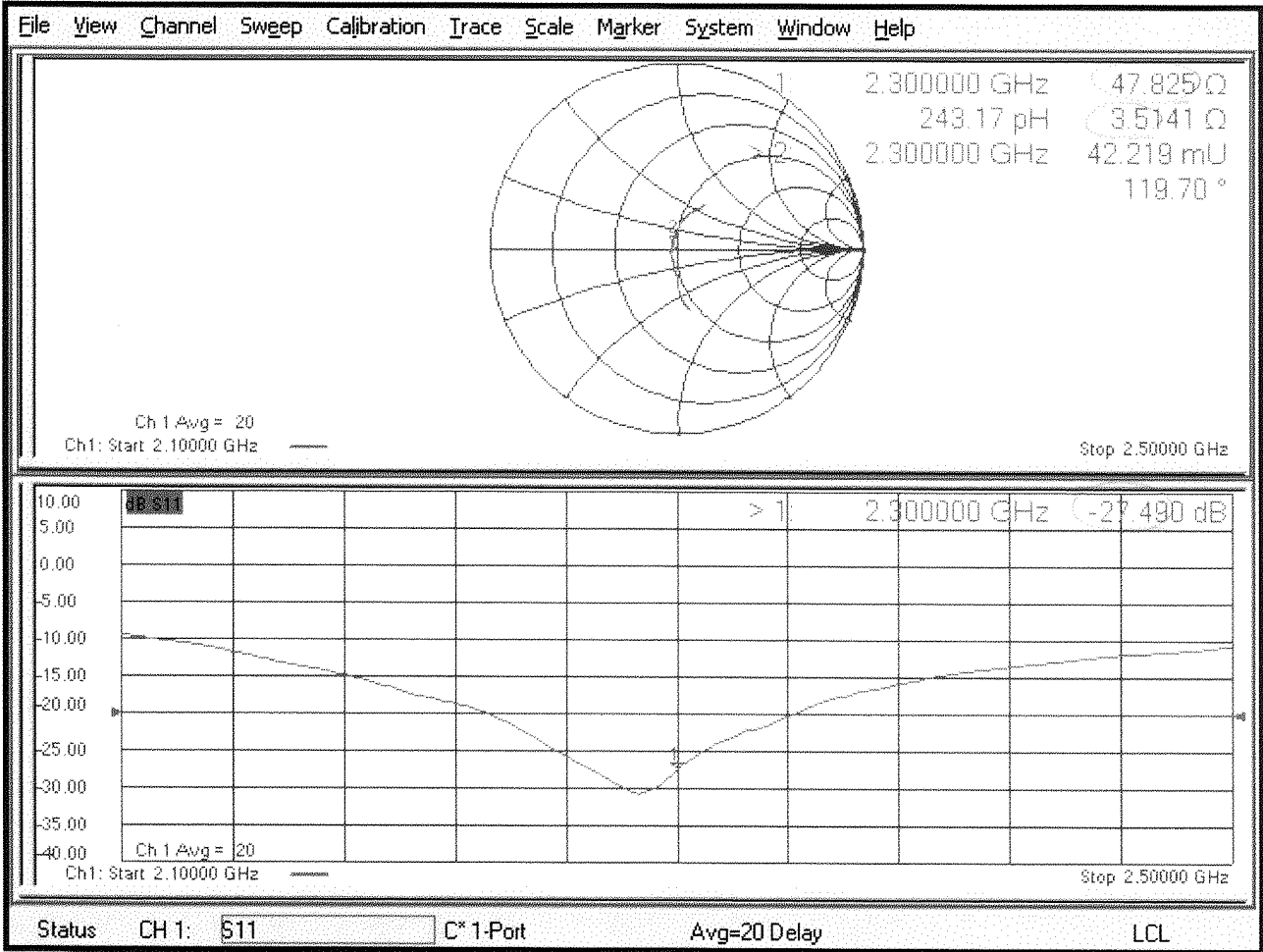
Ratio of SAR at M2 to SAR at M1 = 56.5%

Maximum value of SAR (measured) = 19.1 W/kg



0 dB = 19.1 W/kg = 12.81 dBW/kg

# Impedance Measurement Plot for Head TSL





# DASY5 Validation Report for Body TSL

Date: 12.06.2023

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1117**

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used:  $f = 2300$  MHz;  $\sigma = 1.81$  S/m;  $\epsilon_r = 52.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.97, 7.97, 7.97) @ 2300 MHz; Calibrated: 10.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 106.7 V/m; Power Drift = -0.05 dB

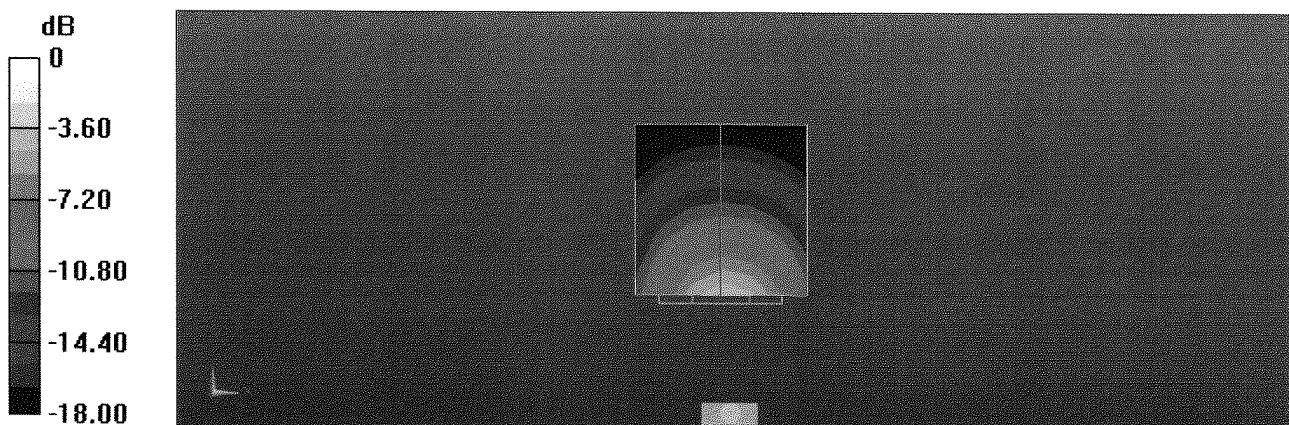
Peak SAR (extrapolated) = 21.5 W/kg

**SAR(1 g) = 11.8 W/kg; SAR(10 g) = 5.78 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.9 mm

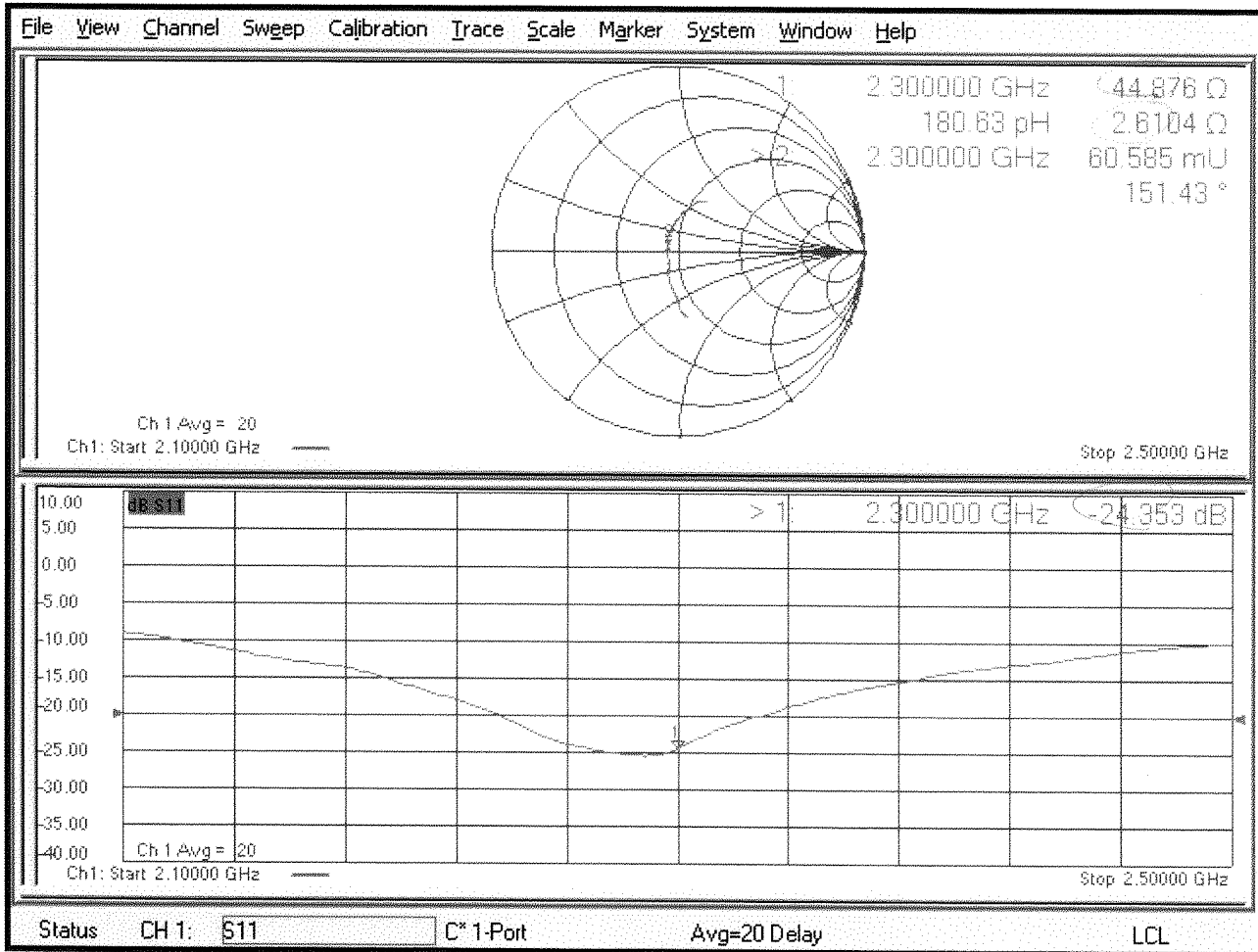
Ratio of SAR at M2 to SAR at M1 = 56.1%

Maximum value of SAR (measured) = 18.4 W/kg



0 dB = 18.4 W/kg = 12.65 dBW/kg

# Impedance Measurement Plot for Body TSL





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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2450V2-981\_Nov21**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN:981**

Calibration procedure(s) **QA CAL-05.v11  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **November 25, 2021**

*BN ✓  
12-09-2021*

*BN ✓  
11-25-22*

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)

*S RS 01/03/24*

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	01-Nov-21 (No. DAE4-601_Nov21)	Nov-22

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

Calibrated by: **Jeffrey Katzman**      Function: **Laboratory Technician**

Approved by: **Niels Kuster**      Quality Manager

Signature

Issued: November 25, 2021

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



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.

<b>DASY Version</b>	DASY52	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2450 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.2	1.80 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	39.1 ± 6 %	1.87 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	13.7 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>53.9 W/kg ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>25.4 W/kg ± 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.7	1.95 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	51.2 ± 6 %	2.01 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	12.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>50.3 W/kg ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	6.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.7 W/kg ± 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.8 $\Omega$ + 5.8 j $\Omega$
Return Loss	- 23.6 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.4 $\Omega$ + 8.5 j $\Omega$
Return Loss	- 21.5 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.163 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
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## DASY5 Validation Report for Head TSL

Date: 25.11.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 981**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.87$  S/m;  $\epsilon_r = 39.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 01.11.2021
- 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 = 118.7 V/m; Power Drift = -0.03 dB

