#### **Calibration Laboratory of** Schmid & Partner

**Engineering AG** Zeughausstrasse 43, 8004 Zurich, Switzerland

ulululu Accredited by the Swiss Accreditation Service (SAS)



Schweizerischer Kalibrierdienst

- Service suisse d'étalonnage
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S **Swiss Calibration Service** 

Certificate No. D1640V2-324\_Jun23

Accreditation No.: SCS 0108

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#### Client UL

Fremont, USA

CALIBRATION C	ERTIFICATI			
Object	D1640V2 - SN:3	24		
Calibration procedure(s)	QA CAL-05.v12 Calibration Proce	edure for SAR Validation Source	s between 0.7-3 GHz	
Calibration date:	June 13, 2023			
The measurements and the uncerta	ainties with confidence p ad in the closed laborator	conal standards, which realize the physical un robability are given on the following pages a y facility: environment temperature $(22 \pm 3)^{\circ}$	nd are part of the certificate.	
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	
<sup>D</sup> ower 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	fantin	>
Approved by:	Sven Kühn	Technical Manager	Sn	
This calibration certificate shall not t	be reproduced except in	full without written approval of the laboratory	Issued: June 22, 2023	

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Accreditation No.: SCS 0108

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#### **Glossary:**

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

# Calibration is Performed According to the Following Standards:

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

# Additional Documentation:

c) DASY System Handbook

# Methods Applied and Interpretation of Parameters:

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

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

### **Measurement Conditions**

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1640 MHz ± 1 MHz	

# Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.2	1.31 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.5 ± 6 %	1.27 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

# SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	8.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	33.9 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.50 W/kg
SAn measureu		4.00 W/Ng

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.4 Ω + 3.9 jΩ	
Return Loss	- 27.0 dB	

#### General Antenna Parameters and Design

Electrical Delay (one direction)	1.234 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

Managed a straight of last	ODEAO	
Manufactured by	SPEAG	

# **DASY5 Validation Report for Head TSL**

Date: 13.06.2023

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 1640 MHz; Type: D1640V2; Serial: D1640V2 - SN:324

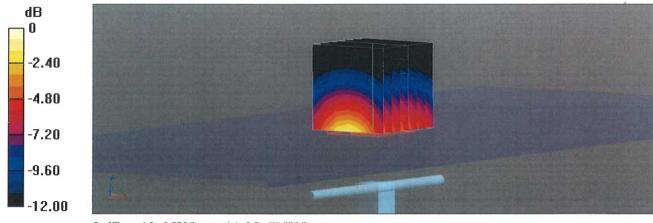
Communication System: UID 0 - CW; Frequency: 1640 MHz Medium parameters used: f = 1640 MHz;  $\sigma$  = 1.27 S/m;  $\epsilon_r$  = 40.5;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

#### DASY52 Configuration:

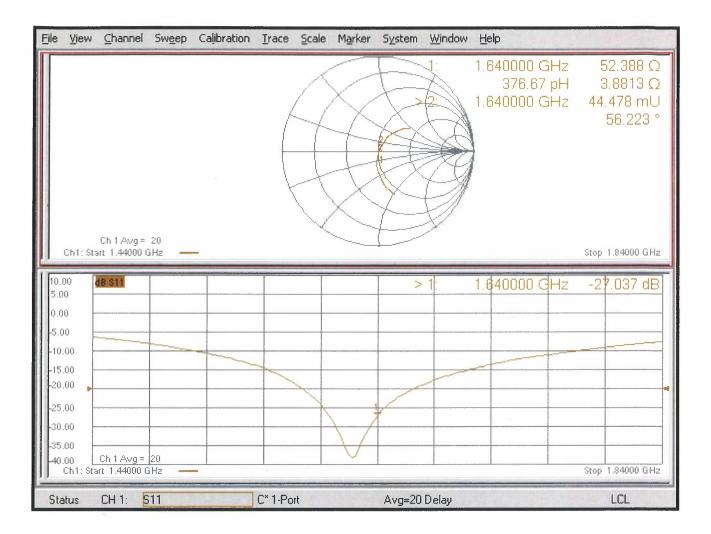
- Probe: EX3DV4 SN7349; ConvF(8.68, 8.68, 8.68) @ 1640 MHz; Calibrated: 10.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 105.8 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 14.9 W/kg **SAR(1 g) = 8.29 W/kg; SAR(10 g) = 4.5 W/kg** Smallest distance from peaks to all points 3 dB below = 10.2 mm Ratio of SAR at M2 to SAR at M1 = 56.1% Maximum value of SAR (measured) = 12.6 W/kg



0 dB = 12.6 W/kg = 11.00 dBW/kg





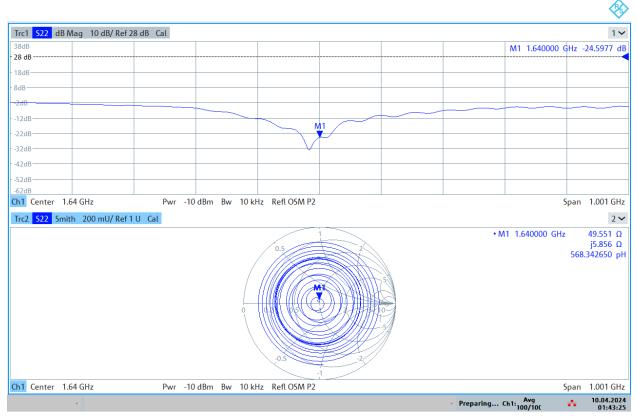
Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D1640V2-324	April 10, 2024
47173 Benicia Street	Antenna		
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Return/Loss and Impedance	Pass
2	Dipole Arms	Pass

Equipment List:		
Equipment Name:	Calibration Date:	
R&S ZNLE6 Vector Network	02/28/2025	
Analyzer		
ZV-Z135 Calibration Kit	03/31/2024	



1) Impedance and Return/Loss

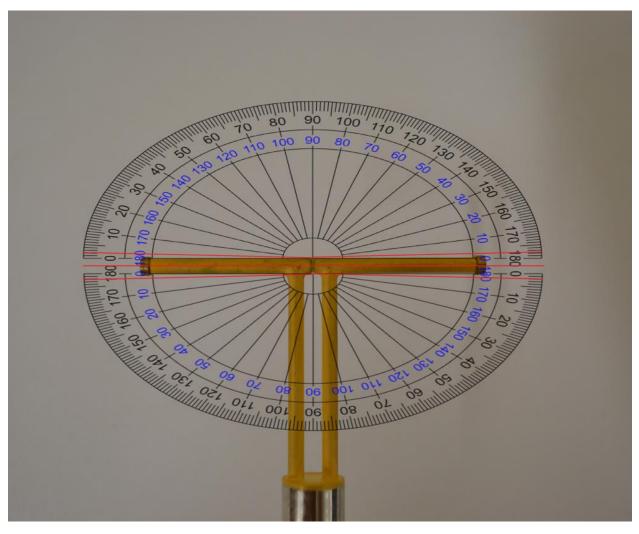


01:43:26 10.04.2024

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



2) Dipole Arms



• The center red line indicates that the arms of the dipole fall within  $\pm 2^{\circ}$ 

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Accreditation No.: SCS 0108

Client UL Fremont, USA		Certificate I	No. D2300V2-1058_Oct23
CALIBRATION C	ERTIFICATI	E	
Object	D2300V2 - SN:1	058	
Calibration procedure(s)	QA CAL-05.v12 Calibration Proce	edure for SAR Validation Sourc	es between 0.7-3 GHz
Calibration date:	October 13, 2023	3	
The measurements and the uncerta	ainties with confidence p	onal standards, which realize the physical robability are given on the following pages	and are part of the certificate.
Calibration Equipment used (M&TE		y facility: environment temperature (22 ± 3	s)°C and numidity < 70%.
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	03-Oct-23 (No. DAE4-601_Oct23)	Oct-24
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-22)	In house check: Oct-24
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24
	Name	Function	Signature
Calibrated by:	Paulo Pina	Laboratory Technician	Furthe
Approved by:	Sven Kühn	Technical Manager	<i>~i</i>

Issued: October 16, 2023 This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

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Certificate No: D2300V2-1058\_Oct23

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### Glossary:

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

# Calibration is Performed According to the Following Standards:

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

# **Additional Documentation:**

c) DASY System Handbook

# Methods Applied and Interpretation of Parameters:

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

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

# **Measurement Conditions**

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

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

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.5	1.67 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.3 ± 6 %	1.70 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

# SAR result with Head TSL

SAR averaged over 1 $cm^3$ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	12.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	48.4 W/kg ± 17.0 % (k=2)
	r	
SAR averaged over 10 $\text{cm}^3$ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.93 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.5 W/kg ± 16.5 % (k=2)

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

#### **Antenna Parameters with Head TSL**

Impedance, transformed to feed point	46.8 Ω - 3.5 jΩ
Return Loss	- 26.2 dB

#### General Antenna Parameters and Design

Electrical Delay (one direction) 1.171 ns	Electrical Delay (one direction)	1.171 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: 13.10.2023

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1058

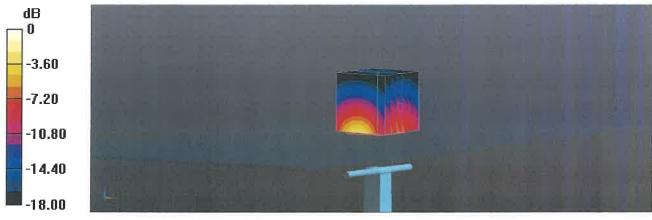
Communication System: UID 0 - CW; Frequency: 2300 MHz Medium parameters used: f = 2300 MHz;  $\sigma = 1.7$  S/m;  $\epsilon_r = 38.3$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

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: 03.10.2023
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

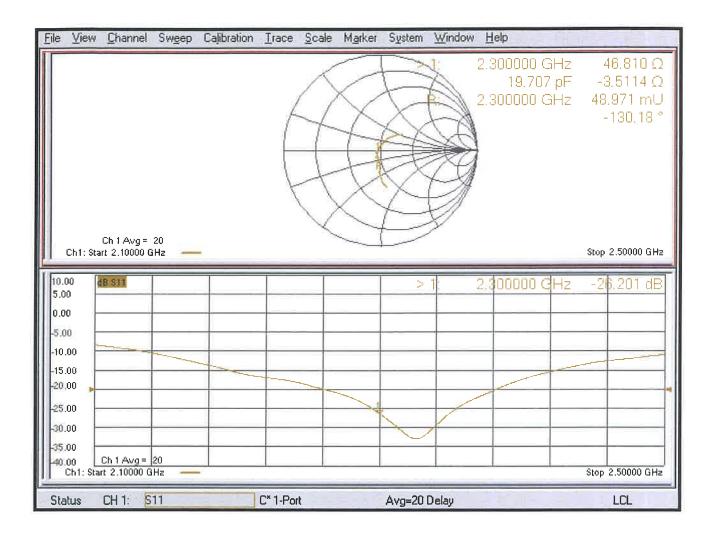
# Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 114.7 V/m; Power Drift = 0.08 dB Peak SAR (extrapolated) = 22.4 W/kg **SAR(1 g) = 12.3 W/kg; SAR(10 g) = 5.93 W/kg** Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 55.8% Maximum value of SAR (measured) = 18.6 W/kg



0 dB = 18.6 W/kg = 12.68 dBW/kg

### Impedance Measurement Plot for Head TSL



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Swiss Calibration Service

Accreditation No.: SCS 0108

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**UL USA** Client

Certificate No: D2450V2-706\_Jan23

# **CALIBRATION CERTIFICATE**

Object	D2450V2 - SN:7	06	
Calibration procedure(s)	QA CAL-05.v12 Calibration Proce	edure for SAR Validation Source	es between 0.7-3 GHz
Calibration date:	January 20, 2023	3 Sector States States in the sector of t	
The measurements and the uncerta	ainties with confidence predimentation and the closed laborator	onal standards, which realize the physical u robability are given on the following pages a y facility: environment temperature (22 ± 3)	and are part of the certificate.
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	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	Janto
Approved by:	Sven Kühn	Technical Manager	5 6
This calibration certificate shall not	pe reproduced except in	full without written approval of the laborator	Issued: January 20, 2023

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### Glossary:

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

# Calibration is Performed According to the Following Standards:

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

# Additional Documentation:

c) DASY System Handbook

# Methods Applied and Interpretation of Parameters:

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

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

# **Measurement Conditions**

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

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

# Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.7 ± 6 %	1.87 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	Laterate.	

#### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.3 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.5 W/kg ± 16.5 % (k=2)

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

# Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.6 Ω + 4.3 jΩ	
Return Loss	- 26.8 dB	-

#### General Antenna Parameters and Design

Electrical Delay (one direction)	1.142 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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Date: 20.01.2023

Test Laboratory: SPEAG, Zurich, Switzerland

# DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:706

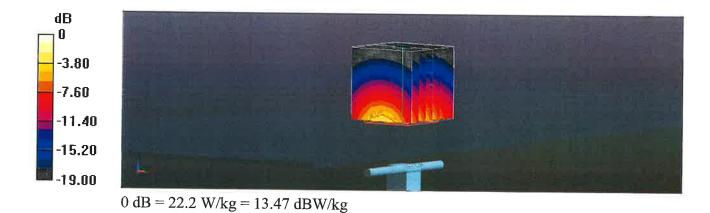
Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma = 1.87$  S/m;  $\epsilon_r = 38.7$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

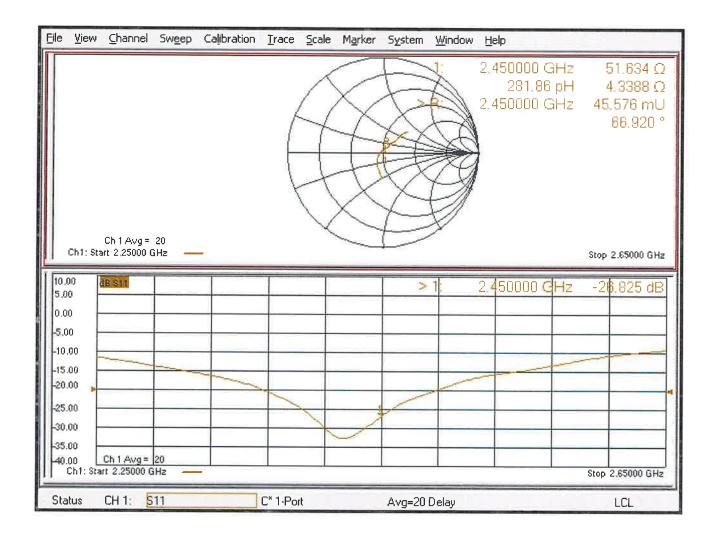
- Probe: EX3DV4 SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 10.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 115.7 V/m; Power Drift = -0.05 dB Peak SAR (extrapolated) = 26.5 W/kg **SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.19 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) = 22.2 W/kg



# Impedance Measurement Plot for Head TSL





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D2450V2-706	January 29,
47173 Benicia Street	Antenna		2024
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Return/Loss and Impedance	Pass
2	Dipole Arms	Pass

Equipment List:				
Equipment Name:	Calibration Date:			
R&S ZNLE6 Vector Network 02/28/2025				
Analyzer				
ZV-Z135 Calibration Kit	03/31/2024			



1) Impedance and Return/Loss

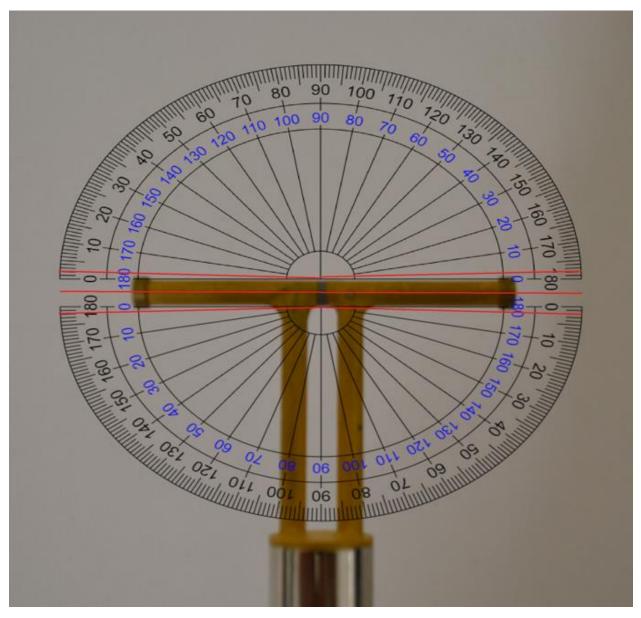
	J/ Ref 1 U Cal	0	0.5		5 0 0	M1 2.450000 (	-j	1 ► 8.005 Ω (2.508 Ω 01227 p
h1 Center 2.45 GHz	Pwr -10	dBm Bw 10k	Hz Refl OSM P1	1			Snan	800 MHz
Frc2 S11 dB Mag 10 df							span	2 ~
0						 M1 2.450000	) GHz -29	
) dB						 		
10						 		
20				11				
0			+	<u> </u>				
0								
0								
0								
0								
0								
0	 Pwr -10	dBm Bw 10 k	Hz Refl OSM P1				Span	800 MH

02:16:35 30.01.2024

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



2) Dipole Arms



• The center red line indicates that the arms of the dipole fall within  $\pm 2^\circ$ 

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



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Accreditation No.: SCS 0108

Certificate No: D2450V2-748\_Feb23

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

**UL USA** Client

CALIBRATION C	ERTIFICATE		
Object	D2450V2 - SN:74	18	
Calibration procedure(s)	QA CAL-05.v12 Calibration Proce	dure for SAR Validation Sources	s between 0.7-3 GHz
Calibration date:	February 08, 202	3	
The measurements and the uncerta	ainties with confidence pr ed in the closed laborator	onal standards, which realize the physical un obability are given on the following pages ar y facility: environment temperature (22 ± 3)°	nd are part of the certificate.
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	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	tant
Approved by:	Sven Kühn	Technical Manager	5.6
			Issued: February 9, 2023
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.

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

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	39.3 ± 6 %	1.85 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	(1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999) (1999)	

### SAR result with Head TSL

SAR averaged over 1 $cm^3$ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.7 W/kg ± 17.0 % (k=2)
	I I	
SAR averaged over 10 $\text{cm}^3$ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.08 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.2 W/kg ± 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	54.1 Ω - 0.6 jΩ
Return Loss	- 27.9 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 ns
----------------------------------	----------

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

# Additional EUT Data

Manufactured by	SPEAG

# **DASY5 Validation Report for Head TSL**

Date: 08.02.2023

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:748

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma = 1.85$  S/m;  $\epsilon_r = 39.3$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

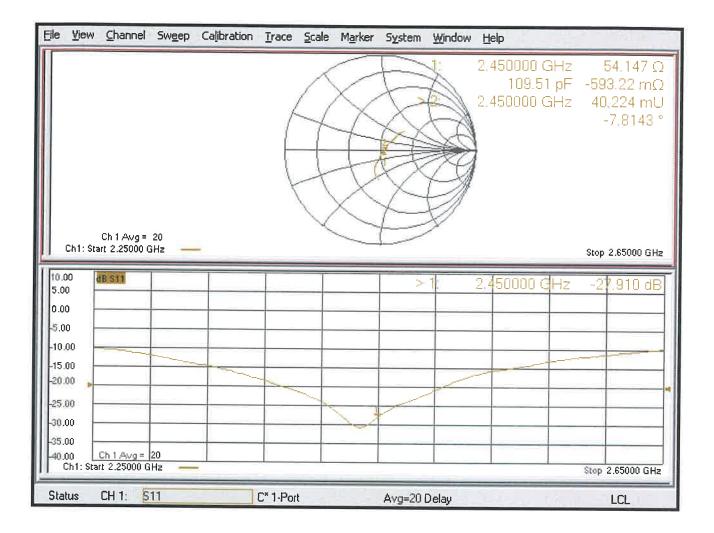
- Probe: EX3DV4 SN7349; ConvF(7.88, 7.88, 7.88) @ 2450 MHz; Calibrated: 10.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 115.0 V/m; Power Drift = 0.05 dB Peak SAR (extrapolated) = 26.0 W/kg **SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.08 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) = 21.5 W/kg



0 dB = 21.5 W/kg = 13.32 dBW/kg





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D2450V2-748	February 08,
47173 Benicia Street	Antenna		2023
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Visual Inspection	Pass
2	Return/Loss and Impedance	Pass
3	Dipole Arms	Pass

Equipment List:		
Equipment Name:	Calibration Date:	
R&S ZNLE6 Vector Network	03/05/2024	
Analyzer		
ZV-Z135 Calibration Kit	03/27/2024	



# 1) Photo of Dipole



• The connector of dipole contains no abnormalities.



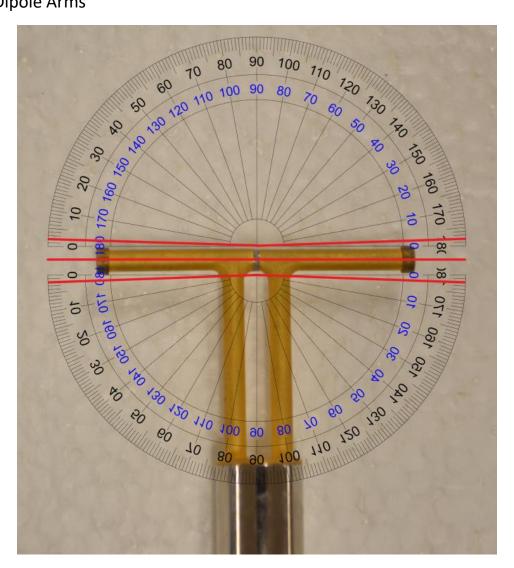
Trc1 S11 Smith 200 mU/ Ref 1 U	Cal					1
		0,00			•M1 2.450000 (	
			_1			
Ch1 Center 2.45 GHz		Bw 10 kHz Refl OSM P1				Span 100 Mi
Trc2 S11 dB Mag 10 dB/ Ref 0 d		Bw 10 kHz Refl OSM P1			M1 2.45000	Span 100 MI 2 00 GHz -31.3208
Trc2 511 dB Mag 10 dB/ Ref 0 d 30		Bw 10 kHz Refl OSM P1			M1 2.45000	2
Trc2 511 dB Mag 10 dB/ Ref 0 d 30 20		Bw 10 kHz Refl OSM P1			M1 2.45000	2
Center     2.45 GHz       Trc2     511     dB Mag     10 dB/ Ref 0 d       20		Bw 10 kHz Refl OSM P1			M1 2.45000	2
Tre2 S11 dB Mag 10 dB/ Ref 0 d		Bw 10 kHz Reft OSM P1			M1 2.450b0	2
Tre2 S11 dB Mag 10 dB/ Ref 0 d 0 0 0 0 0 0 0 0 0 0 10 10		Bw 10 kHz Refl OSM P1			M1 2.450b0	2
Tre2 S11 dB Mag 10 dB/ Ref 0 d 0 0 0 0 0 0 0 0 0 0 10 10		Bw 10 kHz Refl OSM P1			M1 2.45000	2
Tre2 S11 dB Mag 10 dB/ Ref 0 d 0 0 0 0 0 0 0 0 0 0 0 0 0		Bw 10 kHz Refl OSM P1	MI		M1 2.450bc	2
Tre2 S11 dB Mag 10 dB/ Ref 0 d 0 0 0 0 0 0 0 0 0 0 0 0 0		Bw 10 kHz Reft OSM P1	M1		M1 2.45000	2
Trc2 S11 dB Mag 10 dB/ Ref 0 d 0 0 0 0 0 0 0 0 0		Bw 10 kHz Refl OSM P1	MI		M1 2.45000	2
Trc2 S11 dB Mag 10 dB/ Ref 0 d		Bw 10 kHz Refl OSM P1	MI		M1 2.45000	2
Trc2 S11 dB Mag 10 dB/ Ref 0 d		Bw 10 kHz Refl OSM P1	M		M1 2.45000	2

