Calibration Laboratory of

Client UL

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

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S Inchal

Schweizerischer Kalibrierdienst

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 - Swiss Calibration Service

Certificate No. D1900V2-5d140 Apr23

Accreditation No.: SCS 0108

Fremont, USA			
CALIBRATION C	ERTIFICATE		
Object	D1900V2 - SN:50	1140	
Calibration procedure(s)	QA CAL-05.v12 Calibration Proce	dure for SAR Validation Source	es between 0.7-3 GHz
Calibration date:	April 14, 2023		
This calibration certificate documen The measurements and the uncerta	its the traceability to nationality to nationality to nationality to nationality to nationality of the second s	onal standards, which realize the physical u obability are given on the following pages a	inits of measurements (SI). and are part of the certificate.
All calibrations have been conducte	ed in the closed laborator	y facility: environment temperature (22 ± 3)	°C and humidity < 70%
Calibration Equipment used (M&TE	critical for calibration)		
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP2	SN: 104778	30-Mar-23 (No. 217-03804/03805)	Mar-24
Power sensor NRP-Z91	SN: 103244	30-Mar-23 (No. 217-03804)	Mar-24
Power sensor NRP-Z91	SN: 103245	30-Mar-23 (No. 217-03805)	Mar-24
Reference 20 dB Attenuator	SN: BH9394 (20k)	30-Mar-23 (No. 217-03809)	Mar-24
Type-N mismatch combination	SN: 310982 / 06327	30-Mar-23 (No. 217-03810)	Mar-24
Reference Probe EX3DV4	SN: 7349	10-Jan-23 (No. EX3-7349 Jan23)	Jan-24
DAE4	SN: 601	19-Dec-22 (No. DAE4-601_Dec22)	Dec-23
Secondary Standards	םו #	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
RE 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
	Develop	Duration	Signature
Calibrated by:	Name Paulo Pina	Function	Signature
			Janth

Approved by:

Issued: April 21, 2023

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

Sven Kühn

Technical Manager

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



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Servizio svizzero di taratura Swiss Calibration Service

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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	1900 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.9 ± 6 %	1.39 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	9.88 W/kg	
SAR for nominal Head TSL parameters	normalized to 1W	39.4 W/kg ± 17.0 % (k=2)	
SAR averaged over 10 cm^3 (10 g) of Head TSL	condition		
SAP measured		E 40 M/A	
SAR measured	250 mw input power	5.16 W/kg	

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.1 Ω + 5.5 jΩ	
Return Loss	- 24.9 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

Date: 14.04.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d140

Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz; $\sigma = 1.39$ S/m; $\epsilon_r = 38.9$; $\rho = 1000$ kg/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.35, 8.35, 8.35) @ 1900 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 = 108.3 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 18.0 W/kg **SAR(1 g) = 9.88 W/kg; SAR(10 g) = 5.16 W/kg** Smallest distance from peaks to all points 3 dB below = 10 mm Ratio of SAR at M2 to SAR at M1 = 55.2% Maximum value of SAR (measured) = 15.2 W/kg



0 dB = 15.2 W/kg = 11.81 dBW/kg

Impedance Measurement Plot for Head TSL





Equipment Location	Equipment	Model Name	Date of
	Name		Verification
UL Verification Services Inc.	Dipole	D1900V2-	April 14, 2023
47173 Benicia Street	Antenna	5d140	
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 Ω 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 Fremont, USA		Certificate N	lo. D2300V2-1058_Oct23
CALIBRATION C	ERTIFICAT	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	
This calibration certificate documer The measurements and the uncerta All calibrations have been conducte	nts the traceability to nati ainties with confidence p ed in the closed laborator	onal standards, which realize the physical robability are given on the following pages ry facility: environment temperature (22 ± 3	units of measurements (SI). and are part of the certificate. ;)°C and humidity < 70%.
Calibration Equipment used (M&TE	critical for calibration)	Cal Data (Cartificata No.)	Schodulod Calibration
Primary Standards	ID #	Cal Date (Certificate No.)	Mar 24
Power sensor NPP-791	SN: 103244	30 Mar 23 (No. 217 - 03804)	Mar 24
Power sensor NPP-791	SN: 103245	30 Mar 23 (No. 217-03804)	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	Funche
Approved by:	Sven Kühn	Technical Manager	<i>C</i> ,

Issued: October 16, 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	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)
	1	
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.93 W/kg

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
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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/m³ 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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Accreditation No.: SCS 0108