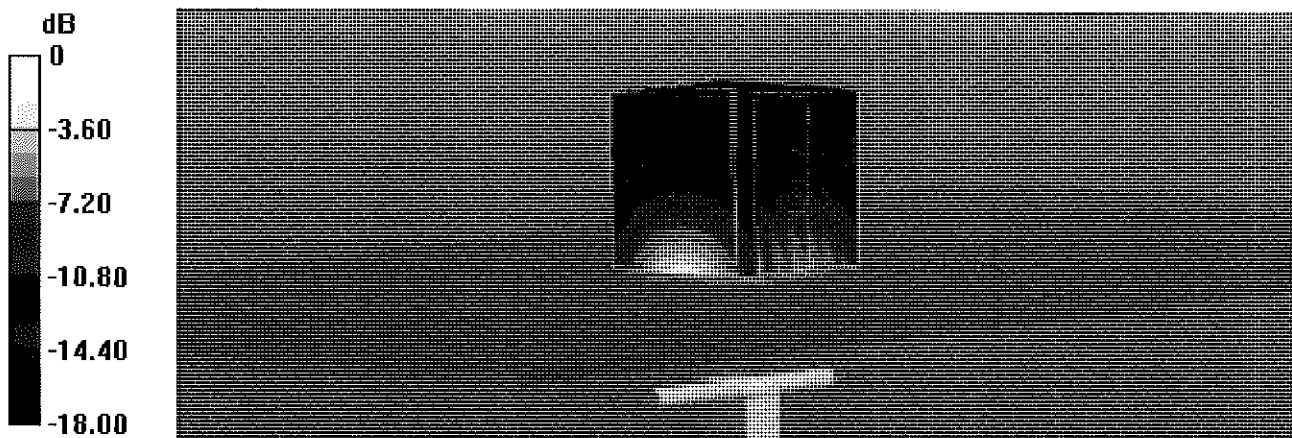
Peak SAR (extrapolated) = 27.1 W/kg

**SAR(1 g) = 13.7 W/kg; SAR(10 g) = 6.42 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

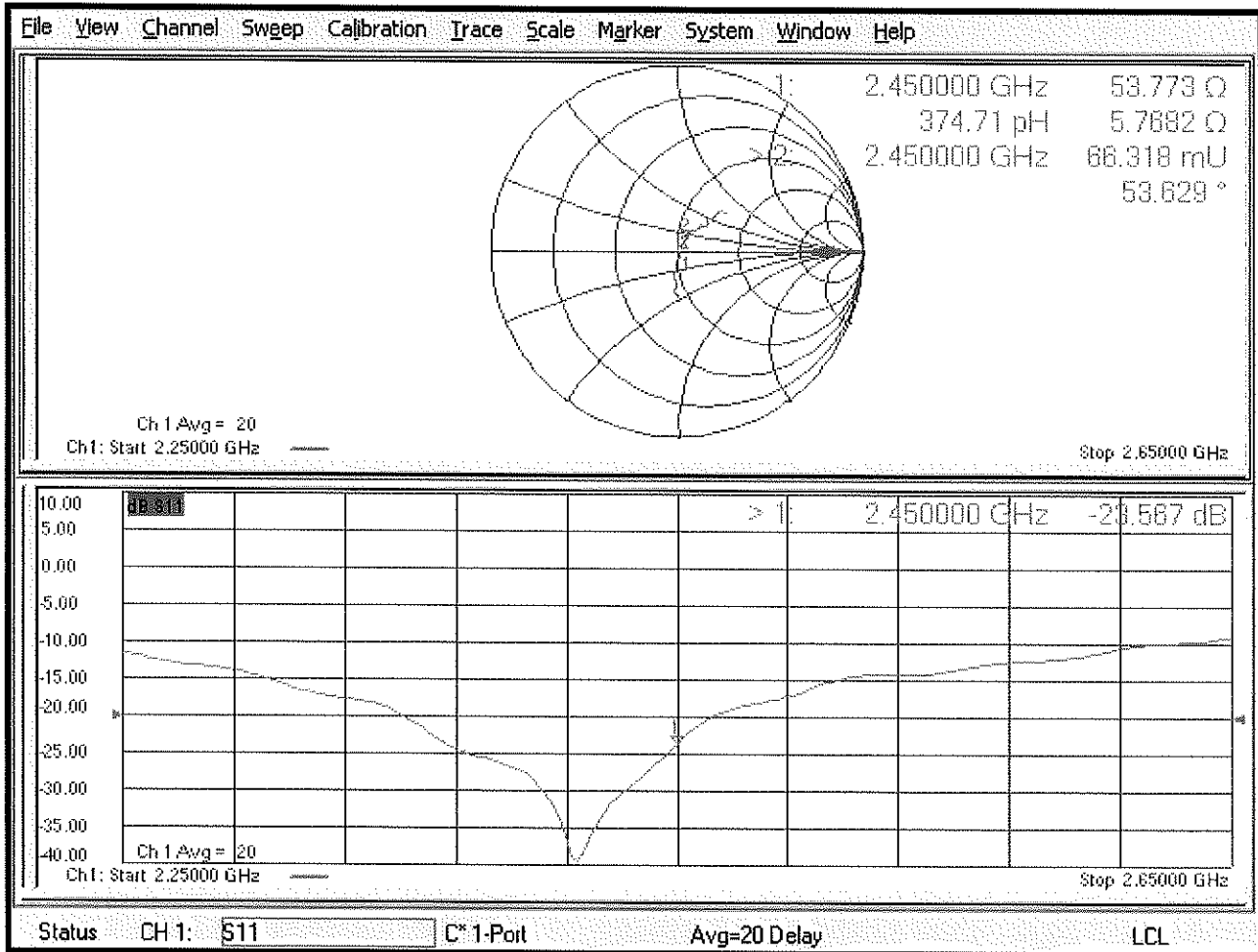
Ratio of SAR at M2 to SAR at M1 = 51.1%

Maximum value of SAR (measured) = 22.6 W/kg



0 dB = 22.6 W/kg = 13.55 dBW/kg

# Impedance Measurement Plot for Head TSL





## DASY5 Validation Report for Body TSL

Date: 25.11.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 981**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.01$  S/m;  $\epsilon_r = 51.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12) @ 2450 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 01.11.2021
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 108.0 V/m; Power Drift = -0.08 dB

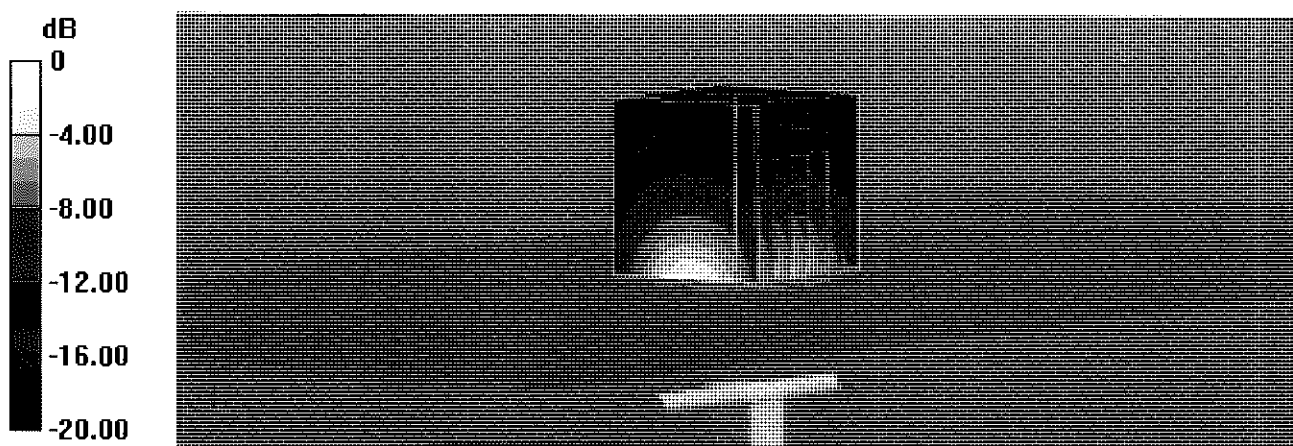
Peak SAR (extrapolated) = 24.3 W/kg

**SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6 W/kg**

Smallest distance from peaks to all points 3 dB below = 8 mm

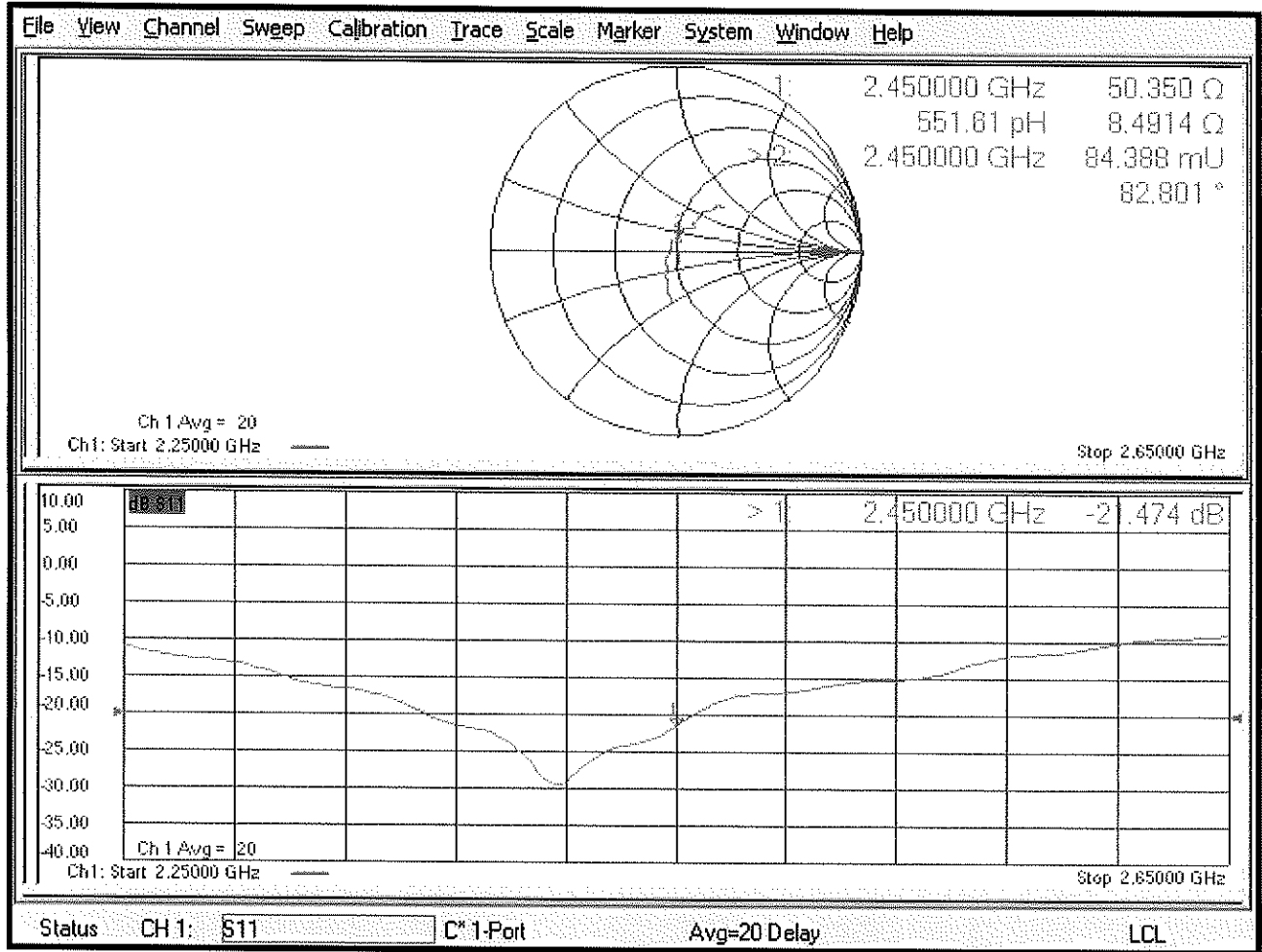
Ratio of SAR at M2 to SAR at M1 = 54.1%

Maximum value of SAR (measured) = 20.2 W/kg



0 dB = 20.2 W/kg = 13.05 dBW/kg

# Impedance Measurement Plot for Body TSL



# Certification of Calibration

Object: D2450V2 – SN: 981

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 11/24/2022

Description: SAR Validation Dipole at 2450 MHz.

## Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	1/12/2022	Annual	1/12/2023	MY47420837
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	3/28/2022	Annual	3/28/2023	1339007
Anritsu	MA2411B	Pulse Power Sensor	3/2/2022	Annual	3/2/2023	1126066
Anritsu	ML2496A	Power Meter	3/31/2022	Annual	3/31/2023	1138001
Anritsu	ML2496A	Power Meter	3/17/2022	Annual	3/17/2023	941001
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/12/2021	Biennial	3/12/2023	210202100
Control Company	4352	Ultra Long Stem Thermometer	1/21/2022	Annual	1/21/2023	160508097
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774678
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/21/2022	Annual	10/21/2023	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2022	Annual	5/12/2023	1070
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/21/2022	Annual	6/21/2023	MY53402352
SPEAG	EX3DV4	SAR Probe	2/21/2022	Annual	2/21/2023	7488
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/23/2022	Annual	2/23/2023	1415
SPEAG	EX3DV4	SAR Probe	6/16/2022	Annual	6/16/2023	7409
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/14/2022	Annual	6/14/2023	1334

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Tho Tong	Test Engineer	<i>Tho Tong</i>
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	<i>KOK</i>

# DIPOLE CALIBRATION EXTENSION

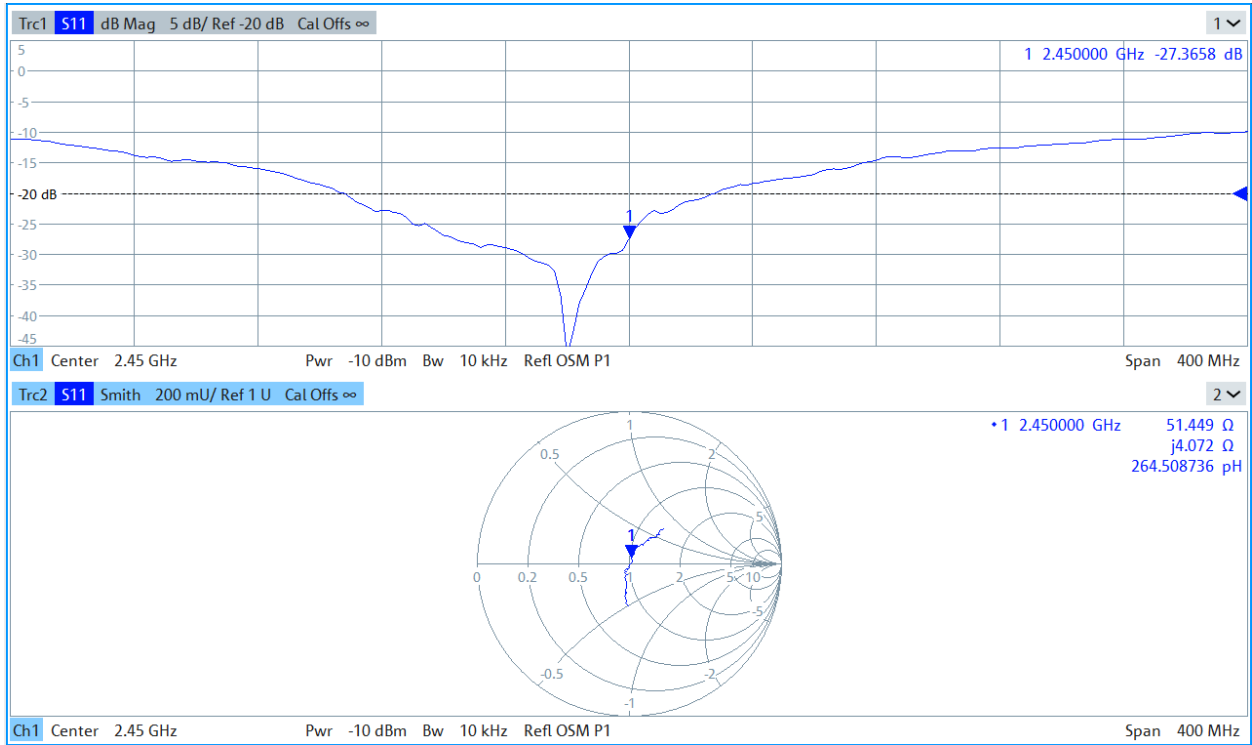
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

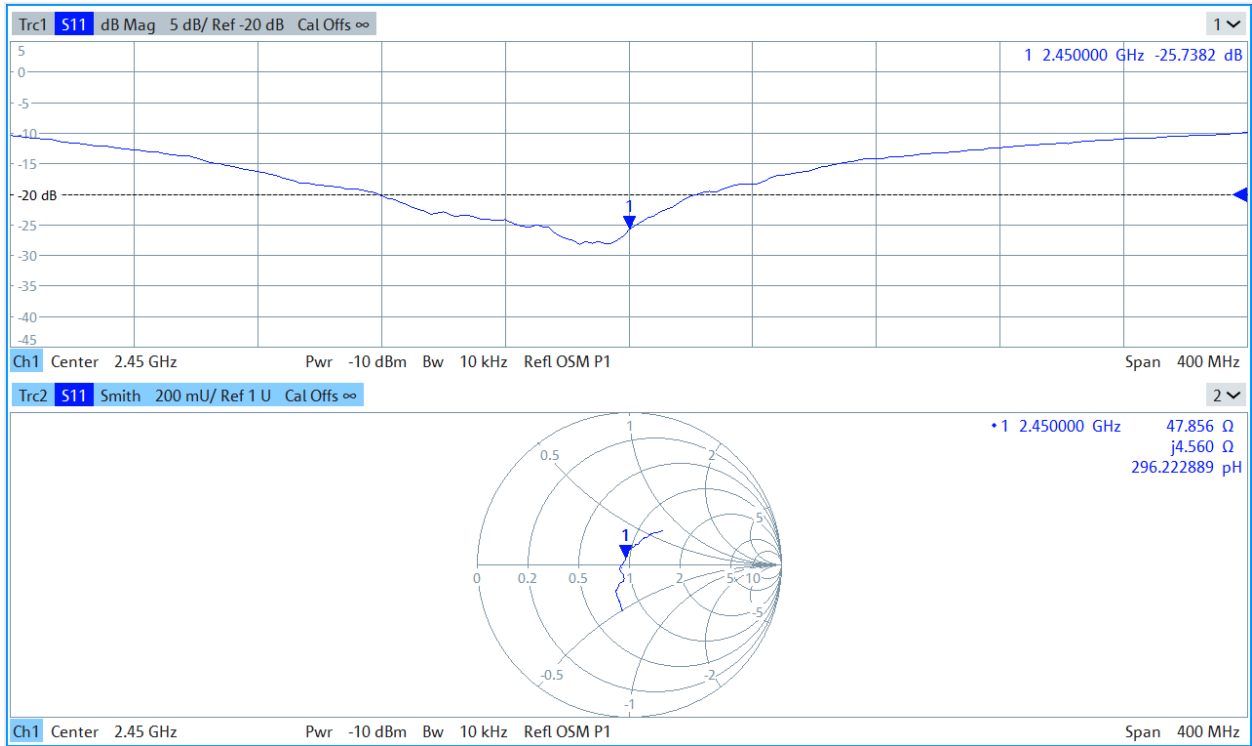
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
11/25/2021	11/24/2022	1.163	5.39	5.22	-3.15%	2.54	2.43	-4.33%	53.8	51.4	2.4	5.8	4.1	1.7	-23.6	-27.4	-16.00%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
11/25/2021	11/24/2022	1.163	5.03	4.88	-2.98%	2.37	2.27	-4.22%	50.4	47.9	2.5	8.5	4.6	3.9	-21.5	-25.7	-19.70%	PASS

### Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL



# Certification of Calibration

Object: D2450V2 – SN: 981

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 11/10/2023

Description: SAR Validation Dipole at 2450 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	11/30/2022	Annual	11/30/2023	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	1/10/2023	Annual	1/10/2024	1315051
Anritsu	ML2496A	Power Meter	6/15/2023	Annual	6/15/2024	1138001
Control Company	4040	Therm./ Clock/ Humidity Monitor	1/17/2023	Biennial	1/17/2024	160574418
Control Company	4353	Long Stem Thermometer	9/15/2022	Biennial	9/15/2024	221767767
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Anritsu	MS46322A	Vector Network Analyzer	9/6/2023	Biennial	9/6/2025	82288
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/13/2023	Annual	11/13/2024	1277
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	11/11/2022	Annual	11/11/2023	MY53401181
SPEAG	EX3DV4	SAR Probe	6/15/2023	Annual	6/15/2024	7409
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/15/2023	Annual	6/15/2024	1334

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Tho Tong	Test Engineer	<i>Tho Tong</i>
Approved By:	Greg Snyder	Executive VP of Operations, Regulatory	<i>Greg Snyder</i>

# DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

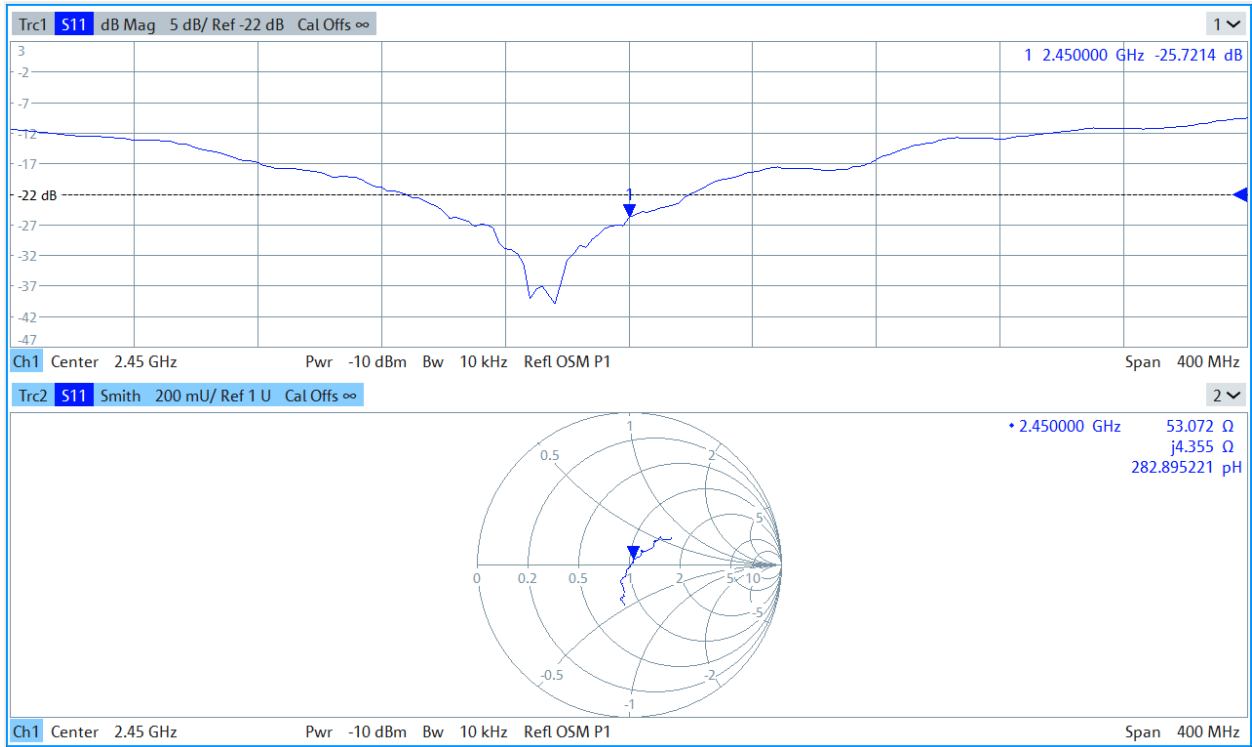
1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
11/25/2021	11/10/2023	1.163	5.39	5.53	2.80%	2.54	2.56	0.79%	53.8	53.1	0.7	5.8	4.4	1.4	-23.6	-25.7	-9.00%	PASS



# Impedance & Return-Loss Measurement Plot for Head TSL





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Multilateral Agreement for the recognition of calibration certificates

Client **Element**  
Yongin, Republic of Korea

Certificate No. **D2450V2-945\_May23**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN:945**

Calibration procedure(s) **QA CAL-05.v12  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **May 11, 2023**

실무자	기술책임자
<i>[Signature]</i>	<i>[Signature]</i>

6/9/2023

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: 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

	Name	Function	Signature
Calibrated by:	Paulo Pina	Laboratory Technician	<i>[Signature]</i>
Approved by:	Sven Kühn	Technical Manager	<i>[Signature]</i>

Issued: May 16, 2023

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



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.

<b>DASY Version</b>	DASY52	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2450 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.2	1.80 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	37.7 ± 6 %	1.86 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	---	---

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>51.9 W/kg ± 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.6 W/kg ± 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.7	1.95 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	52.6 ± 6 %	2.02 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	---	---

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	12.7 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>49.9 W/kg ± 17.0 % (k=2)</b>

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

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$54.4 \Omega + 1.8 j\Omega$
Return Loss	- 26.8 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	$50.4 \Omega + 4.8 j\Omega$
Return Loss	- 26.4 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.157 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
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# DASY5 Validation Report for Head TSL

Date: 11.05.2023

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:945**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.86$  S/m;  $\epsilon_r = 37.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.9, 7.9, 7.9) @ 2450 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 = 115.4 V/m; Power Drift = 0.00 dB

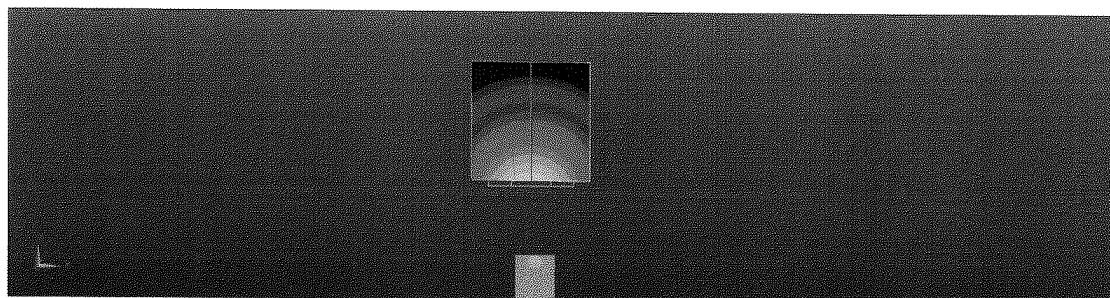
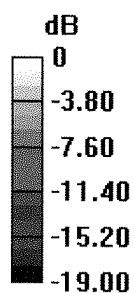
Peak SAR (extrapolated) = 25.8 W/kg

**SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.23 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

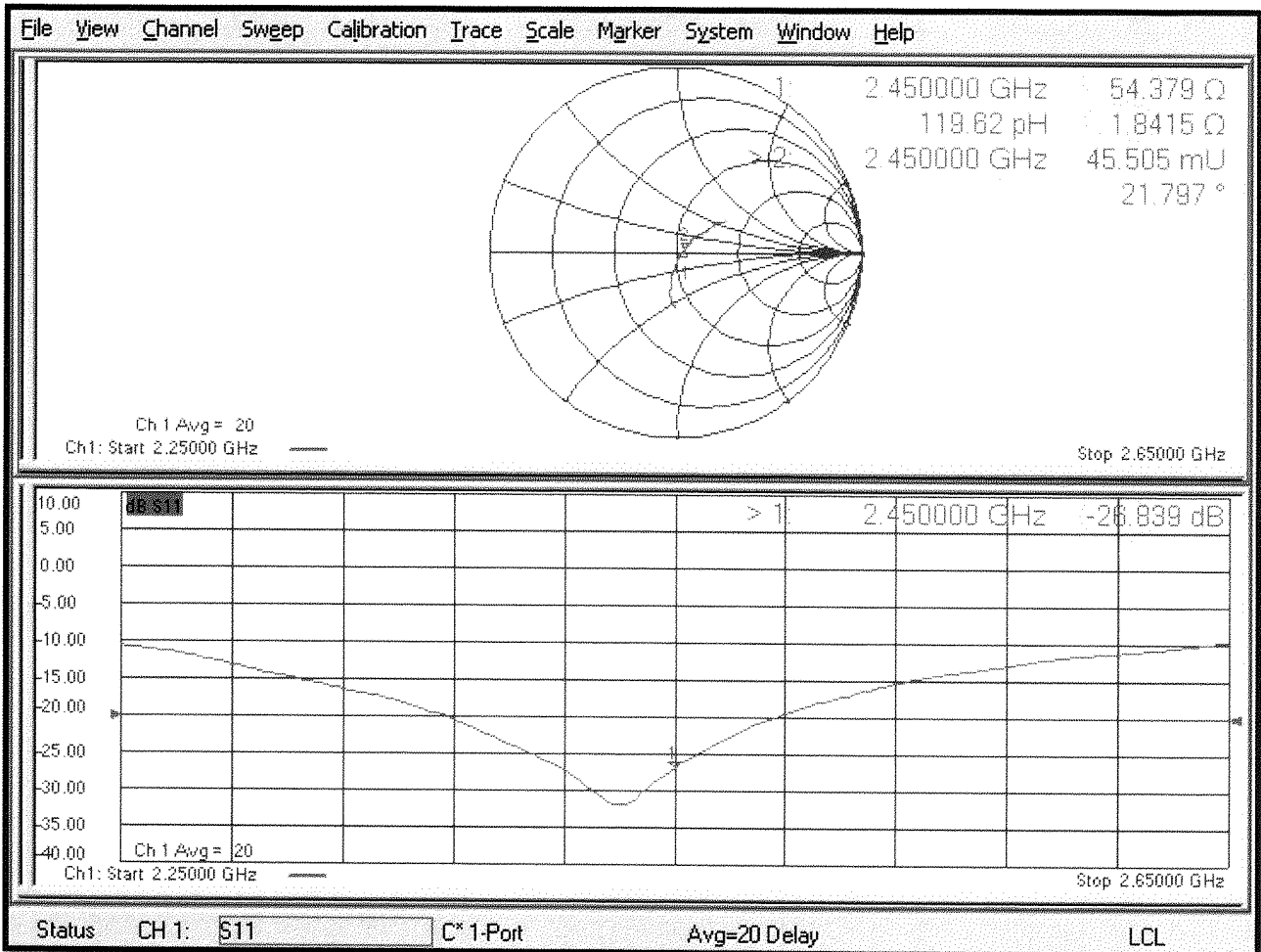
Ratio of SAR at M2 to SAR at M1 = 51.7%

Maximum value of SAR (measured) = 21.7 W/kg



0 dB = 21.7 W/kg = 13.36 dBW/kg

# Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 09.05.2023

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:945**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.02$  S/m;  $\epsilon_r = 52.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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: 10.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 107.6 V/m; Power Drift = -0.09 dB

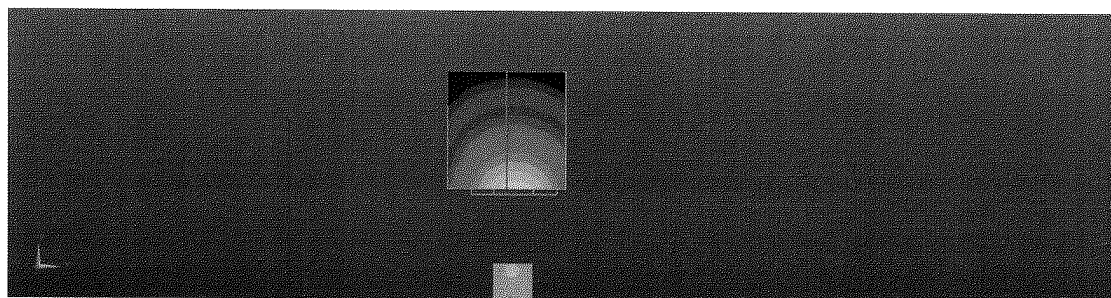
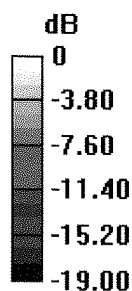
Peak SAR (extrapolated) = 23.4 W/kg