2) Impedance and Return/Loss

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



3) Dipole Arms



• The center red line indicates that the arms of the dipole fall within  $\pm 2^\circ$ 

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Accreditation No.: SCS 0108

Client UL Fremo

CALIBR

Object

	Certificate No.	D2600V2-1006_Oct23
ont, USA		
ATION CERTIFICATE		
D2600V2 - SN:1006		

Calibration procedure(s)

QA CAL-05.v12 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz

Calibration date:

October 13, 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	03-Oct-23 (No. DAE4-601_Oct23)	Oct-24
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB39512475	30-Oct-14 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
Power sensor HP 8481A	SN: MY41093315	07-Oct-15 (in house check Oct-22)	In house check: Oct-24
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-22)	In house check: Oct-24
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24
	Name	Function	Signature
Calibrated by:	Paulo Pina	Laboratory Technician	tante
Approved by:	Sven Kühn	Technical Manager	S.L
			laguad: October 16, 2022
This calibration certificate shall not b	a reproduced except in	full without written approval of the labora	Issued: October 16, 2023

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





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### Glossary:

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

# Calibration is Performed According to the Following Standards:

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

# Additional Documentation:

c) DASY System Handbook

# Methods Applied and Interpretation of Parameters:

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

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

#### **Measurement Conditions**

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

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

#### Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.1 ± 6 %	2.03 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	2	

#### SAR result with Head TSL

SAR averaged over 1 $\text{cm}^3$ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	56.1 W/kg ± 17.0 % (k=2)
SAR averaged over 10 $\text{cm}^3$ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.45 W/kg
		•·····

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	47.3 Ω - 3.8 jΩ
Return Loss	- 26.4 dB

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.149 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

SPEAG

#### **DASY5 Validation Report for Head TSL**

Date: 13.10.2023

Test Laboratory: SPEAG, Zurich, Switzerland

#### DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1006

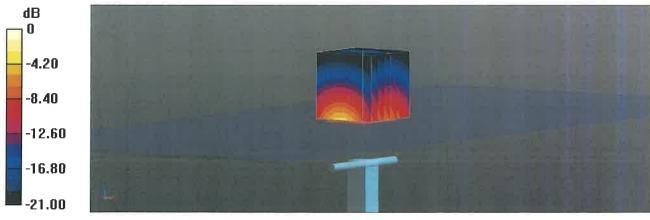
Communication System: UID 0 - CW; Frequency: 2600 MHz Medium parameters used: f = 2600 MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 37.1$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.68, 7.68, 7.68) @ 2600 MHz; Calibrated: 10.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 03.10.2023
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

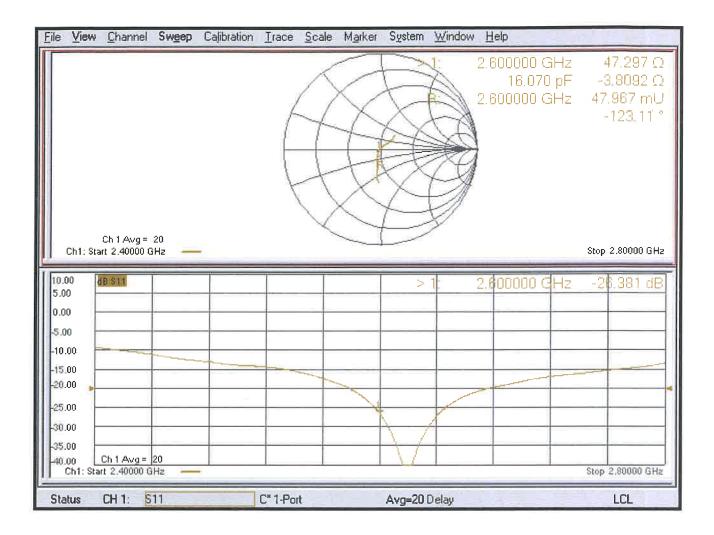
#### Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mmReference Value = 118.2 V/m; Power Drift = 0.09 dB Peak SAR (extrapolated) = 28.6 W/kg **SAR(1 g) = 14.4 W/kg; SAR(10 g) = 6.45 W/kg** Smallest distance from peaks to all points 3 dB below = 9 mm Ratio of SAR at M2 to SAR at M1 = 51% Maximum value of SAR (measured) = 23.1 W/kg



0 dB = 23.1 W/kg = 13.64 dBW/kg

#### Impedance Measurement Plot for Head TSL



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Accreditation No.: SCS 0108

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Client UL USA

Certificate No: D3500V2-1060\_Feb23

Object	D3500V2 - SN:10	060	
Calibration procedure(s)	QA CAL-22.v7 Calibration Proce	edure for SAR Validation Source	es between 3-10 GHz
Calibration date:	February 07, 202	23	
The measurements and the uncert	ainties with confidence p ed in the closed laborator	onal standards, which realize the physical u robability are given on the following pages a ry facility: environment temperature (22 $\pm$ 3)	and are part of the certificate.
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
ower sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Ower sensor NRP-Z91			7 ipi 20
	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23
eference 20 dB Attenuator	SN: BH9394 (20k) SN: 310982 / 06327	04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528)	Apr-23 Apr-23
eference 20 dB Attenuator pe-N mismatch combination	, ,	04-Apr-22 (No. 217-03528)	Apr-23 Apr-23 Mar-23
eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4	SN: 310982 / 06327		Apr-23
Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 310982 / 06327 SN: 3503	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22)	Apr-23 Mar-23
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards	SN: 310982 / 06327 SN: 3503 SN: 601	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22)	Apr-23 Mar-23 Dec-23
Reference 20 dB Attenuator ype-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards rower meter E4419B	SN: 310982 / 06327 SN: 3503 SN: 601	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house)	Apr-23 Mar-23 Dec-23 Scheduled Check
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards Power meter E4419B Power sensor HP 8481A	SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house) 30-Oct-14 (in house check Oct-22)	Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24
Reference 20 dB Attenuator ype-N mismatch combination Reference Probe EX3DV4 PAE4 Recondary Standards rower meter E4419B rower sensor HP 8481A rower sensor HP 8481A rower sensor HP 8481A rower sensor HP 8481A	SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: 100972	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house) 30-Oct-14 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 15-Jun-15 (in house check Oct-22)	Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24 In house check: Oct-24
Reference 20 dB Attenuator ype-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards rower meter E4419B rower sensor HP 8481A Power sensor HP 8481A Regenerator R&S SMT-06	SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house) 30-Oct-14 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 07-Oct-15 (in house check Oct-22)	Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24 In house check: Oct-24 In house check: Oct-24
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Becondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: 100972 SN: US41080477 Name	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house) 30-Oct-14 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 15-Jun-15 (in house check Oct-22) 31-Mar-14 (in house check Oct-22) Function	Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24 In house check: Oct-24 In house check: Oct-24 In house check: Oct-24 In house check: Oct-24
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Becondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: 100972 SN: US41080477	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house) 30-Oct-14 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 15-Jun-15 (in house check Oct-22) 31-Mar-14 (in house check Oct-22)	Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24 In house check: Oct-24
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Becondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: 100972 SN: US41080477 Name	04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house) 30-Oct-14 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 15-Jun-15 (in house check Oct-22) 31-Mar-14 (in house check Oct-22) Function	Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24 In house check: Oct-24

#### **Calibration Laboratory of**

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



Schweizerischer Kalibrierdienst

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Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Glossary:

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

#### Calibration is Performed According to the Following Standards:

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

#### Additional Documentation:

c) DASY System Handbook

#### Methods Applied and Interpretation of Parameters:

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

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

#### **Measurement Conditions**

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	3500 MHz ± 1 MHz	

#### **Head TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	37.9	2.91 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	37.9 ± 6 %	2.96 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL

SAR averaged over 1 $cm^3$ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	6.59 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	65.7 W/kg ± 19.9 % (k=2)
	1	
SAR averaged over 10 $cm^3$ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.49 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.9 W/kg ± 19.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.4 Ω - 6.3 jΩ
Return Loss	- 23.6 dB

#### General Antenna Parameters and Design

Electrical Delay (one direction)	1.132 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

#### Additional EUT Data

Manufactured by	SPEAG

#### **DASY5 Validation Report for Head TSL**

Date: 07.02.2023

Test Laboratory: SPEAG, Zurich, Switzerland

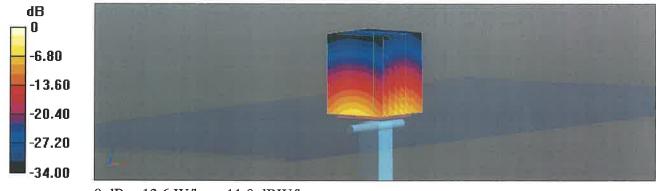
#### DUT: Dipole 3500 MHz; Type: D3500V2; Serial: D3500V2 - SN:1060

Communication System: UID 0 - CW; Frequency: 3500 MHz Medium parameters used: f = 3500 MHz;  $\sigma = 2.96$  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)

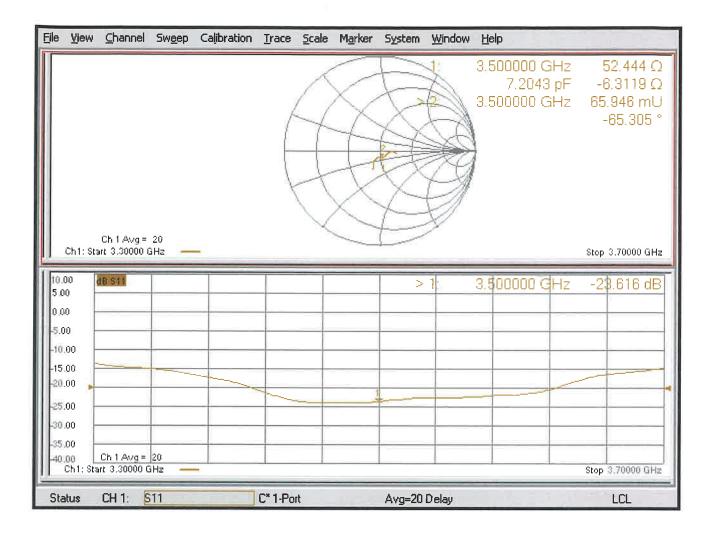
DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(7.91, 7.91, 7.91) @ 3500 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

**Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3500MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 69.44 V/m; Power Drift = -0.07 dB Peak SAR (extrapolated) = 17.5 W/kg **SAR(1 g) = 6.59 W/kg; SAR(10 g) = 2.49 W/kg** Smallest distance from peaks to all points 3 dB below = 8.2 mm Ratio of SAR at M2 to SAR at M1 = 75.9% Maximum value of SAR (measured) = 12.6 W/kg



0 dB = 12.6 W/kg = 11.0 dBW/kg





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D3500V2-1060	February 07,
47173 Benicia Street	Antenna		2023
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Visual Inspection	Pass
2	Return/Loss and Impedance	Pass
3	Dipole Arms	Pass

Equipment List:		
Equipment Name:	Calibration Date:	
R&S ZNLE6 Vector Network	03/05/2024	
Analyzer		
ZV-Z135 Calibration Kit	03/27/2024	



## 1) Photo of Dipole



• The connector of dipole contains no abnormalities.