**SAR(1 g) = 12.7 W/kg; SAR(10 g) = 6.01 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.9 mm

Ratio of SAR at M2 to SAR at M1 = 55.9%

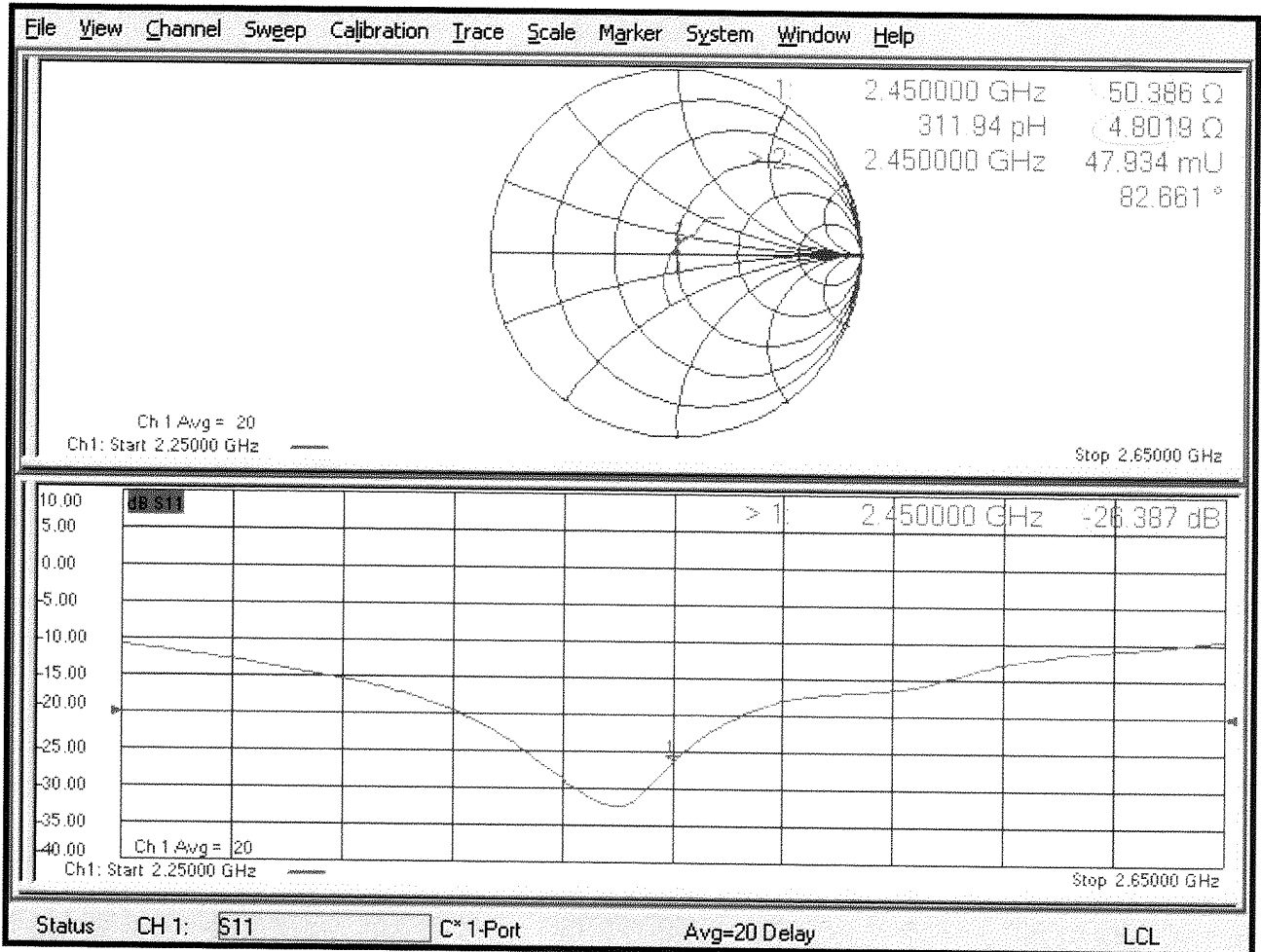
Maximum value of SAR (measured) = 19.4 W/kg



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



# Impedance Measurement Plot for Body TSL





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 **PC Test**

Certificate No: **D2450V2-719\_Aug21**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN:719**

Calibration procedure(s) **QA CAL-05.v11  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **August 18, 2021**

BN<sup>✓</sup>  
08-10-22

BN<sup>✓</sup>  
9-3-2021

BN<sup>✓</sup>  
08-27-23

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Technical Manager	

Issued: August 18, 2021

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



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:

- 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.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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.

<b>DASY Version</b>	DASY52	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2450 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.2	1.80 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	37.9 $\pm$ 6 %	1.87 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	14.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>55.0 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.53 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>25.7 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.7	1.95 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	52.0 $\pm$ 6 %	2.03 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>52.0 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	6.26 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>24.7 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.9 $\Omega$ + 6.0 j $\Omega$
Return Loss	- 22.0 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	51.3 $\Omega$ + 8.4 j $\Omega$
Return Loss	- 21.5 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.149 ns
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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
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## DASY5 Validation Report for Head TSL

Date: 17.08.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:719**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.87$  S/m;  $\epsilon_r = 37.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- 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 = 119.5 V/m; Power Drift = -0.06 dB

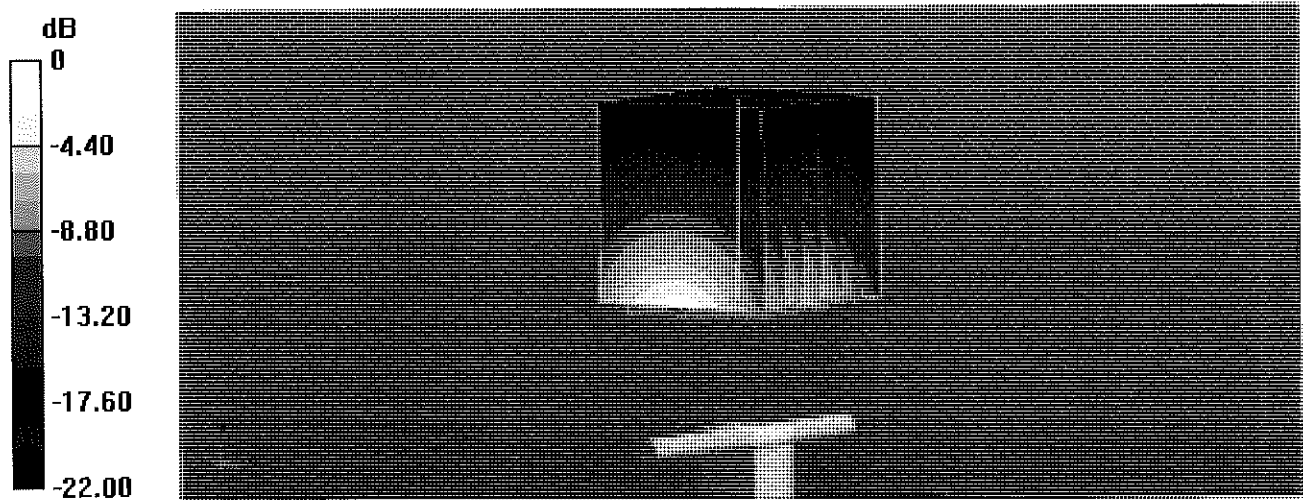
Peak SAR (extrapolated) = 28.1 W/kg

**SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.53 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

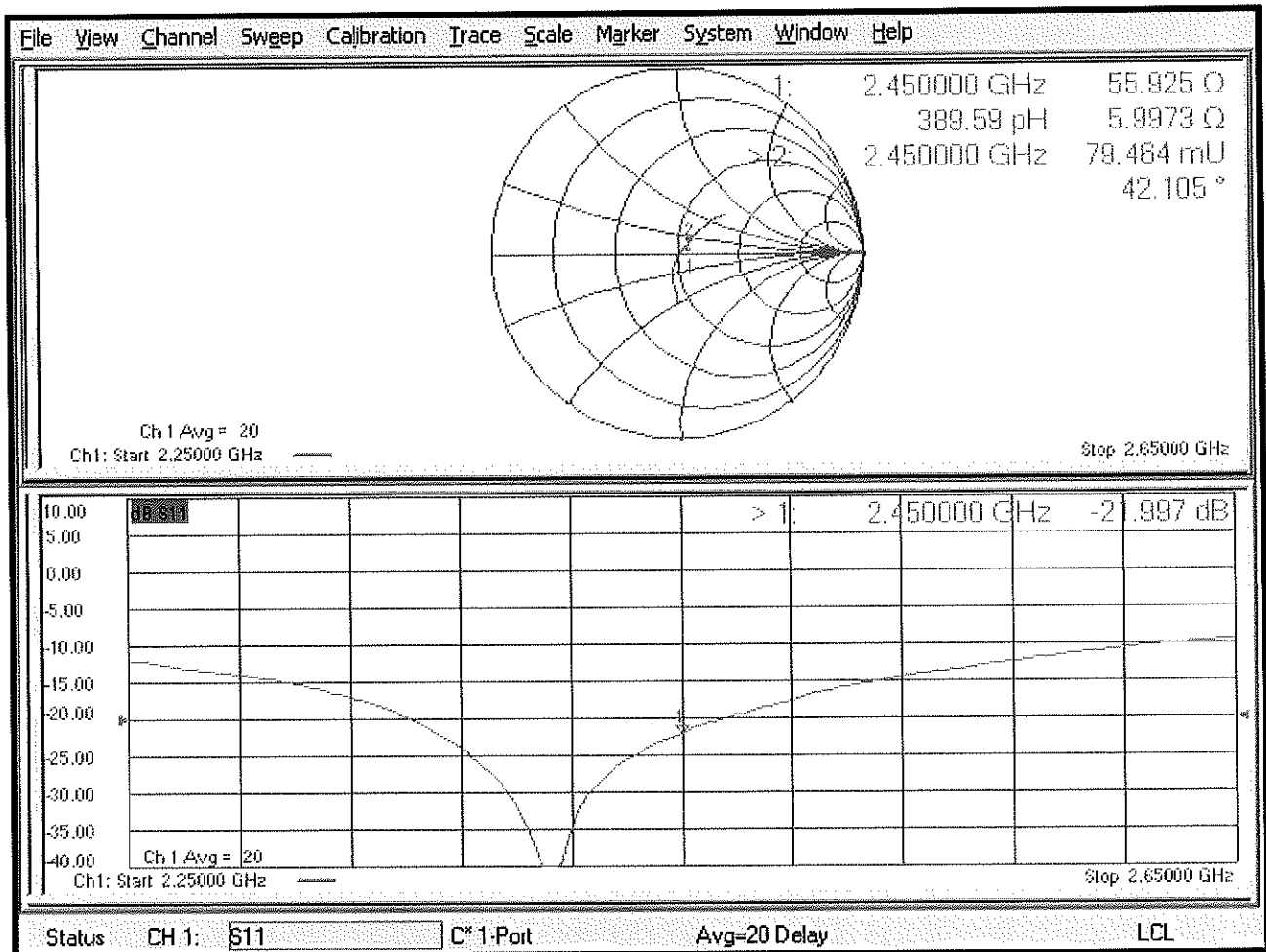
Ratio of SAR at M2 to SAR at M1 = 50.5%

Maximum value of SAR (measured) = 22.8 W/kg



0 dB = 22.8 W/kg = 13.58 dBW/kg

# Impedance Measurement Plot for Head TSL



# DASY5 Validation Report for Body TSL

Date: 18.08.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:719**

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 52$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12) @ 2450 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 111.3 V/m; Power Drift = -0.03 dB

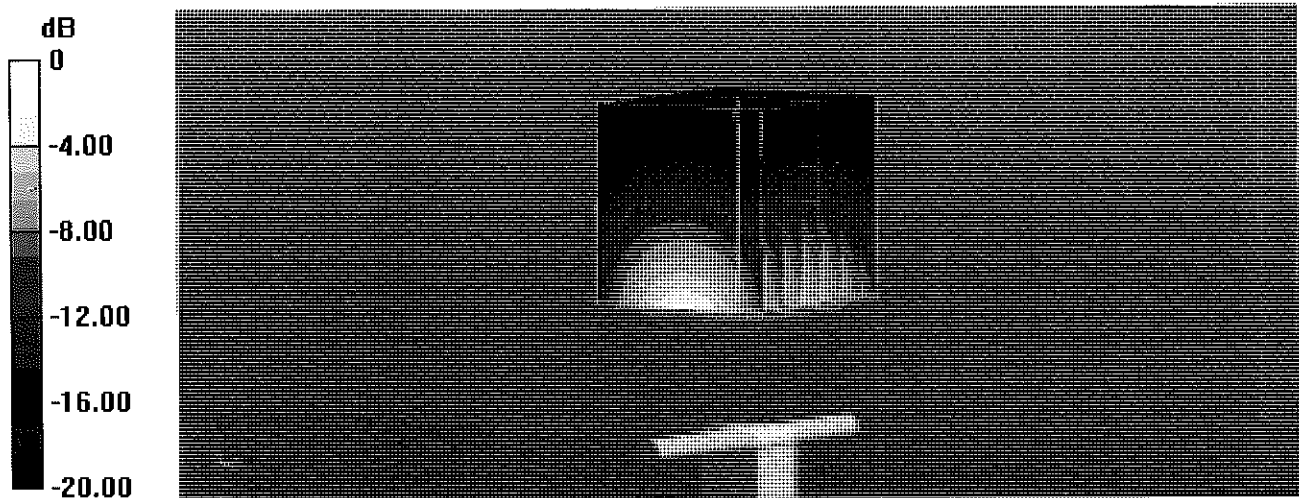
Peak SAR (extrapolated) = 24.8 W/kg

**SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.26 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.2 mm

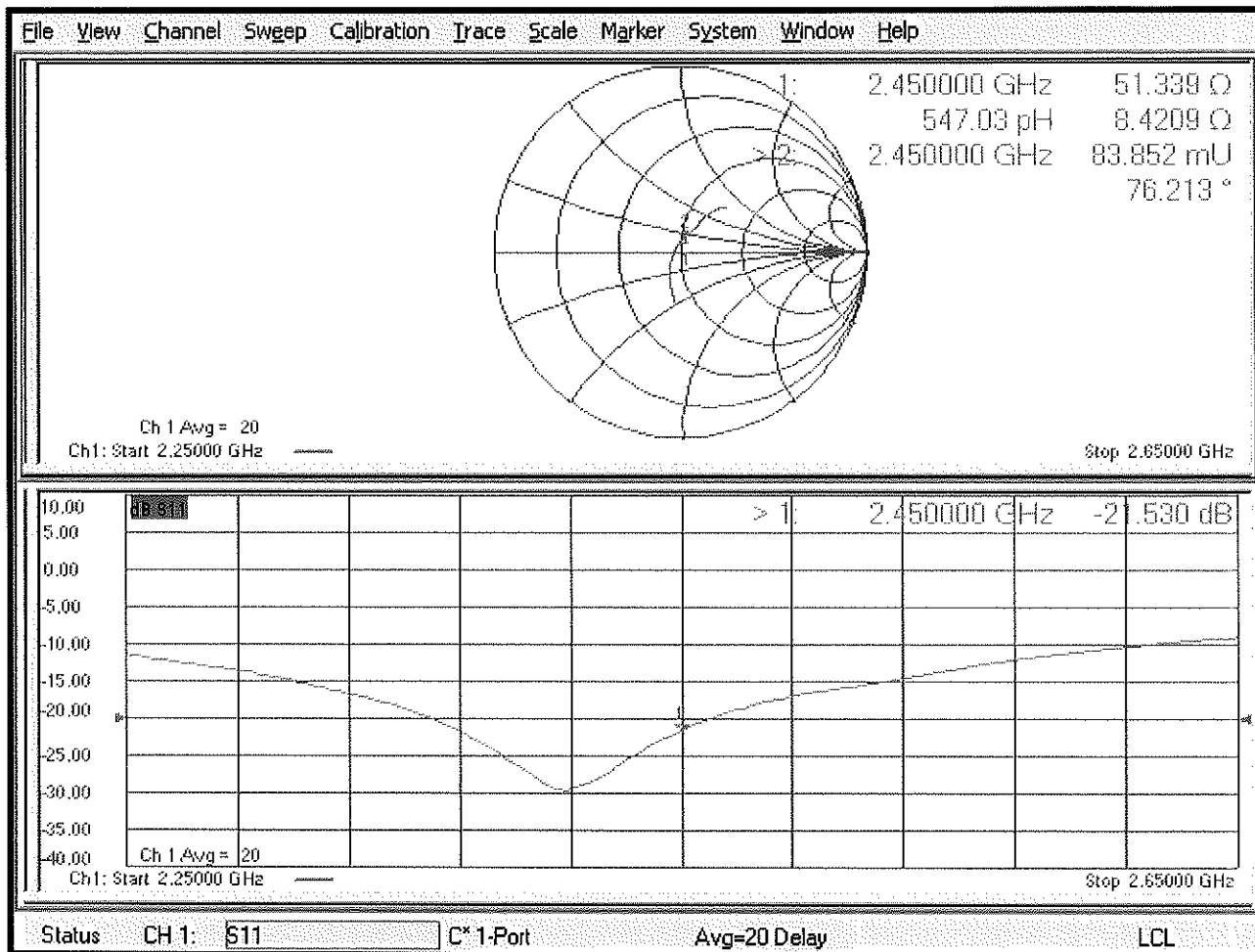
Ratio of SAR at M2 to SAR at M1 = 54.6%

Maximum value of SAR (measured) = 21.1 W/kg





# Impedance Measurement Plot for Body TSL



# Certification of Calibration

Object D2450V2 – SN: 719  
 Calibration procedure(s) Procedure for Calibration Extension for SAR Dipoles.  
 Extension Calibration date: 08/10/2022  
 Description: SAR Validation Dipole at 2450 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	6/21/2022	Annual	6/21/2023	MY47420651
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	9/21/2021	Annual	9/21/2022	1339008
Anritsu	MA2411B	Pulse Power Sensor	10/21/2021	Annual	10/21/2022	1339027
Anritsu	ML2496A	Power Meter	11/29/2021	Annual	11/29/2022	1840005
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/12/2021	Biennial	3/12/2023	210202100
Control Company	4352	Ultra Long Stem Thermometer	10/25/2021	Annual	10/25/2022	200645916
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670653
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	NC-100	Torque Wrench	3/19/2022	Annual	3/19/2023	N/A
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/20/2021	Annual	10/20/2022	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	8/18/2021	Annual	8/18/2022	1041
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	9/27/2021	Annual	9/27/2022	MY53401181
SPEAG	EX3DV4	SAR Probe	2/22/2022	Annual	2/22/2023	7417
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/22/2022	Annual	2/22/2023	665