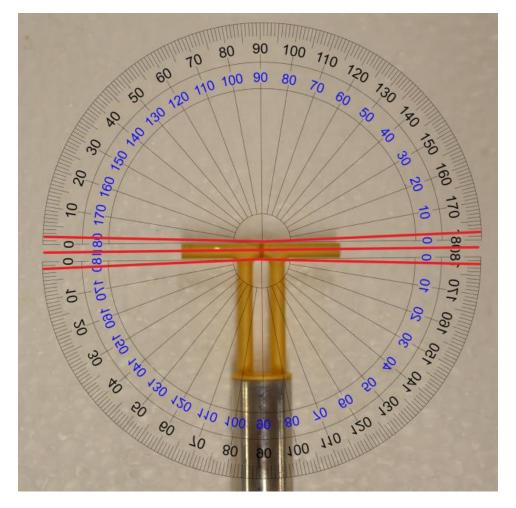
Trc1 S11 Smith 200 mU/ Ref 1 U Cal		1~
		- M1 3.50000 GHz 56.166 C ;4.886 9.284118 p
h1 Center 3.5 GHz	Pwr -10 dBm Bw 10 kHz Refl OSM P1	Span 200 MH
Ch1 Center 3.5 GHz Trc2 S11 dB Mag 10 dB/ Ref 0 dB Cal	Pwr -10 dBm Bw 10 kHz Refl OSM P1	Span 200 MH
Trc2 511 dB Mag 10 dB/ Ref 0 dB Cal	Pwr -10 dBm Bw 10 kHz Refl OSM P1	
Trc2 511 dB Mag 10 dB/ Ref 0 dB Cal	Pwr -10 dBm Bw 10 kHz Refl OSM P1	2.
Trc2 S11 dB Mag 10 dB/ Ref 0 dB Cal	Pwr -10 dBm Bw 10 kHz Refl OSM P1	2.
Trc2     S11     dB Mag     10 dB/ Ref 0 dB     Cal       30	Pwr -10 dBm Bw 10 kHz Refl OSM P1	2
Trc2 511 dB Mag 10 dB/ Ref 0 dB Cat 10 10 10 0 dB 10 10 10 10 10 10 10 10 10 10	Pwr -10 dBm Bw 10 kHz Refl OSM P1	2
Trc2 511 dB Mag 10 dB/ Ref 0 dB Cat 10 10 10 0 dB 10 10 10 10 10 10 10 10 10 10		2
Trc2 [S11] dB Mag 10 dB/ Ref 0 dB Cat 00 10 00 0 dB 10 10	Pwr -10 dBm Bw 10 kHz Refl OSM P1	2
Trc2 S11 dB Mag 10 dB/ Ref 0 dB Cat 0 0 0 0 0 0 0 0 0 0 0 0 0		2
Trc2 S11 dB Mag 10 dB/ Ref 0 dB Cat 0 0 0 0 0 0 0 0 0 0 0 0 0		2
Trc2 [S11] dB Mag 10 dB/ Ref 0 dB Cat 10 10 10 10 10 10 20 30 10 10 10 10 10 10 10 10 10 1		2
TrC2 S11 dB Mag 10 dB/ Ref 0 dB Cat 30 20 10 0 dB 30 30 40 40 51 51 51 51 51 51 51 51 51 51		2.
Trc2     S11     dB Mag     10 dB/ Ref 0 dB     Cat       30		2.
Trc2 511 dB Mag 10 dB/ Ref 0 dB Cal		2 .

## 2) Impedance and Return/Loss

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



3) Dipole Arms



• The center red line indicates that the arms of the dipole fall within  $\pm 2^{\circ}$ 

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



Schweizerischer Kalibrierdienst

Service suisse d'étalonnage

Servizio svizzero di taratura

S Swiss Calibration Service

Accreditation No.: SCS 0108

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Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Client UL USA

Certificate No: D5GHzV2-1003\_Feb23

Object	D5GHzV2 - SN:	1003	
Calibration procedure(s)	QA CAL-22.v7		
	Calibration Proce	edure for SAR Validation Sources	s between 3-10 GHz
Calibration date:	February 22, 202	23	
This calibration certificate docume	nts the traceability to nati	ional standards, which realize the physical un	nits of measurements (SI)
he measurements and the uncert	ainties with confidence n	probability are given on the following pages ar	nd are part of the certificate
	antico with confidence p	robability are given on the following pages ar	id are part of the certificate.
U oplikastiene kom kom som det t			
il calibrations have been conducto	ed in the closed laborator	ry facility: environment temperature (22 $\pm$ 3)°	C and humidity < 70%.
Calibration Equipment used (M&TE	E critical for calibration)		
alibration Equipment used (M&TE	E critical for calibration)		
	E critical for calibration)	Cal Date (Certificate No.)	Scheduled Calibration
rimary Standards	1	Cal Date (Certificate No.) 04-Apr-22 (No. 217-03525/03524)	Scheduled Calibration
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rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 reference 20 dB Attenuator	ID # SN: 104778 SN: 103244 SN: 103245	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527)	Apr-23 Apr-23 Apr-23 Apr-23
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k)	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23
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Calibration Equipment used (M&TE Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503	04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22)	Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Mar-23 Dec-23
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#### Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



Schweizerischer Kalibrierdienst

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Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### Glossary:

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

#### Calibration is Performed According to the Following Standards:

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

#### Additional Documentation:

c) DASY System Handbook

#### Methods Applied and Interpretation of Parameters:

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

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

#### **Measurement Conditions**

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

DASY Version	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz 5850 MHz ± 1 MHz	

#### Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

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

## SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.03 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.9 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	5.06 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.7 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

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

### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 $cm^3$ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.92 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.4 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5850 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.2	5.32 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.4 ± 6 %	5.25 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

## SAR result with Head TSL at 5850 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.13 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg ± 19.5 % (k=2)

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

#### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	48.6 Ω - 5.6 jΩ	
Return Loss	- 24.7 dB	

#### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	55.3 Ω + 0.9 jΩ
Return Loss	- 25.8 dB

#### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	56.1 Ω - 2.9 jΩ
Return Loss	- 24.0 dB

#### Antenna Parameters with Head TSL at 5850 MHz

Impedance, transformed to feed point	60.4 Ω - 3.7 jΩ	
Return Loss	- 20.1 dB	

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.204 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
	OF EAG

Date: 22.02.2023

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1003

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5850 MHz Medium parameters used: f = 5250 MHz;  $\sigma = 4.67$  S/m;  $\varepsilon_r = 36$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5600 MHz;  $\sigma = 5.06$  S/m;  $\varepsilon_r = 35.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5750 MHz;  $\sigma = 5.17$  S/m;  $\varepsilon_r = 35.7$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5850 MHz;  $\sigma = 5.25$  S/m;  $\varepsilon_r = 35.4$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5850 MHz;  $\sigma = 5.25$  S/m;  $\varepsilon_r = 35.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(4.99, 4.99, 4.99) @ 5850 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

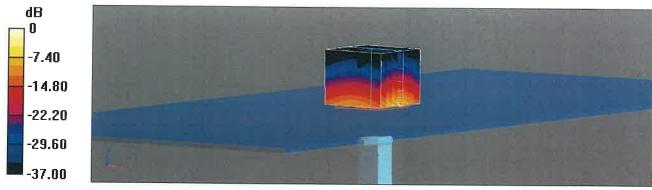
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.24 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 27.1 W/kg SAR(1 g) = 8.03 W/kg; SAR(10 g) = 2.29 W/kg Smallest distance from peaks to all points 3 dB below = 6.8 mm Ratio of SAR at M2 to SAR at M1 = 70.7% Maximum value of SAR (measured) = 17.8 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 74.53 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 30.4 W/kg SAR(1 g) = 8.28 W/kg; SAR(10 g) = 2.36 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 67.8% Maximum value of SAR (measured) = 18.9 W/kg

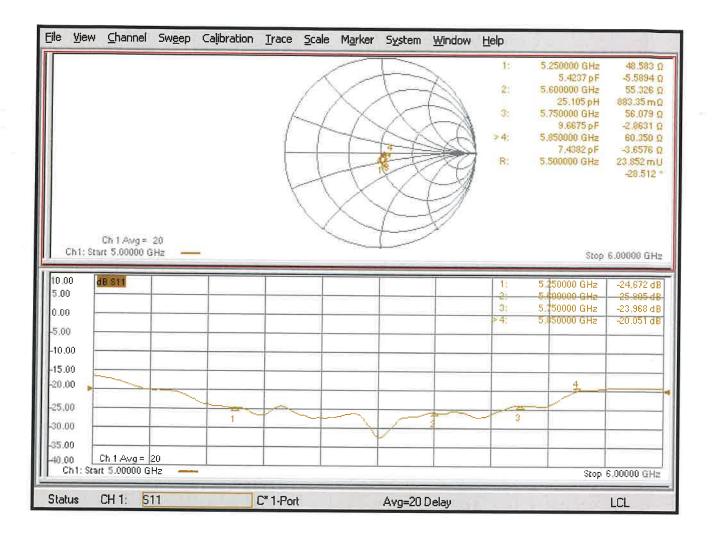
#### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 72.42 V/m; Power Drift = -0.03 dB Peak SAR (extrapolated) = 30.7 W/kg SAR(1 g) = 7.92 W/kg; SAR(10 g) = 2.24 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 66% Maximum value of SAR (measured) = 18.5 W/kg

## Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5850 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 72.25 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 32.4 W/kg SAR(1 g) = 8.13 W/kg; SAR(10 g) = 2.31 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 65.2% Maximum value of SAR (measured) = 19.1 W/kg



0 dB = 19.1 W/kg = 12.80 dBW/kg





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D5GHzV2-1003	February 22,
47173 Benicia Street	Antenna		2023
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Visual Inspection	Pass
2	Return/Loss and Impedance	Pass
3	Dipole Arms	Pass

Equipment List:			
Equipment Name: Calibration Date:			
R&S ZNLE6 Vector Network 03/05/2024			
Analyzer			
ZV-Z135 Calibration Kit 03/27/2024			



## 1) Photo of Dipole



• The connector of dipole contains no abnormalities.



#### Trc1 S11 Smith 200 mU/ Ref 1 U Cal 1~ M1 5.250000 GHz 56.246 Ω j6.141 Ω 186.157226 pH : 46.716 Ω M2 5.600000 GHz j449.589 mΩ 12.777547 pH 58.150 Ω M3 5.750000 GHz j3.740 Ω j3./40 Ω 103.532214 pH 2 54.788 Ω -j8.145 Ω 3.340214 pF M4 5.850000 GHz Ch1 Center 5.5 GHz Pwr -10 dBm Bw 10 kHz Refl OSM P1 Span 1 GHz Trc2 511 dB Mag 10 dB/ Ref 0 dB Cal 2 🗸 M1 5.250000 GHz -21.6915 dB M2 5.600000 GHz -29.3023 dB 30 20 M3 5.763300 GHz -21.3461 dB 10-M4 5.850000 GHz -20.9257 dB 0 dB -10-M3 M4 M1 -30 -40 -60 Pwr -10 dBm Bw 10 kHz Refl OSM P1 Ch1 Center 5.5 GHz Span 1 GHz 30.01.2024 03:00:07 Idle Ch1: Avg 100/100 \*\*

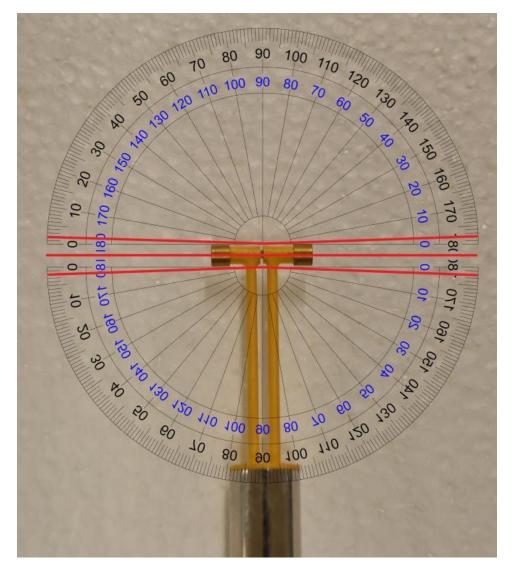
#### 2) Impedance and Return/Loss

03:00:08 30.01.2024

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



3) Dipole Arms



• The center red line indicates that the arms of the dipole fall within  $\pm 2^{\circ}$ 

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



S Schweizerischer Kalibrierdienst

C Service suisse d'étalonnage

Servizio svizzero di taratura

S Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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

**UL USA** Client

Certificate No: D5GHzV2-1138\_Feb23

# **CALIBRATION CERTIFICATE**

The measurements and the uncertainties with confidence probability are given on the following pages and are par     All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and hun     Calibration Equipment used (M&TE critical for calibration)     Primary Standards   ID #   Cal Date (Certificate No.)   Solution     Power meter NRP   SN: 104778   04-Apr-22 (No. 217-03525/03524)   Aprecian (No.)     Power sensor NRP-Z91   SN: 103244   04-Apr-22 (No. 217-03525)   Aprecian (No.)     Power sensor NRP-Z91   SN: 103245   04-Apr-22 (No. 217-03526)   Aprecian (No.)     Power sensor NRP-Z91   SN: 103245   04-Apr-22 (No. 217-03527)   Aprecian (No.)     SN: 310982 / 06327   04-Apr-22 (No. 217-03528)   Aprecian (No.)   Aprecian (No.)     SN: 601   19-Dec-22 (No. DAE4-601_Dec22)   Dotecian (No.)   Dotecian (No.)   Aprecian (No.)     SN: 601   19-Dec-22 (No. DAE4-601_Dec22)   Dotecian (No.)   Solution (No.)   Solution (No.)   Solution (No.)     Power sensor HP 8481A   SN: US37292783   07-Oct-14 (in house check Oct-22)   In     Power sensor HP 8481A   SN: US41080477   31-Mar-14 (in house check Oct-22)   In     SN: 100972   15-Jun-1	
Calibration Procedure for SAR Validation Sources between the second s	
Calibration date:   February 03, 2023     This calibration certificate documents the traceability to national standards, which realize the physical units of measurements and the uncertainties with confidence probability are given on the following pages and are part of the measurements and the uncertainties with confidence probability are given on the following pages and are part All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and hunce calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and hunce calibration Equipment used (M&TE critical for calibration)     Primary Standards   ID #   Cal Date (Certificate No.)   So     Power sensor NRP-Z91   SN: 104778   04-Apr-22 (No. 217-03520)   Au     Power sensor NRP-Z91   SN: 103244   04-Apr-22 (No. 217-03525)   Au     Power sensor NRP-Z91   SN: 103245   04-Apr-22 (No. 217-03526)   Au     Power sensor NRP-Z91   SN: 103245   04-Apr-22 (No. 217-03526)   Au     Reference 20 dB Attenuator   SN: BH9394 (20k)   04-Apr-22 (No. 217-03528)   Au     SN: 303   08-Mar-22 (No. 217-03520)   Au   Au     SN: 601   19-Dec-22 (No. DAE4-601_Dec22)   Du     SN: 601   19-Dec-22 (No. DAE4-601_Dec22)   Du     SN: 0037292783   07-Oct-15 (in house check Oct-22)   In <	
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Calibration Laboratory of

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland



Schweizerischer Kalibrierdienst

Service suisse d'étalonnage

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Swiss Calibration Service

Accreditation No.: SCS 0108

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Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

#### **Glossary:**

TSL	tissue simulating liquid
	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.

DASY52	V52.10.4
Advanced Extrapolation	
Modular Flat Phantom V5.0	
10 mm	with Spacer
dx, dy = 4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
5250 MHz ± 1 MHz 5600 MHz ± 1 MHz 5750 MHz ± 1 MHz 5850 MHz ± 1 MHz	
	Advanced Extrapolation     Modular Flat Phantom V5.0     10 mm     dx, dy = 4 mm, dz = 1.4 mm     5250 MHz ± 1 MHz     5600 MHz ± 1 MHz

#### Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	4.70 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

## SAR result with Head TSL at 5250 MHz

SAR averaged over 1 $cm^3$ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.97 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.6 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.4 ± 6 %	5.07 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5600 MHz

SAR averaged over 1 $cm^3$ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.25 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.4 W/kg ± 19.5 % (k=2)

#### Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.4	5.22 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.2 ± 6 %	5.18 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5750 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.84 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	78.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.2 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5850 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.2	5.32 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.9 ± 6 %	5.27 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

#### SAR result with Head TSL at 5850 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.02 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.7 W/kg ± 19.5 % (k=2)

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

#### Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	48.1 Ω - 4.5 jΩ	
Return Loss	- 26.0 dB	

#### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	53.7 Ω + 0.1 jΩ	
Return Loss	- 28.9 dB	

#### Antenna Parameters with Head TSL at 5750 MHz

Impedance, transformed to feed point	56.4 Ω + 0.3 jΩ
Return Loss	- 24.4 dB

#### Antenna Parameters with Head TSL at 5850 MHz

Impedance, transformed to feed point	57.1 Ω - 1.5 jΩ	
Return Loss	- 23.3 dB	

#### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.201 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

Date: 03.02.2023

Test Laboratory: SPEAG, Zurich, Switzerland

## DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1138

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5850 MHz Medium parameters used: f = 5250 MHz;  $\sigma = 4.7$  S/m;  $\varepsilon_r = 35.5$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5600 MHz;  $\sigma = 5.07$  S/m;  $\varepsilon_r = 35.4$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5750 MHz;  $\sigma = 5.18$  S/m;  $\varepsilon_r = 35.2$ ;  $\rho = 1000$  kg/m<sup>3</sup> Medium parameters used: f = 5850 MHz;  $\sigma = 5.27$  S/m;  $\varepsilon_r = 34.9$ ;  $\rho = 1000$  kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(4.99, 4.99, 4.99) @ 5850 MHz; Calibrated: 08.03.2022
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 19.12.2022
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

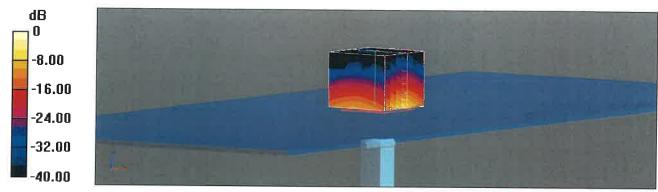
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 75.08 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 27.2 W/kg SAR(1 g) = 7.97 W/kg; SAR(10 g) = 2.27 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 71% Maximum value of SAR (measured) = 18.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 73.91 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 30.3 W/kg SAR(1 g) = 8.25 W/kg; SAR(10 g) = 2.35 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 68.4%Maximum value of SAR (measured) = 19.3 W/kg

#### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 71.97 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 30.4 W/kg SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.22 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 66.5%Maximum value of SAR (measured) = 18.7 W/kg

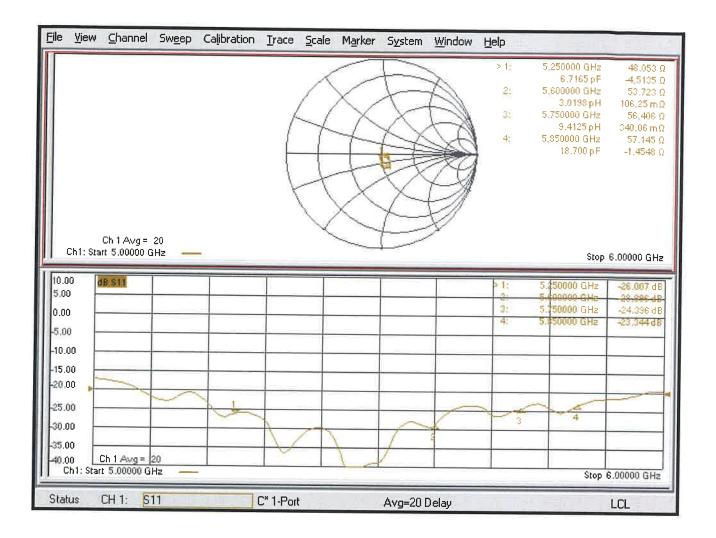
## Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5850 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 71.46 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 31.7 W/kg SAR(1 g) = 8.02 W/kg; SAR(10 g) = 2.28 W/kg Smallest distance from peaks to all points 3 dB below = 7.2 mm Ratio of SAR at M2 to SAR at M1 = 65.6% Maximum value of SAR (measured) = 19.5 W/kg



0 dB = 19.5 W/kg = 12.89 dBW/kg

## Impedance Measurement Plot for Head TSL





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D5GHzV2-1038	January 29,
47173 Benicia Street	Antenna		2024
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Return/Loss and Impedance	Pass
2	Dipole Arms	Pass

Equipment List:			
Equipment Name: Calibration Date:			
R&S ZNLE6 Vector Network 02/28/2025			
Analyzer			
ZV-Z135 Calibration Kit	03/31/2024		