Measurement Uncertainty = ±23% (k=2)

	Name	Function	Signature
Calibrated By:	Bizunesh Baldinazzo	Test Engineer	BB
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

# DIPOLE CALIBRATION EXTENSION

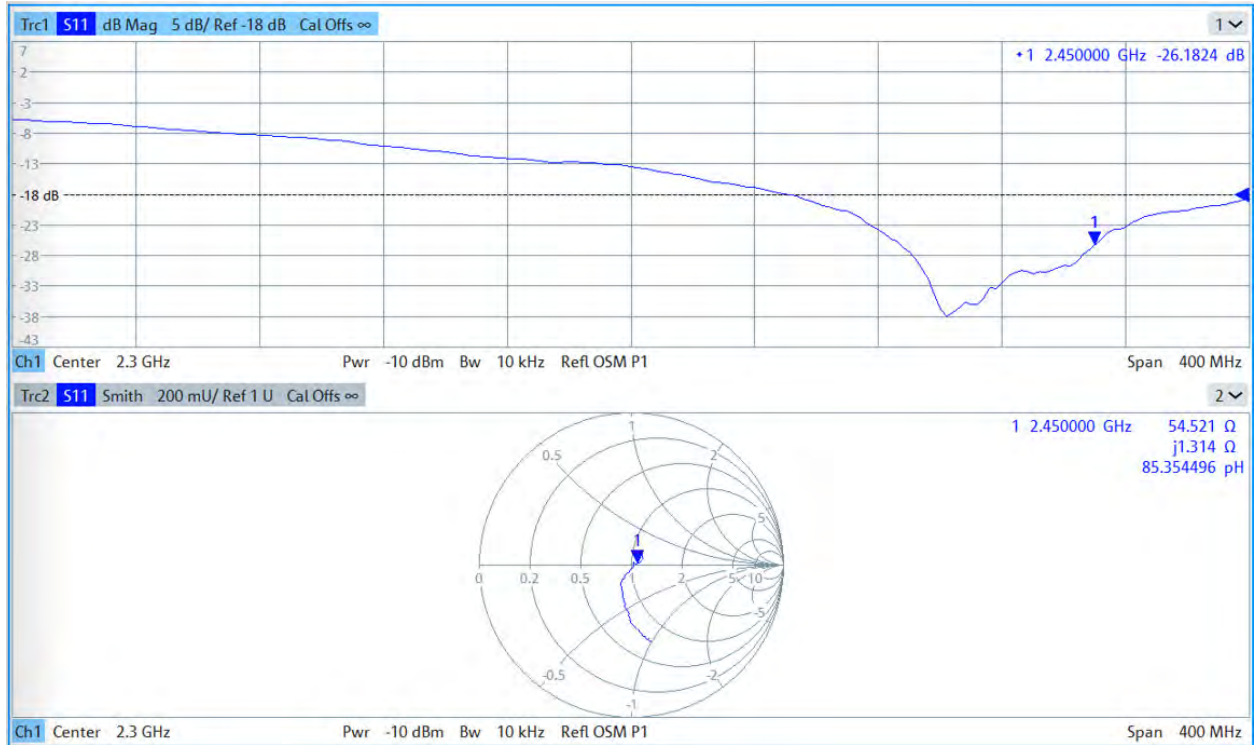
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

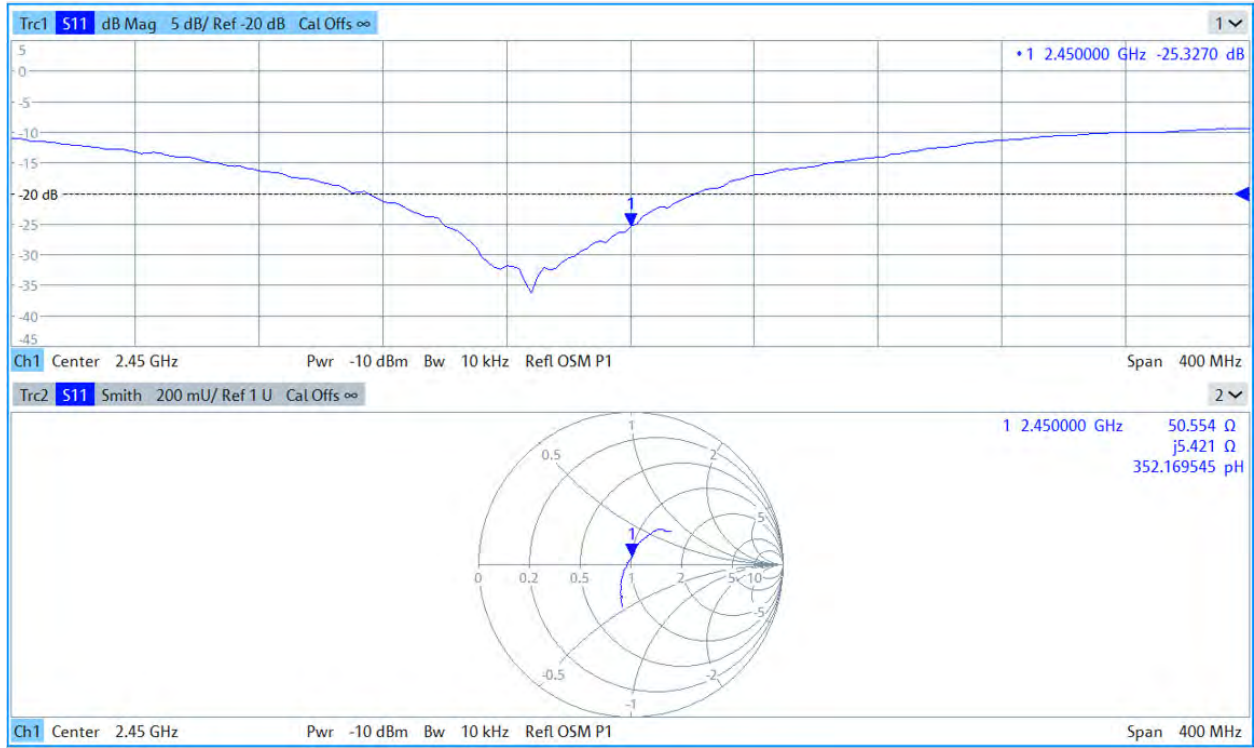
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
8/18/2021	8/10/2022	1.149	5.5	5.22	-5.09%	2.57	2.33	-9.34%	55.9	54.5	1.4	6	1.3	4.7	-22	-26.2	-19.00%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
8/18/2021	8/10/2022	1.149	5.2	4.93	-5.19%	2.47	2.32	-6.07%	51.3	50.6	0.7	8.4	5.4	3	-21.5	-25.3	-17.80%	PASS

### Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL



# Certification of Calibration

Object: D2450V2 – SN: 719

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 08/01/2023

Description: SAR Validation Dipole at 2450 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	11/30/2022	Annual	11/30/2023	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	10/21/2022	Annual	10/21/2023	1207364
Anritsu	ML2496A	Power Meter	8/16/2022	Annual	8/16/2023	1351001
Control Company	4040	Therm./ Clock/ Humidity Monitor	1/17/2023	Biennial	1/17/2024	160574418
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774678
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/21/2022	Annual	10/21/2023	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/14/2022	Annual	11/14/2023	1277
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	11/11/2022	Annual	11/11/2023	MY53401181
SPEAG	EX3DV4	SAR Probe	6/15/2023	Annual	6/15/2024	7409
SPEAG	DAE4	Dasy Data Acquisition Electronics	6/15/2023	Annual	6/15/2024	1334

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Tho Tong	Test Engineer	<i>Tho Tong</i>
Approved By:	Greg Snyder	Executive VP of Operations, Regulatory	<i>Greg Snyder</i>

# DIPOLE CALIBRATION EXTENSION

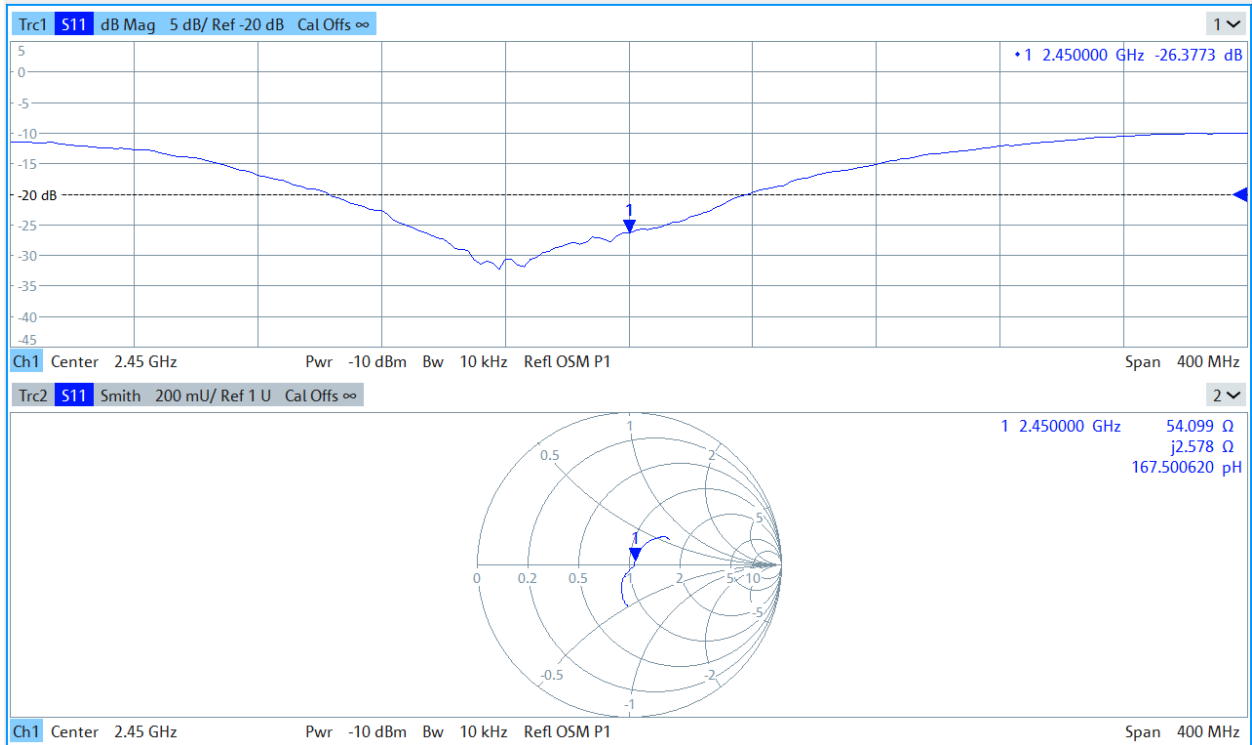
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
8/19/2021	8/1/2023	1.149	5.5	5.34	-2.81%	2.57	2.49	-3.11%	55.9	54.1	1.8	6	2.6	3.4	-22	-26.4	-19.50%	PASS

### Impedance & Return-Loss Measurement Plot for Head TSL







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 **PC Test**

Certificate No: **D2600V2-1004\_Apr21**

## CALIBRATION CERTIFICATE

Object **D2600V2 - SN:1004**

Calibration procedure(s) **QA CAL-05.v11  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **April 14, 2021**

*BN ✓  
4-27-2021*

*BN ✓  
04-04-22*

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%.