~

1) Impedance and Return/Loss

1 S11 Smith 200 mU/ Ref 1 U Cal					1.
			М	1 5.250000 GHz	
	0.5	2			j3.902 Ω
		7			118.301283 p
		+-//	M	2 5.600000 GHz	
		5			-j613.332 m
				2 E 750000 CU-	46.337893 pl 54.016 Ω
			IVI	3 5.750000 GHz	j5.350 Ω
	0 0.2 0.5 2	5 10			148.090180 pl
		$\subseteq \mathbb{N}$	м	4 5.850000 GHz	
	$\land \land \land \times \times$	<i>□</i> 2#		11 5.050000 0112	-j4.497 Ω
					6.050115 pl
Center 5.5 GHz Pr	vr -10 dBm Bw 10 kHz Refl OSM P1				Span 1GF
	vr -10 dBm Bw 10 kHz Refl OSM P1			M1 5,250000 (	2
	vr -10 dBm Bw 10 kHz Refl OSM P1			M1 5.250000 ( M2 5.600000 (	
	vr -10 dBm Bw 10 kHz Refl OSM P1			M2 5.600000 ( • M3 5.763300 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
2 S11 dB Mag 10 dB/ Ref 0 dB Cal	vr -10 dBm Bw 10 kHz Refl OSM P1			M2 5.600000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
2 S11 dB Mag 10 dB/ Ref 0 dB Cal	vr -10 dBm Bw 10 kHz Refl OSM P1			M2 5.600000 ( • M3 5.763300 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
S11 dB Mag 10 dB/ Ref 0 dB Cal			 	M2 5.600000 ( • M3 5.763300 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
S11 dB Mag 10 dB/ Ref 0 dB Cal			M3	M2 5.600000 ( • M3 5.763300 ( M4 5.850000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
S11 dB Mag 10 dB/ Ref 0 dB Cal		M2		M2 5.600000 ( • M3 5.763300 ( M4 5.850000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
S11 dB Mag 10 dB/ Ref 0 dB Cal		M2		M2 5.600000 ( • M3 5.763300 ( M4 5.850000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
2 S11 dB Mag 10 dB/ Ref 0 dB Cal		M2		M2 5.600000 ( • M3 5.763300 ( M4 5.850000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
2 S11 dB Mag 10 dB/ Ref 0 dB Cal		M2		M2 5.600000 ( • M3 5.763300 ( M4 5.850000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
Biggin and the second s		M2		M2 5.600000 ( • M3 5.763300 ( M4 5.850000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c
2 S11 dB Mag 10 dB/ Ref 0 dB Cal		M2		M2 5.600000 ( • M3 5.763300 ( M4 5.850000 (	GHz -25.1461 c GHz -30.2766 c GHz -23.6338 c

02:51:29 30.01.2024

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



# 2) Dipole Arms



- The center red line indicates that the arms of the dipole fall within  $\pm 2^\circ$ 

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Accreditation No.: SCS 0108

Certificate No: D6.5GHzV2-1033\_Mar23

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CALIBRATION CERTIFICATE

#### Client UL USA Fremont, USA

Object	D6.5GHzV2 - SM	J:1033		
Calibration procedure(s)	QA CAL-22.v7 Calibration Procedure for SAR Validation Sources between 3-10 GHz			
Calibration date:	March 15, 2023			
		onal standards, which realize the physical un robability are given on the following pages ar		
All calibrations have been conducte	d in the closed laborato	ry facility: environment temperature (22 $\pm$ 3)°	C and humidity < 70%.	
Calibration Equipment used (M&TE	critical for calibration)			
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration	
Power sensor R&S NRP33T	SN: 100967	01-Apr-22 (No. 217-03526)	Apr-23	
Reference 20 dB Attenuator	SN: BH9394 (20k)	04-Apr-22 (No. 217-03527)	Apr-23	
dismatch combination	SN: 84224 / 360D	26-Apr-22 (No. 217-03545)	Apr-23	
Reference Probe EX3DV4	SN: 7405	02-Jun-22 (No. EX3-7405_Jun22)	Jun-23	
DAE4	SN: 908	27-Jun-22 (No. DAE4-908_Jun22)	Jun-23	
Secondary Standards	ID #	Check Date (in house)	Scheduled Check	
RF generator Anapico APSIN20G	SN: 827	18-Dec-18 (in house check Dec-21)	In house check: Dec-23	
Network Analyzer Keysight E5063A	SN:MY54504221	31-Oct-19 (in house check Oct-22)	In house check: Oct-25	
	Name	Function	Signature	
Calibrated by:	Leif Klysner	Laboratory Technician	Sol the	
Approved by:	Sven Kühn	Technical Manager	S. C	
			Issued: March 16, 2023	
This calibration certificate shall not b	e 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.

### Additional Documentation:

b) 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 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.
- 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 absorbed power density (APD): The absorbed power density is evaluated according to Samaras T, Christ A, Kuster N, "Compliance assessment of the epithelial or absorbed power density above 6 GHz using SAR measurement systems", Bioelectromagnetics, 2021 (submitted). The additional evaluation uncertainty of 0.55 dB (rectangular distribution) is considered.

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

#### **Measurement Conditions**

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

DASY Version	DASY6	V16.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	5 mm	with Spacer
Zoom Scan Resolution	dx, dy = 3.4 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	6500 MHz ± 1 MHz	

# Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	34.5	6.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.3 ± 6 %	6.02 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

## SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	28.9 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	288 W/kg ± 24.7 % (k=2)
SAR averaged over 8 cm <sup>3</sup> (8 g) of Head TSL	Condition	
SAR measured	100 mW input power	6.48 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	64.7 W/kg ± 24.4 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL condition		
SAR measured	100 mW input power	5.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.1 W/kg ± 24.4 % (k=2)

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.2 Ω - 3.4 jΩ	
Return Loss	- 29.0 dB	

### **APD (Absorbed Power Density)**

APD averaged over 1 cm <sup>2</sup>	Condition	
APD measured	100 mW input power	288 W/m <sup>2</sup>
APD measured	normalized to 1W	2880 W/m² ± 29.2 % (k=2)

APD averaged over 4 cm <sup>2</sup>	condition	
APD measured	100 mW input power	130 W/m <sup>2</sup>
APD measured	normalized to 1W	1300 W/m <sup>2</sup> ± 28.9 % (k=2)

\*The reported APD values have been derived using the psSAR1g and psSAR8g.

## **General Antenna Parameters and Design**

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.

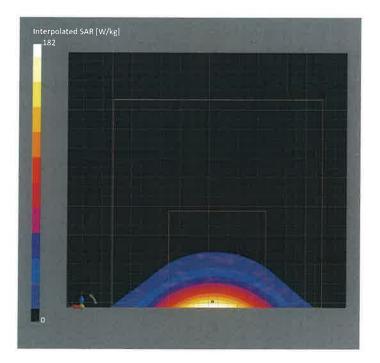
## Additional EUT Data

Manufactured by	SPEAG
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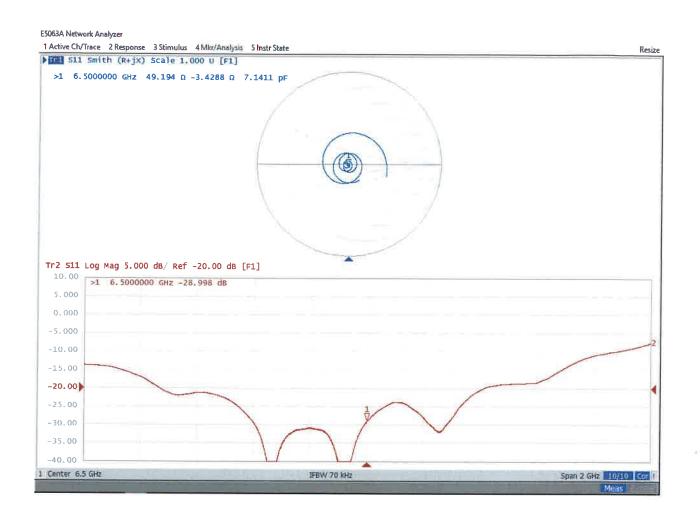
# **DASY6 Validation Report for Head TSL**

#### Measurement Report for D6.5GHz-1033, UID 0 -, Channel 6500 (6500.0MHz)

Device under T	est Properties						
Name, Manufa	cturer D	imensions	[mm] //	VIEI	DUT Typ	e	
D6.5GHz	1	l6.0 x 6.0 x	300.0 S	N: 1033			
Exposure Cond							
Phantom Section, TSL	Position, Test Distance [mm]	Band	Group, UID	Frequency [MHz]	Conversion Factor	TSL Cond. [S/m]	TSL Permittivity
Flat, HSL	5.00	Band	CW,	6500	5.50	6.02	34.3
Hardware Setu Phantom	•	SL		Probe, Calib	pration Date	DAE, Calib	ration Date
MFP V8.0 Cente	er - 1182 H	BBL600-10	000V6	EX3DV4 - SM	17405, 2022-06-02	DAE4 Sn90	08, 2022-06-27
Scan Setup				Measureme	nt Results		
			Zoom Scan				Zoom Scan
Grid Extents [n	nm]		22.0 x 22.0 x 22.0	Date		20	023-03-15, 12:39
Grid Steps [mn	n]		3.4 x 3.4 x 1.4	psSAR1g [\	N/Kg]		28.9
Sensor Surface	e [mm]		1.4	psSAR8g [\	N/Kg]		6.48
Graded Grid			Yes	psSAR10g	[W/Kg]		5.31
Grading Ratio			1.4	Power Drif	t [dB]		0.01
MAIA			N/A	Power Scal	ling		Disabled
Surface Detect	ion		VMS + 6p	Scaling Fac	tor [dB]		
Scan Method			Measured				No correction
				M2/M1 [%	-		55.2
				Dist 3dB Pe	eak [mm]		4.7



## Impedance Measurement Plot for Head TSL





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D6.55GHzV2-	March 15,
47173 Benicia Street	Antenna	1033	2024
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Visual Inspection	Pass
2	Return/Loss and Impedance	Pass
3	Dipole Arms	Pass

Equipment List:				
Equipment Name: Calibration Date:				
R&S ZNLE6 Vector Network 03/05/2024				
Analyzer				
ZV-Z135 Calibration Kit 03/27/2024				

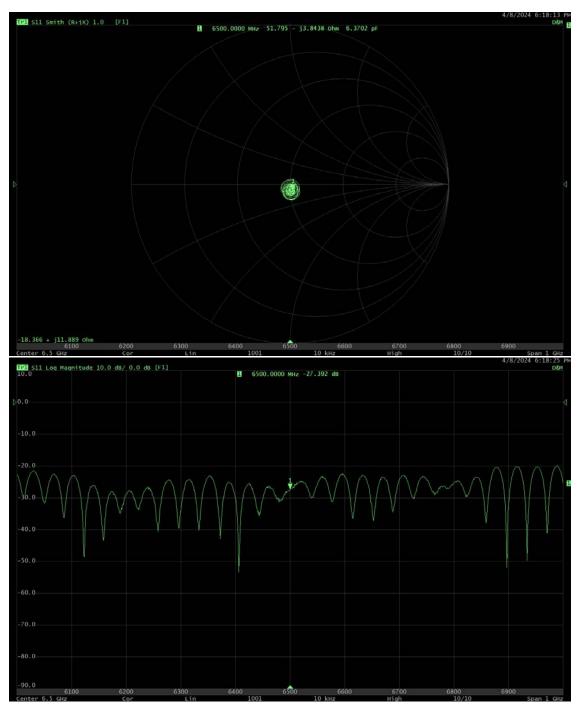


# 1) Photo of Dipole



• The connector of dipole contains no abnormalities.



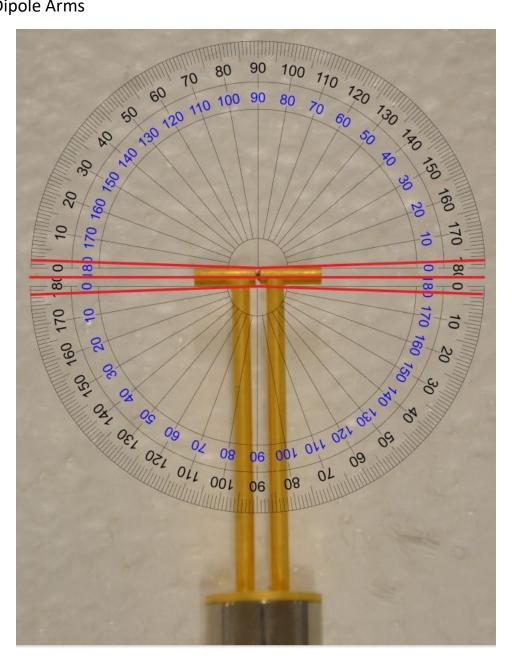


2) Impedance and Return/Loss

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



3) Dipole Arms



The center red line indicates that the arms of the dipole fall within  $\pm 2^{\circ}$ •

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Client UL USA

Certificate No: CLA13-1008\_Jan23

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# CALIBRATION CERTIFICATE

Object	CLA13 - SN: 100	8	
Calibration procedure(s)	QA CAL-15.v10		
	Calibration Proce	dure for SAR Validation Sources	below 700 MHz
Calibration date:	January 12, 2023		
	,		
This calibration certificate documen	ts the traceability to natio	onal standards, which realize the physical units	s of measurements (SI).
The measurements and the uncerta	ainties with confidence pr	obability are given on the following pages and	are part of the certificate.
All calibrations have been conducted	ed in the closed laborator	y facility: environment temperature (22 $\pm$ 3)°C	and humidity < 70%.
Calibration Equipment used (M&TE	critical for calibration)		
	· · · · · · · · · · · · · · · · · · ·		
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-22 (No. 217-03525/03524)	Apr-23
Power sensor NRP-Z91	SN: 103244	04-Apr-22 (No. 217-03524)	Apr-23
Power sensor NRP-Z91	SN: 103245	04-Apr-22 (No. 217-03525)	Apr-23
Reference 20 dB Attenuator	SN: CC2552 (20x)	04-Apr-22 (No. 217-03527)	Apr-23
Type-N mismatch combination	SN: 310982 / 06327	04-Apr-22 (No. 217-03528)	Apr-23
Reference Probe EX3DV4	SN: 3877	06-Jan-23 (No. EX3-3877_Jan23)	Jan-24
DAE4	SN: 654	26-Jan-22 (No. DAE4-654_Jan22)	Jan-23
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter NRP2	SN: 107193	08-Nov-21 (in house check Dec-22)	In house check: Dec-24
Power sensor NRP-Z91	SN: 100922	15-Dec-09 (in house check Dec-22)	In house check: Dec-24
Power sensor NRP-Z91	SN: 100418	01-Jan-04 (in house check Dec-22)	In house check: Dec-24
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-22)	In house check: Jun-24
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24
	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	M. Hess
Approved by:	Sven Kühn	Technical Manager	S. L
			Issued: January 16, 2023

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**Swiss Calibration Service** 

Accreditation No.: SCS 0108

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Multilateral Agreement for the recognition of calibration certificates

# **Glossary:**

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

# Calibration is Performed According to the Following Standards:

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

## **Additional Documentation:**

c) DASY System Handbook

# Methods Applied and Interpretation of Parameters:

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

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

# **Measurement Conditions**

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

DASY Version	DASY5	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	ELI4 Flat Phantom	Shell thickness: 2 ± 0.2 mm
EUT Positioning	Touch Position	
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	13 MHz ± 1 MHz	

# **Head TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	55.0	0.75 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	53.3 ± 6 %	0.72 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	402140	

# SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	1 W input power	0.530 W/ka
SAR for nominal Head TSL parameters	normalized to 1W	0.544 W/kg ± 18.4 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	1 W input power	0.329 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	0.338 W/kg ± 18.0 % (k=2)

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

# Antenna Parameters with Head TSL

Impedance, transformed to feed point	53.7 Ω - 1.8 jΩ		
Return Loss	- 28.1 dB		

# Additional EUT Data

.

Manufactured by	SPEAG
· · · · · · · · · · · · · · · · · · ·	SFEAG

Date: 12.01.2023

Test Laboratory: SPEAG, Zurich, Switzerland

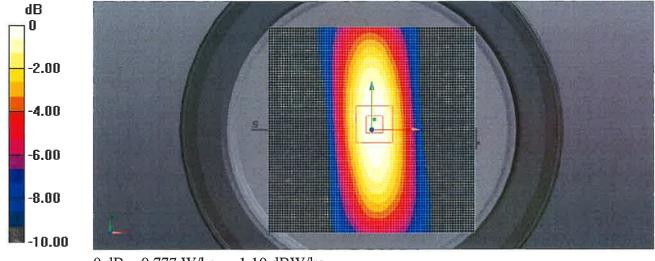
### DUT: CLA13; Type: CLA13; Serial: CLA13 - SN: 1008

Communication System: UID 0 - CW; Frequency: 13 MHz Medium parameters used: f = 13 MHz;  $\sigma$  = 0.72 S/m;  $\epsilon_r$  = 53.3;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

#### DASY52 Configuration:

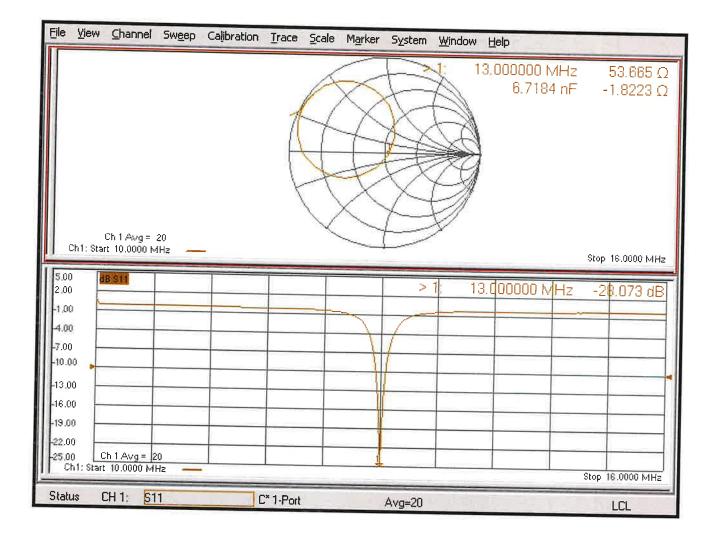
- Probe: EX3DV4 SN3877; ConvF(15.33, 15.33, 15.33) @ 13 MHz; Calibrated: 06.01.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn654; Calibrated: 26.01.2022
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

CLA Calibration for HSL-LF Tissue/CLA-13, touch configuration, Pin=1W/Zoom Scan, dist=1.4mm (8x10x8)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm Reference Value = 31.00 V/m; Power Drift = -0.09 dB Peak SAR (extrapolated) = 1.07 W/kg SAR(1 g) = 0.530 W/kg; SAR(10 g) = 0.329 W/kg Smallest distance from peaks to all points 3 dB below = 16.6 mm Ratio of SAR at M2 to SAR at M1 = 78.7% Maximum value of SAR (measured) = 0.777 W/kg



0 dB = 0.777 W/kg = -1.10 dBW/kg

# Impedance Measurement Plot for Head TSL





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	CLA13-1008	January 12,
47173 Benicia Street	Antenna		2023
Fremont, CA 94538, U.S.A.			

Number:	Check List:	Result:
1	Visual Inspection	Pass
2	Return/Loss and Impedance	Pass
3	Dipole Arms	Pass

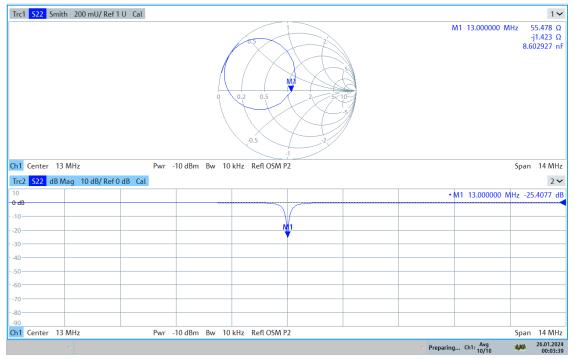
Equipment List:				
Equipment Name: Calibration Date:				
R&S ZNLE6 Vector Network	03/05/2024			
Analyzer				
ZV-Z135 Calibration Kit	03/27/2024			



- 1) Photo of Dipole
  - The connector of dipole contains no abnormalities.



# 2) Impedance and Return/Loss



00:03:40 26.01.2024

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5  $\Omega$  of previous value.



- 3) Dipole Arms
  - The center red line indicates that the arms of the dipole fall within  $\pm 2^\circ$

## Calibration Laboratory of Schmid & Partner

Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland Schweizerischer Kalibrierdienst Service suisse d'étalonnage Servizio svizzero di taratura

Swiss Calibration Service

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Accreditation No.: SCS 0108

Certificate No. 5G-Veri10-1015\_Sep23

Accredited by the Swiss Accreditation Service (SAS) The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Client	UL	
	Fremont, USA	

Calibration procedure(s)									
Calibration procedure(s)									
	QA CAL-45.v4 Calibration procedure for sources in air above 6 GHz								
Calibration date:	September 05, 2	2023							
The measurements and the unc	ertainties with confidence	tional standards, which realize the physical units probability are given on the following pages and pry facility: environment temperature $(22 \pm 3)^{\circ}$ C	are part of the certificate.						
Calibration Equipment used (M8	TE critical for calibration)								
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration						
Reference Probe EUmmWV3	SN: 9374	22-May-23 (No. EUmm-9374_May23)	May-24						
DAE4ip	SN: 1602	05-Jul-23 (No. DAE4ip-1602_Jul23)	Jul-24						
Secondary Standards	ID #	Check Date (in house)	Scheduled Check						
RF generator R&S SMF100A	SN: 100184	19-May-22 (in house check Nov-22)	In house check: Nov-23						
Power sensor R&S NRP18S-10	SN: 101258	31-May-22 (in house check Nov-22)	In house check: Nov-23						
Network Analyzer Keysight E506	3A   SN: MY54504221	31-Oct-19 (in house check Oct-22)	In house check: Oct-25						
	Name	Function	Signature						
Calibrated by	Joanna Lleshaj	Laboratory Teohnician	Applicity						
Approved by:	Sven Kühn	Technical Manager	5.6						

## **Calibration Laboratory of**

Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich, Switzerland





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

Accreditation No.: SCS 0108

### Glossary

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CW

Continuous wave

## **Calibration is Performed According to the Following Standards**

- Internal procedure QA CAL-45, Calibration procedure for sources in air above 6 GHz.
- IEC/IEEE 63195-1, "Assessment of power density of human exposure to radio frequency fields from wireless devices in close proximity to the head and body (frequency range of 6 GHz to 300 GHz)", May 2022

## Methods Applied and Interpretation of Parameters

- Coordinate System: z-axis in the waveguide horn boresight, x-axis is in the direction of the E-field, y-axis normal to the others in the field scanning plane parallel to the horn flare and horn flange.
- *Measurement Conditions: (1) 10 GHz:* The radiated power is the forward power to the horn antenna minus ohmic and mismatch loss. The forward power is measured prior and after the measurement with a power sensor. During the measurements, the horn is directly connected to the cable and the antenna ohmic and mismatch losses are determined by far-field measurements. *(2) 30, 45, 60 and 90 GHz*: The verification sources are switched on for at least 30 minutes. Absorbers are used around the probe cub and at the ceiling to minimize reflections.
- *Horn Positioning:* The waveguide horn is mounted vertically on the flange of the waveguide source to allow vertical positioning of the EUmmW probe during the scan. The plane is parallel to the phantom surface. Probe distance is verified using mechanical gauges positioned on the flare of the horn.
- E- field distribution: E field is measured in two x-y-plane (10mm, 10mm + λ/4) with a vectorial E-field probe. The E-field value stated as calibration value represents the E-field-maxima and the averaged (1cm<sup>2</sup> and 4cm<sup>2</sup>) power density values at 10mm in front of the horn.
- *Field polarization:* Above the open horn, linear polarization of the field is expected. This is verified graphically in the field representation.