*BN ✓  
04-14-2023*

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7349	28-Dec-20 (No. EX3-7349_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

Calibrated by: **Jeffrey Katzman**      Function: **Laboratory Technician**

Signature: *[Signature]*

Approved by: **Katja Pokovic**      Technical Manager

Signature: *[Signature]*

Issued: April 14, 2021

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



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:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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

## Measurement Conditions

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

<b>DASY Version</b>	DASY5	V52.10.4
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	2600 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.0	1.96 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	37.5 $\pm$ 6 %	2.03 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	14.8 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>57.8 W/kg <math>\pm</math> 17.0 % (k=2)</b>

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

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.5	2.16 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	51.0 $\pm$ 6 %	2.22 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	14.1 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>55.4 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	6.26 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>24.8 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.9 $\Omega$ - 4.8 j $\Omega$
Return Loss	- 26.1 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.9 $\Omega$ - 3.6 j $\Omega$
Return Loss	- 25.0 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.150 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
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## DASY5 Validation Report for Head TSL

Date: 14.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1004**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 37.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.84, 7.84, 7.84) @ 2600 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

### **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 = 120.6 V/m; Power Drift = 0.05 dB

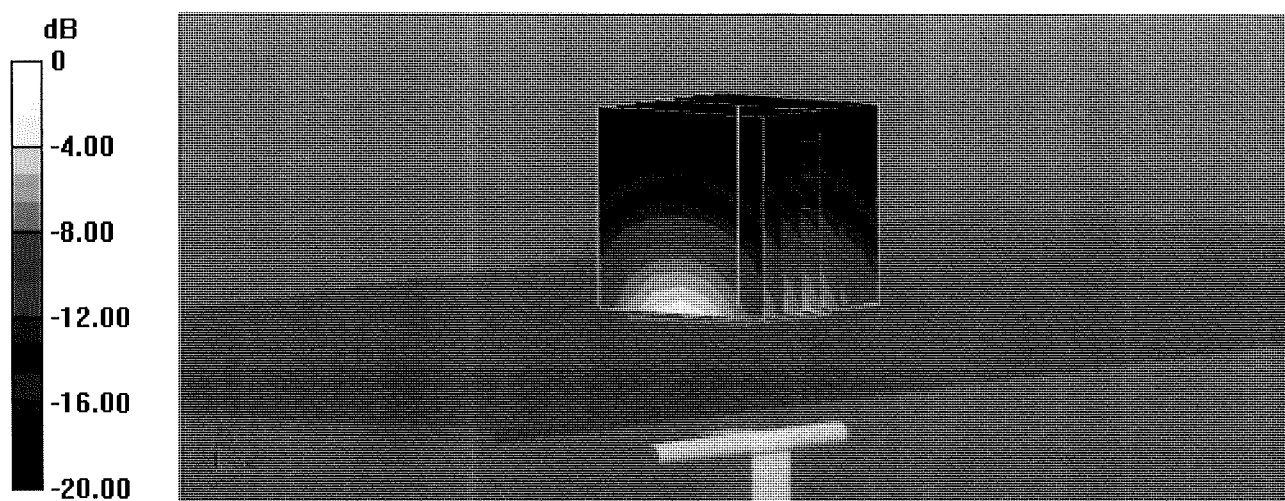
Peak SAR (extrapolated) = 29.8 W/kg

**SAR(1 g) = 14.8 W/kg; SAR(10 g) = 6.52 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.5 mm

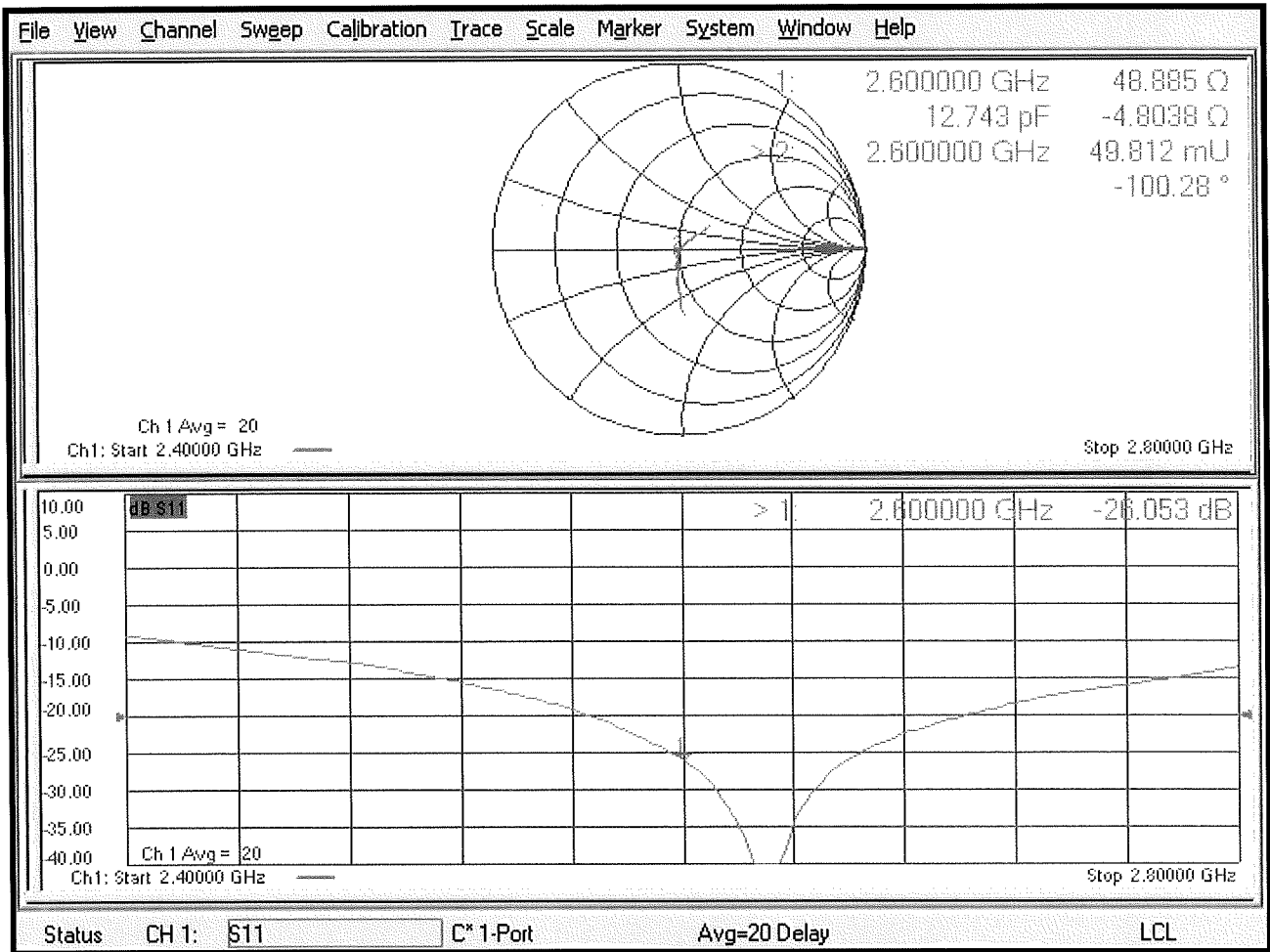
Ratio of SAR at M2 to SAR at M1 = 49.5%

Maximum value of SAR (measured) = 24.8 W/kg



0 dB = 24.8 W/kg = 13.94 dBW/kg

# Impedance Measurement Plot for Head TSL



# DASY5 Validation Report for Body TSL

Date: 14.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1004**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.22$  S/m;  $\epsilon_r = 51.0$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.91, 7.91, 7.91) @ 2600 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

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

Reference Value = 111.6 V/m; Power Drift = -0.02 dB

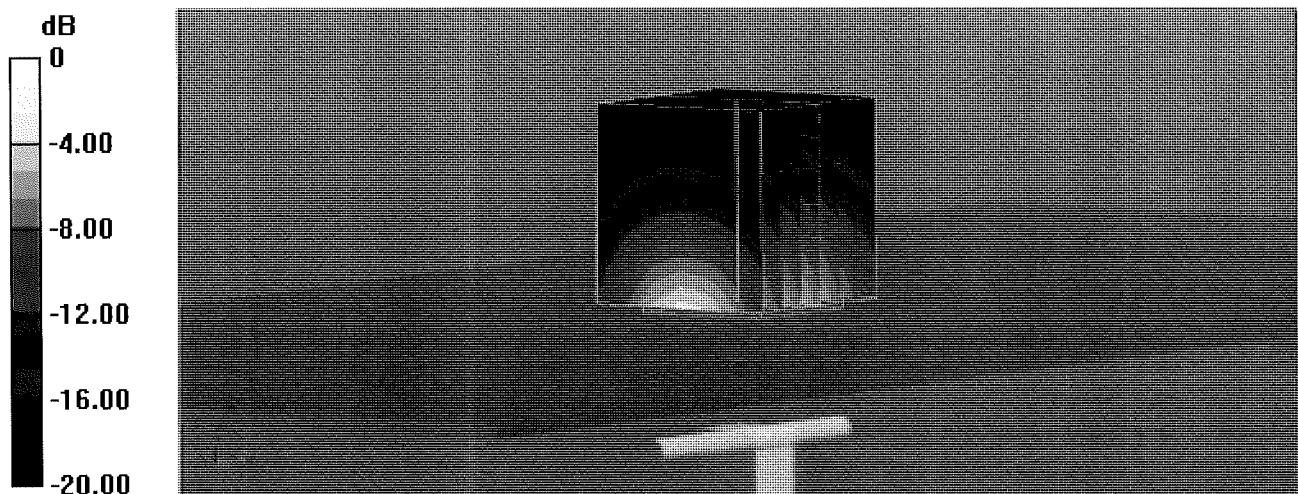
Peak SAR (extrapolated) = 28.1 W/kg

**SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.26 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.2 mm

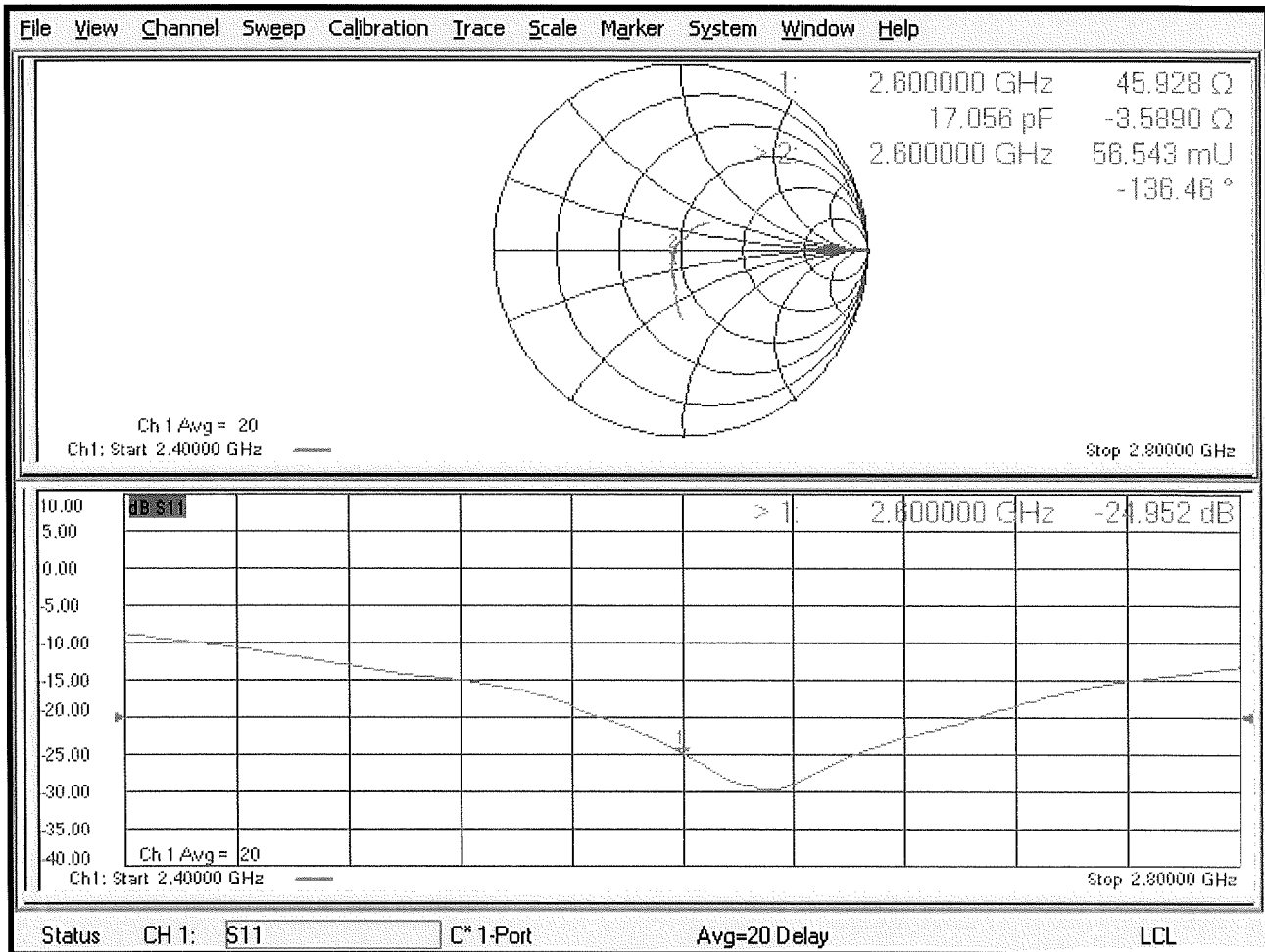
Ratio of SAR at M2 to SAR at M1 = 51%

Maximum value of SAR (measured) = 23.4 W/kg



0 dB = 23.4 W/kg = 13.69 dBW/kg

# Impedance Measurement Plot for Body TSL





# Certification of Calibration

Object: D2600V2 – SN: 1004

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 04/04/2022

Description: SAR Validation Dipole at 2600 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	6/21/2021	Annual	6/21/2022	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	9/21/2021	Annual	9/21/2022	1339008
Anritsu	MA2411B	Pulse Power Sensor	10/21/2021	Annual	10/21/2022	1339027
Anritsu	ML2496A	Power Meter	11/29/2021	Annual	11/29/2022	1840005
Anritsu	ML2496A	Power Meter	4/21/2021	Annual	4/21/2022	1351001
Control Company	4040	Therm./ Clock/ Humidity Monitor	3/12/2021	Biennial	3/12/2023	210202100
Control Company	4352	Ultra Long Stem Thermometer	10/25/2021	Annual	10/25/2022	200645916
Control Company	4353	Long Stem Thermometer	10/28/2020	Biennial	10/28/2022	200670653
MiniCircuits	VLF-6000+	Low Pass Filter	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	NC-100	Torque Wrench	8/4/2020	Biennial	8/4/2022	N/A
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/20/2021	Annual	10/20/2022	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2021	Annual	5/12/2022	1070
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	9/27/2021	Annual	9/27/2022	MY53401181
SPEAG	EX3DV4	SAR Probe	8/5/2021	Annual	8/5/2022	7670
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/3/2021	Annual	8/3/2022	1681

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Bizunesh Baldinazzo	Test Engineer	BB
Approved By:	Kaitlin O'Keefe	Senior Technical Manager	KOK

# DIPOLE CALIBRATION EXTENSION

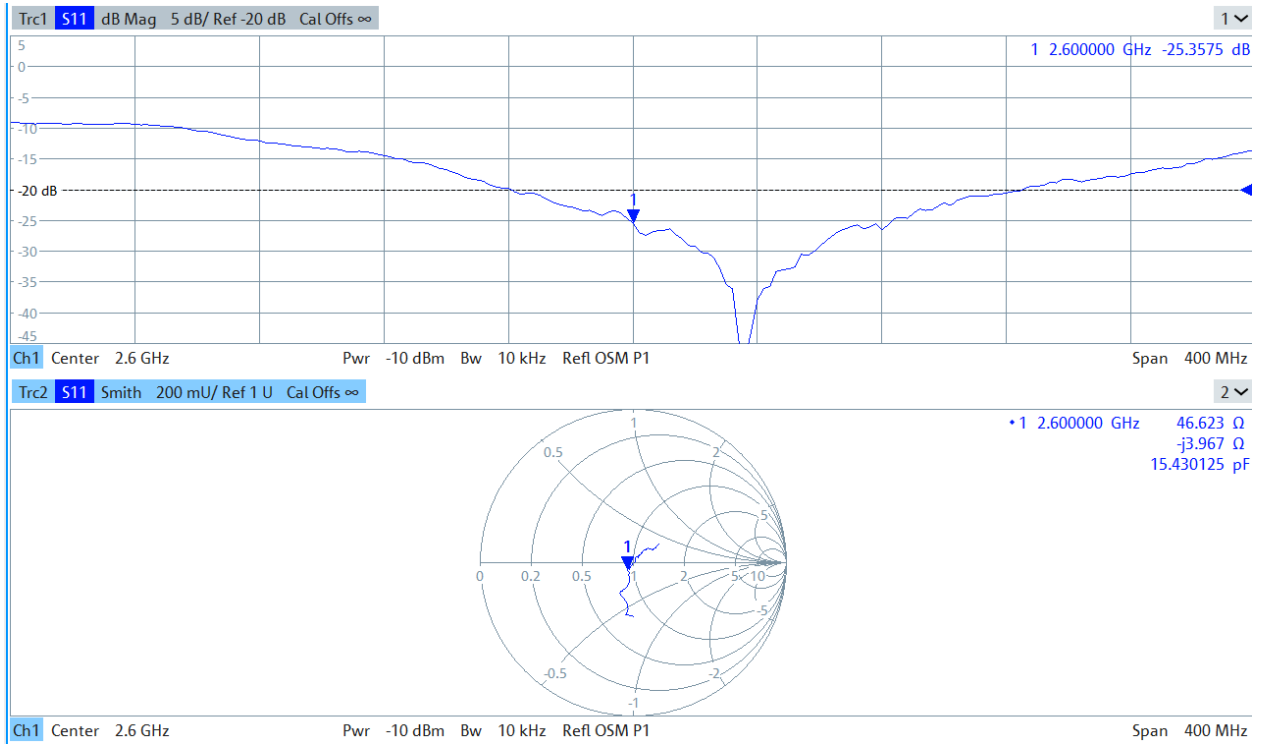
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

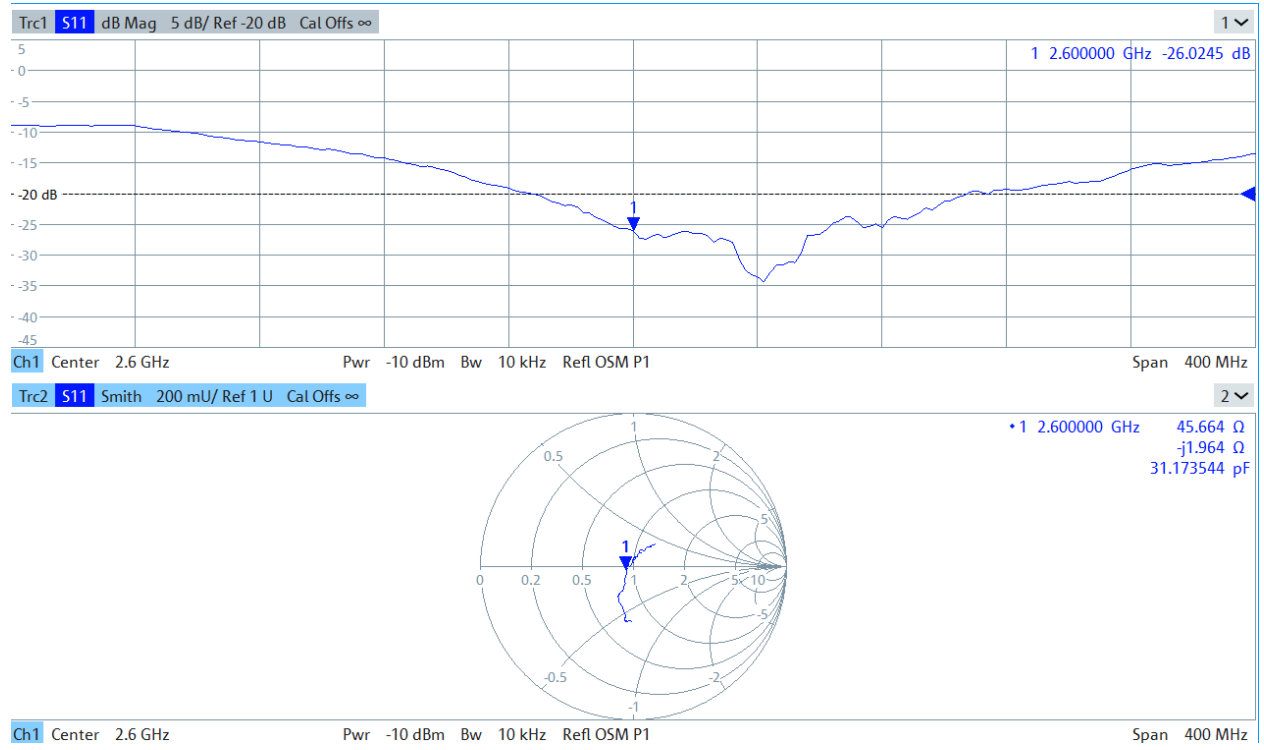
The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
4/14/2021	4/4/2022	1.15	5.75	5.85	1.73%	2.57	2.63	2.33%	45.9	46.6	2.3	-4.8	-4	0.8	-26.1	-25.4	2.80%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
4/14/2021	4/4/2022	1.15	5.54	5.54	0.00%	2.48	2.47	-0.40%	45.9	45.7	0.2	-3.6	-2	1.6	-25	-26	-4.10%	PASS

# Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL



# Certification of Calibration

Object: D2600V2 – SN: 1004

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 04/13/2023

Description: SAR Validation Dipole at 2600 MHz.

## Calibration Equipment used:

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	11/30/2022	Annual	11/30/2023	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	4/29/2022	Annual	4/29/2023	1207470
Anritsu	MA2411B	Pulse Power Sensor	10/21/2022	Annual	10/21/2023	1207364
Anritsu	ML2496A	Power Meter	8/16/2022	Annual	8/16/2023	1351001
Control Company	4410	Ambient Thermometer	5/13/2021	Biennial	5/13/2023	210403093
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774678
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/21/2022	Annual	10/21/2023	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	5/12/2022	Annual	5/12/2023	1070
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/21/2022	Annual	6/21/2023	MY53402352
SPEAG	EX3DV4	SAR Probe	7/19/2022	Annual	7/19/2023	7410
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/18/2022	Annual	7/18/2023	1583
SPEAG	EX3DV4	SAR Probe	10/17/2022	Annual	10/17/2023	7539
SPEAG	DAE4	Dasy Data Acquisition Electronics	10/17/2022	Annual	10/17/2023	1450

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Tho Tong	Test Engineer	<i>Tho Tong</i>
Approved By:	Greg Snyder	Executive VP of Operations, Regulatory	<i>Greg Snyder</i>

# DIPOLE CALIBRATION EXTENSION

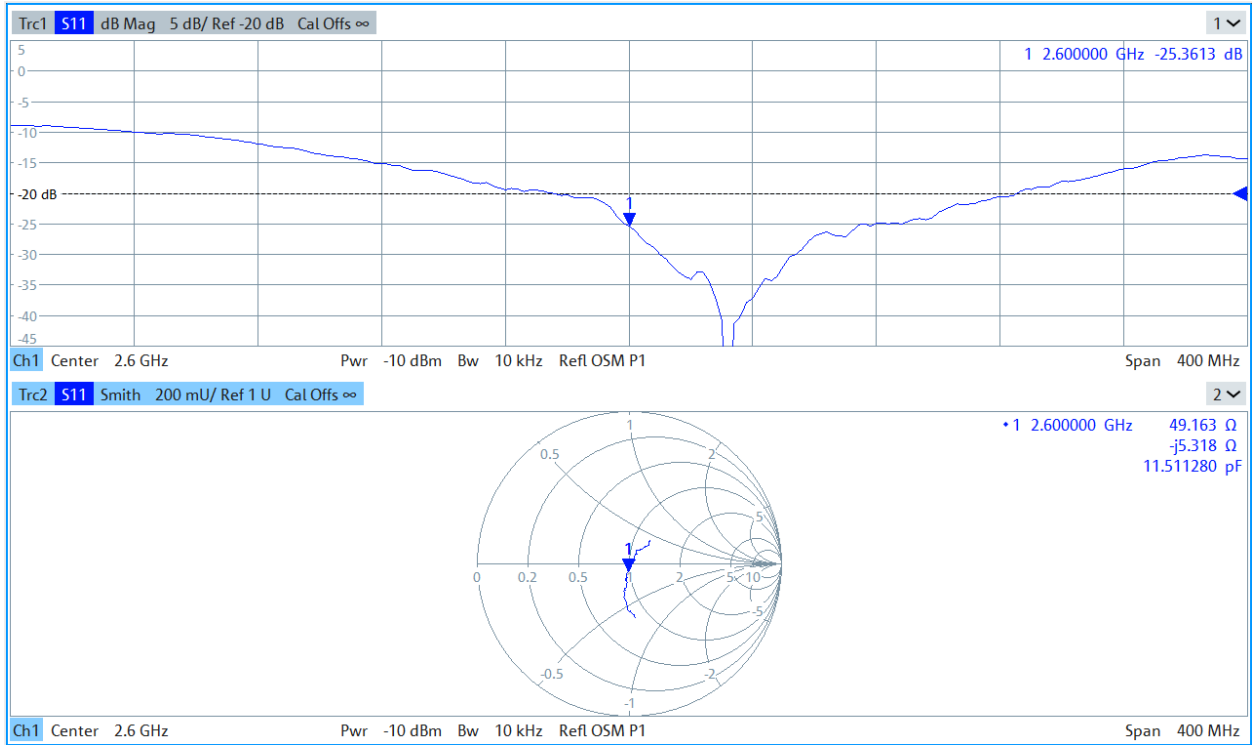
Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

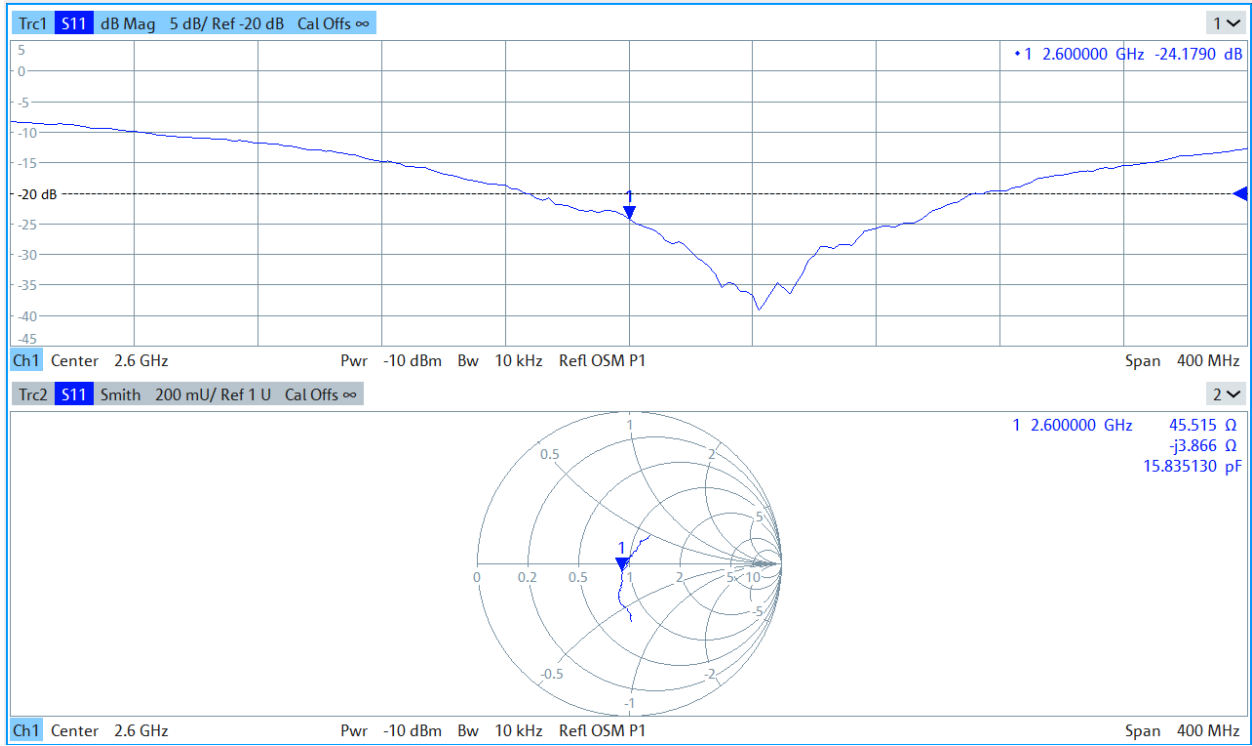
The following dipole was checked to pass the above 3 requirements to have 3-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
4/14/2021	4/13/2023	1.15	5.78	5.76	-0.35%	2.57	2.6	1.17%	48.9	49.2	0.3	-4.8	-5.3	0.5	-26.1	-25.4	2.80%	PASS
Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Body (1g) W/kg @ 20.0 dBm	Measured Body SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Body (10g) W/kg @ 20.0 dBm	Measured Body SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Body (Ohm) Real	Measured Impedance Body (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Body (Ohm) Imaginary	Measured Impedance Body (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Body (dB)	Measured Return Loss Body (dB)	Deviation (%)	PASS/FAIL
4/14/2021	4/13/2023	1.15	5.54	5.44	-1.81%	2.48	2.41	-2.82%	45.9	45.5	0.4	-3.6	-3.9	0.3	-25	-24.2	3.30%	PASS

### Impedance & Return-Loss Measurement Plot for Head TSL



# Impedance & Return-Loss Measurement Plot for Body TSL







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 **Element**

Certificate No: **D2600V2-1064\_Jun22**

## CALIBRATION CERTIFICATE

Object **D2600V2 - SN:1064**

Calibration procedure(s) **QA CAL-05.v11  
Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

*BNV  
07-08-2022*

*BNV  
06-22-2023*

Calibration date: **June 13, 2022**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-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: 7349	31-Dec-21 (No. EX3-7349_Dec21)	Dec-22
DAE4	SN: 601	02-May-22 (No. DAE4-601_May22)	May-23

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-22

Calibrated by:	Name	Function	Signature
	Joanna Lleshaj	Laboratory Technician	<i>[Signature]</i>

Approved by:	Name	Function
	Sven Kühn	Technical Manager

Issued: June 17, 2022

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



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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:

- 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.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- 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.