## **Calibrated Quantity**

 Local peak E-field (V/m) and average of peak spatial components of the poynting vector (W/m<sup>2</sup>) averaged over the surface area of 1 cm<sup>2</sup> and 4cm<sup>2</sup> at the nominal operational frequency of the verification source. Both square and circular averaging results are listed.

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

# **Measurement Conditions**

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

DASY Version	DASY8 Module mmWave	V3.2
Phantom	5G Phantom	
Distance Horn Aperture - plane	10 mm	
Number of measured planes	2 (10mm, 10mm + λ/4)	
Frequency	10 GHz ± 10 MHz	

# Calibration Parameters, 10 GHz

## **Circular Averaging**

Distance Horn Aperture to Measured Plane	Prad <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	3	PDtot+, psPDmod+)	Uncertainty (k = 2)
				<b>1</b> cm <sup>2</sup>	<b>4</b> cm <sup>2</sup>	
10 mm	93.3	155	1.27 dB	60.5	56.2	1.28 dB

Distance Horn Aperture to Measured Plane	Prad <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Power Density psPDn+, psPDtot+, psPDmod+ (W/m²)		Uncertainty (k = 2)
				1 cm <sup>2</sup>	4 cm <sup>2</sup>	
10 mm	93.3	155	1.27 dB	60.3, 60.5, 60.6	56.0, 56.2, 56.4	1.28 dB

## **Square Averaging**

Distance Horn Aperture to Measured Plane	Prad¹ (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m <sup>2</sup> )		Uncertainty (k = 2)
				1 cm <sup>2</sup>	<b>4</b> cm <sup>2</sup>	
10 mm	93.3	155	1.27 dB	60.5	56.1	1.28 dB

Distance Horn Aperture to Measured Plane	Prad <sup>1</sup> (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Power Density psPDn+, psPDtot+, psPDmod+ (W/m²)		Uncertainty (k = 2)
				1 cm <sup>2</sup>	<b>4</b> cm <sup>2</sup>	
10 mm	93.3	155	1.27 dB	60.4, 60.5, 60.6	55.9, 56.1, 56.4	1.28 dB

### Max Power Density

Distance Horn Aperture to Measured Plane	Prad¹ (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Max Power Density Sn, Stot,  Stot  (W/m²)	Uncertainty (k = 2)
10 mm	93.3	155	1.27 dB	62.1, 62.1, 62.2	1.28 dB

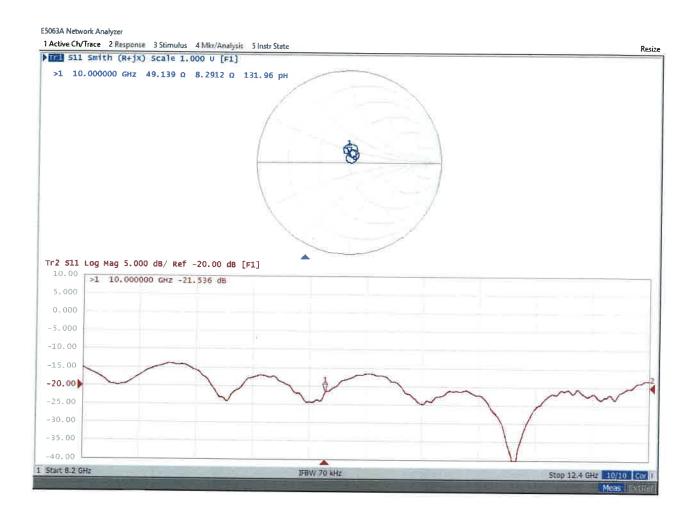
 $<sup>^1</sup>$  Assessed ohmic and mismatch loss plus numerical offset: 0.30 dB

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

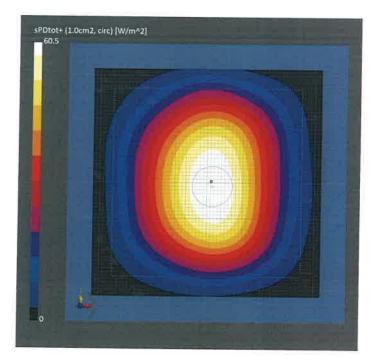
#### Antenna Parameters

Impedance, transformed to feed point	49.1 Ω + 8.3 jΩ		
Return Loss	- 21.5 dB	_	

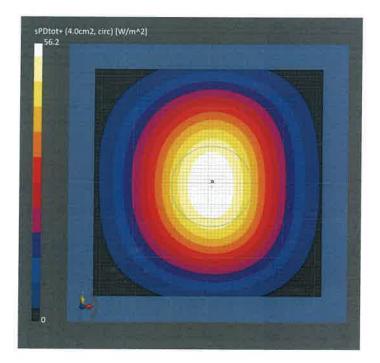
### **Impedance Measurement Plot**



Device under Test Pro Name, Manufacturer	Dimensions [mn	n]	IMEI	DUT Type	
5G Verification Source 10	GHz 100.0 x 100.0 x 1	172.0	SN: 1015	-	
Exposure Conditions Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0
Ha <b>rdware Setup</b> Phantom	Medium		Probe, Calibra	tion Date	DAE Collibustion Data
mmWave Phantom - 1002	Air			N9374_F1-55GHz,	DAE, Calibration Date DAE4ip Sn1602, 2023-07-05
Scan Setup			Measureme	ent Results	
Sensor Surface [mm]		5G Sc	an ).0 Date		5G Scan
MAIA		MAIA not us		n²] /m²] V/m²] n²] /m²]	2023-09-05, 16:21 1.00 Circular Averaging 60.3 60.5 60.6 62.1 62.1 62.2 155



Name, Manufacturer	Dimensions [mm	1	IMEI	DUT Type	
5G Verification Source 10	GHz 100.0 x 100.0 x 1	172.0	SN: 1015	365	
Exposure Conditions					
Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	<b>Conversion Factor</b>
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0
Hardware Setup					
Phantom	Medium		Probe, Calibra	tion Date	DAE, Calibration Date
mmWave Phantom - 1002	Air		EUmmWV3 - S	N9374_F1-55GHz,	DAE4ip Sn1602,
			2023-05-22		2023-07-05
Scan Setup			Measurem	ent Results	2023-07-05
		5G Sc	Measureme	ent Results	2023-07-05 5G Scar
Sensor Surface [mm]		10	Measurem an 0.0 Date		
			Measureme an 0.0 Date ed Avg. Area [cr		<b>5G Scar</b> 2023-09-05, 16:2: 4.00
Sensor Surface [mm]		10	Measureme an 0.0 Date ed Avg. Area [cr Avg. Type	n²]	<b>5G Scar</b> 2023-09-05, 16:2: 4.00 Circular Averaging
Sensor Surface [mm]		10	Measureme an 0.0 Date ed Avg. Area [cr Avg. Type psPDn+ [W/r	n²] n²]	<b>5G Scar</b> 2023-09-05, 16:2: 4.00 Circular Averaging 56.0
Sensor Surface [mm]		10	Measureme an 0.0 Date ed Avg. Area [cr Avg. Type psPDn+ [W/r psPDtot+ [W	n²] n²] /m²]	<b>5G Scar</b> 2023-09-05, 16:2: 4.00 Circular Averaging 56.0 56.2
Sensor Surface [mm]		10	Measureme an o.0 Date ed Avg. Area [cr Avg. Type psPDn+ [W/r psPDtot+ [W psPDmod+ [V	n²] n²] /m²] N/m²]	5G Scar 2023-09-05, 16:2 4.00 Circular Averaging 56.0 56.2 56.4
Sensor Surface [mm]		10	Measureme an 0.0 Date ed Avg. Area [cr Avg. Type psPDn+ [W/r psPDtot+ [W psPDmod+ [V Max(Sn) [W/	n²] /m²] //m²] N/m²] m²]	<b>5G Sca</b> 2023-09-05, 16:2: 4.00 Circular Averaging 56.0 56.2 56.4 62.1
Sensor Surface [mm]		10	Measureme an 0.0 Date ed Avg. Area [cr Avg. Type psPDn+ [W/r psPDtot+ [W psPDmod+ [V Max(Sn) [W/ Max(Stot) [W	n²] /m²] //m²] M/m²] m²] //m²]	<b>5G Sca</b> 2023-09-05, 16:2: 4.00 Circular Averaging 56.0 56.2 56.4 62.1 62.1
Sensor Surface [mm]		10	Measureme an 0.0 Date ed Avg. Area [cr Avg. Type psPDn+ [W/r psPDtot+ [W psPDmod+ [V Max(Sn) [W/	n²] /m²] //m²] M/m²] m²] //m²]	<b>5G Sca</b> 2023-09-05, 16:2 4.0 Circular Averagin 56. 56. 56. 56.



Name, Manufacturer	Dimensions [mm	1]	IMEI	DUT Type	
5G Verification Source 10 G	GHz 100.0 x 100.0 x 1	172.0	SN: 1015	3 <b>*</b> )	
Exposure Conditions					
Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	<b>Conversion Factor</b>
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0
lardware Setup	Medium		Probe, Calibra	tion Data	DAT Collinguise Date
mmWave Phantom - 1002	Air			N9374_F1-55GHz,	DAE, Calibration Date DAE4ip Sn1602, 2023-07-05
Scan Setup			Measureme	ent Results	
Sensor Surface [mm]		5G Sc	an ).0 Date		5G Scan
MAIA		MAIA not us		<sup>-</sup> /m²] V/m²] n²] /m²]	2023-09-05, 16:21 1.00 Square Averaging 60.4 60.5 60.6 62.1 62.1 62.2 155



Name, Manufacturer	Dimensions [mn	n]	IMEI	DUT Type	
5G Verification Source 10 (	GHz 100.0 x 100.0 x	172.0	SN: 1015	*	
Exposure Conditions					
Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz] Channel Number	
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0
Hardware Setup	Medium		Droho Colibrati	- Dete	
mmWave Phantom - 1002	Air		Probe, Calibratio EUmmWV3 - SN 2023-05-22		DAE, Calibration Date DAE4ip Sn1602, 2023-07-05
Scan Setup			Measuremen	it Results	
Sensor Surface [mm]		5G Sc			5G Scan
MAIA		MAIA not us	0.0 Date ed Avg. Area [cm <sup>2</sup> ] Avg. Type psPDn+ [W/m <sup>2</sup> ] psPDtot+ [W/m psPDmod+ [W/ Max(Sn) [W/m <sup>2</sup> Max(Stot) [W/m <sup>2</sup> ]	, r²] [ n²]	2023-09-05, 16:21 4.00 Square Averaging 55.9 56.1 56.4 62.1 62.1