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

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	39.0	1.96 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	37.8 $\pm$ 6 %	2.01 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	14.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>56.4 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	condition	
SAR measured	250 mW input power	6.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>25.2 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	52.5	2.16 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	50.6 $\pm$ 6 %	2.22 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	13.9 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>54.6 W/kg <math>\pm</math> 17.0 % (k=2)</b>

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	condition	
SAR measured	250 mW input power	6.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>24.4 W/kg <math>\pm</math> 16.5 % (k=2)</b>

## Appendix (Additional assessments outside the scope of SCS 0108)

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.3 $\Omega$ - 5.7 $j\Omega$
Return Loss	- 24.4 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.5 $\Omega$ - 4.6 $j\Omega$
Return Loss	- 24.5 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.151 ns
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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
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## DASY5 Validation Report for Head TSL

Date: 13.06.2022

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1064**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.01$  S/m;  $\epsilon_r = 37.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.84, 7.84, 7.84) @ 2600 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- 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 = 116.4 V/m; Power Drift = 0.09 dB

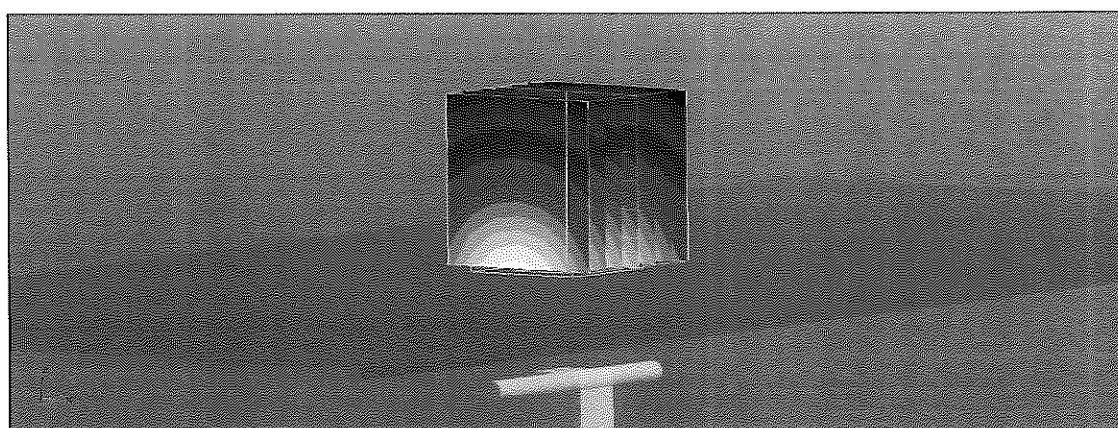
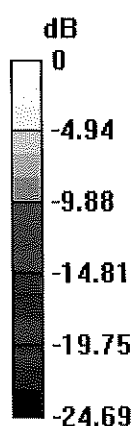
Peak SAR (extrapolated) = 29.1 W/kg

**SAR(1 g) = 14.4 W/kg; SAR(10 g) = 6.38 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.9 mm

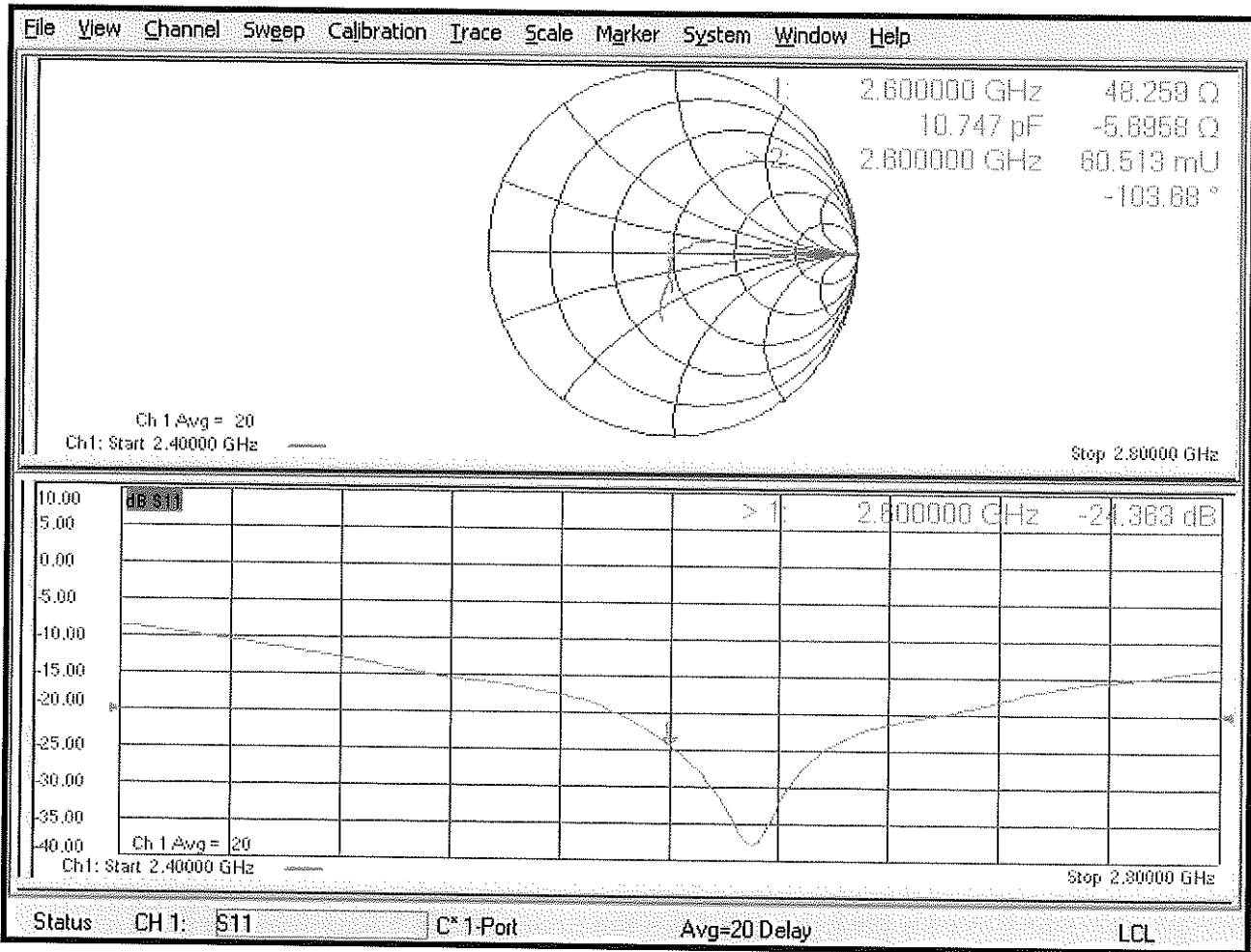
Ratio of SAR at M2 to SAR at M1 = 49.2%

Maximum value of SAR (measured) = 23.9 W/kg



0 dB = 23.9 W/kg = 13.79 dBW/kg

# Impedance Measurement Plot for Head TSL



# DASY5 Validation Report for Body TSL

Date: 13.06.2022

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1064**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.22$  S/m;  $\epsilon_r = 50.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.91, 7.91, 7.91) @ 2600 MHz; Calibrated: 31.12.2021
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.05.2022
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 108.3 V/m; Power Drift = 0.01 dB

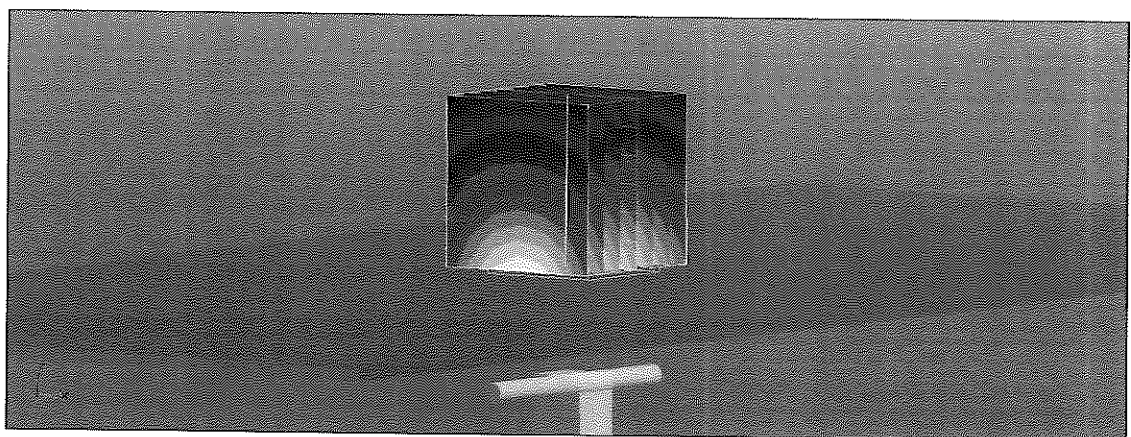
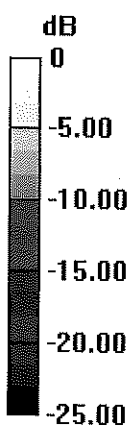
Peak SAR (extrapolated) = 28.0 W/kg

**SAR(1 g) = 13.9 W/kg; SAR(10 g) = 6.18 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.5 mm

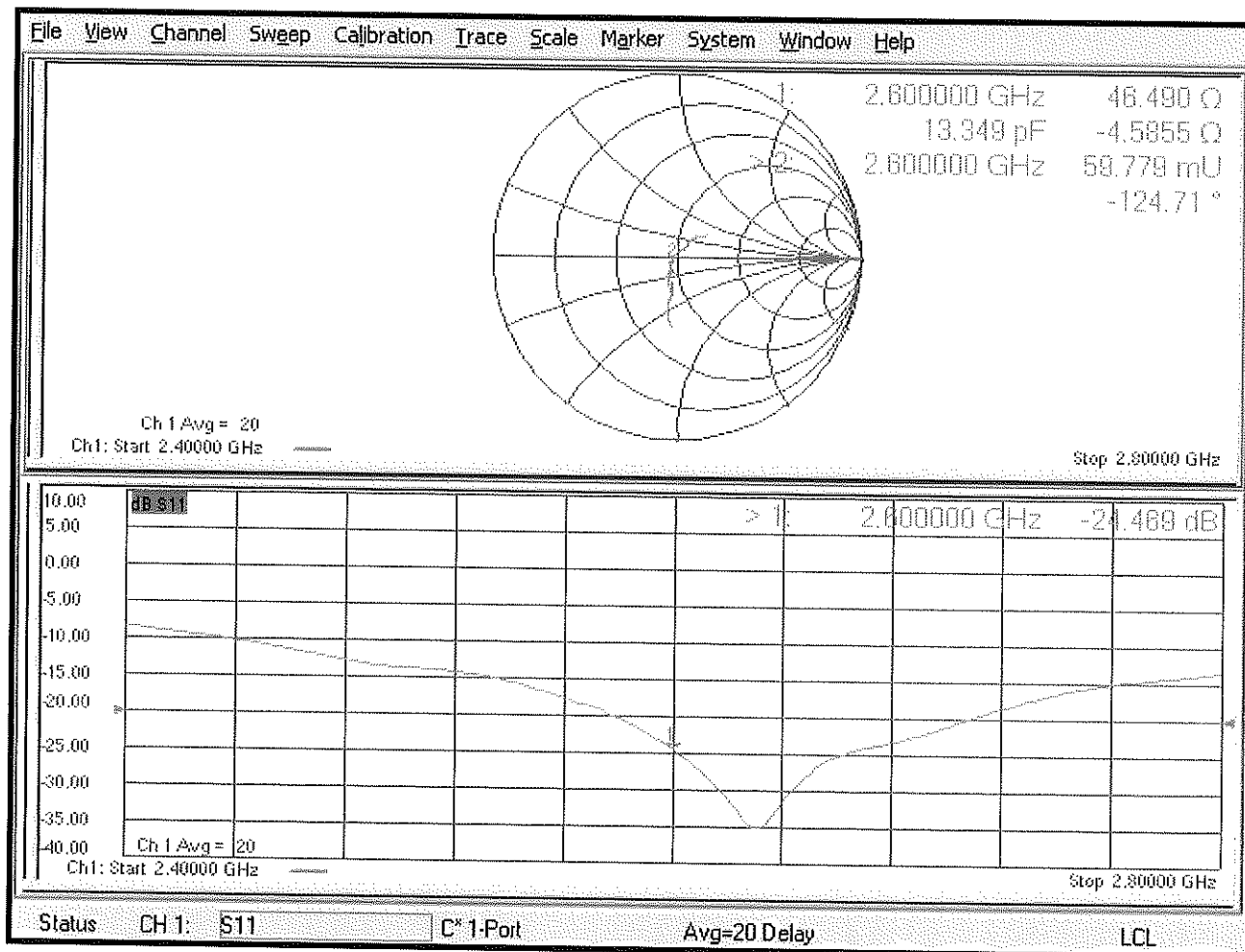
Ratio of SAR at M2 to SAR at M1 = 50.3%

Maximum value of SAR (measured) = 23.2 W/kg



0 dB = 23.2 W/kg = 13.65 dBW/kg

# Impedance Measurement Plot for Body TSL





# Certification of Calibration

Object: D2600V2 – SN: 1064

Calibration procedure(s): Procedure for Calibration Extension for SAR Dipoles.

Extension Calibration date: 06/12/2023

Description: SAR Validation Dipole at 2600 MHz.

**Calibration Equipment used:**

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	11/30/2022	Annual	11/30/2023	MY47420603
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	343971
Anritsu	MA2411B	Pulse Power Sensor	10/21/2022	Annual	10/21/2023	1207364
Anritsu	ML2496A	Power Meter	8/16/2022	Annual	8/16/2023	1351001
Control Company	4040	Therm./ Clock/ Humidity Monitor	1/17/2023	Biennial	1/17/2024	160574418
Control Company	4352	Long Stem Thermometer	9/10/2021	Biennial	9/10/2023	210774678
Mini-Circuits	BW-N20W5+	DC to 18 GHz Precision Fixed 20 dB Attenuator	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Narda	4772-3	Attenuator (3dB)	CBT	N/A	CBT	9406
Pasternack	PE5011-1	Torque Wrench	12/21/2021	Biennial	12/21/2023	82475
Mini-Circuits	ZHDC-16-63-S+	Coupler	CBT	N/A	CBT	N/A
Rohde & Schwarz	ZNLE6	Vector Network Analyzer	10/21/2022	Annual	10/21/2023	101307
SPEAG	DAK-3.5	Dielectric Assessment Kit	11/14/2022	Annual	11/14/2023	1277
Keysight Technologies	85033E	Standard Mechanical Calibration Kit (DC to 9GHz, 3.5mm)	6/21/2022	Annual	6/21/2023	MY53402352
SPEAG	EX3DV4	SAR Probe	7/18/2022	Annual	7/18/2023	7406
SPEAG	DAE4	Dasy Data Acquisition Electronics	7/18/2022	Annual	7/18/2023	1677

Measurement Uncertainty =  $\pm 23\%$  (k=2)

	Name	Function	Signature
Calibrated By:	Tho Tong	Test Engineer	<i>Tho Tong</i>
Approved By:	Greg Snyder	Executive VP of Operations, Regulatory	<i>Greg Snyder</i>

# DIPOLE CALIBRATION EXTENSION

Per KDB 865664 D01, calibration intervals of up to three years may be considered for reference dipoles when it is demonstrated that the SAR target, impedance and return loss of a dipole have remained stable according to the following requirements:

1. The measured SAR does not deviate more than 10% from the target on the calibration certificate.
2. The return-loss does not deviate more than 20% from the previous measurement and meets the required 20dB minimum return-loss requirement.
3. The measurement of real or imaginary parts of impedance does not deviate more than 5Ω from the previous measurement.

The following dipole was checked to pass the above 3 requirements to have 2-year calibration period from the calibration date:

Calibration Date	Extension Date	Certificate Electrical Delay (ns)	Certificate SAR Target Head (1g) W/kg @ 20.0 dBm	Measured Head SAR (1g) W/kg @ 20.0 dBm	Deviation 1g (%)	Certificate SAR Target Head (10g) W/kg @ 20.0 dBm	Measured Head SAR (10g) W/kg @ 20.0 dBm	Deviation 10g (%)	Certificate Impedance Head (Ohm) Real	Measured Impedance Head (Ohm) Real	Difference (Ohm) Real	Certificate Impedance Head (Ohm) Imaginary	Measured Impedance Head (Ohm) Imaginary	Difference (Ohm) Imaginary	Certificate Return Loss Head (dB)	Measured Return Loss Head (dB)	Deviation (%)	PASS/FAIL
6/13/2022	6/12/2023	1.151	5.64	5.53	-1.95%	2.52	2.51	-0.40%	48.3	51.2	2.9	-5.7	-4.9	0.8	-24.4	-26.0	-6.50%	PASS

### Impedance & Return-Loss Measurement Plot for Head TSL