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UL USA Client

Certificate No: D2450V2-706_Jan23

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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	Bernard Strategy Strategy Francisco	
This calibration certificate documer The measurements and the uncerta All calibrations have been conducte Calibration Equipment used (M&TE	nts the traceability to nation ainties with confidence pr and in the closed laborator critical for calibration)	onal standards, which realize the physical u robability are given on the following pages a y facility: environment temperature (22 ± 3)°	nits of measurements (SI). Ind are part of the certificate. °C and humidity < 70%.
Primary Standards		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	Jantito
Approved by:	Sven Kühn	Technical Manager	5.4
This calibration certificate shall not	he reproduced except in	full without written approval of the laborator	Issued: January 20, 2023

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Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

c) DASY System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

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

SAR result with Head TSL

SAR averaged over 1 cm^3 (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)
SAP averaged over 10 em ³ (10 m) of the d TSI		
SAR averaged over 10 cm² (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.19 W/kg
SAR for nominal Head TSL parameters	permalized to 114/	$24 \in W//r_{m} \pm 46 \in 9/(/r_{m}-2)$

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

1.142 ns	
	1.142 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

Manuactured by SPEAG	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/m³ Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 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

Equipm	ent 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

		 (*)
Trc1 S11 Smith 200 mU/ Ref 1 U Cal		1~
•M1 2.450000 0.5 0.5 0.5 0.5 0.5 0.5 0.5	GHz 25.	48.005 Ω -j2.508 Ω 901227 pF
Ch1 Center 2.45 GHz Pwr -10 dBm Bw 10 kHz Refl OSM P1	Span	800 MHz
Trc2 S11 dB Mag 10 dB/ Ref 0 dB Cal		2 🗸
10 M1 2.45000	0 GHz -2	9.7128 dB
0 dB		
20		
-30		
40		
-50		
-60		
-70	_	
	—	
-90 Ch1 Center 245 CH2 Dur 10 dPm Dur 10 kHz Defl OSM D1		800 MH-
	span	30.01.2024
· Idle Ch1: 100/100	**	02:16:34

^{02:16:35 30.01.2024}

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5 Ω 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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С

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	48	
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	
This calibration certificate documen The measurements and the uncerta All calibrations have been conducte Calibration Equipment used (M&TE	ts the traceability to nation inties with confidence pr ed in the closed laborator critical for calibration)	conal standards, which realize the physical ur robability are given on the following pages ar y facility: environment temperature $(22 \pm 3)^{\circ}$	nits of measurements (SI). nd are part of the certificate. C and humidity < 70%.
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-791	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	Furthe
Approved by:	Sven Kühn	Technical Manager	5.00
This calibration certificate shall not	be reproduced except in	full without written approval of the laboratory	Issued: February 9, 2023

Calibration Laboratory of

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



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- С Servizio svizzero di taratura
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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	میدار	

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)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR averaged over 10 cm ³ (10 g) of Head TSL SAR measured	condition 250 mW input power	6.08 W/kg

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	
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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/m³ 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

Equipm	ent 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 Ω 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

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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	its of measurements (SI).
he measurements and the uncert	tainties with confidence p	robability are given on the following pages ar	nd are part of the certificate.
All calibrations have been conduct	ed in the closed laborato	rv facility: environment temperature (22 ± 3)°(C and humidity < 70%
Calibration Equipment used (M&TI	E critical for calibration)		
rimary Standards	IID#	Cal Date (Certificate No.)	Scheduled Calibration
rimary Standards ower meter NRP	SN: 104778	Cal Date (Certificate No.) 04-Apr-22 (No. 217-03525/03524)	Scheduled Calibration
rimary Standards ower meter NRP ower sensor NRP-Z91	SN: 104778 SN: 103244	Cal Date (Certificate No.) 04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524)	Scheduled Calibration Apr-23
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91	SN: 104778 SN: 103244 SN: 103245	Cal Date (Certificate No.) 04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03524) 04-Apr-22 (No. 217-03525)	Scheduled Calibration Apr-23 Apr-23 Apr-23
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k)	Cal Date (Certificate No.) 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)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327	Cal Date (Certificate No.) 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)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 Apr-23
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4	SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503	Cal Date (Certificate No.) 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)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Mar-23
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Peference 20 dB Attenuator ype-N mismatch combination Peference Probe EX3DV4 AE4	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503 SN: 601	Cal Date (Certificate No.) 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)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Mar-23 Dec-23
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 PAE4 econdary Standards	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503 SN: 601	Cal Date (Certificate No.) 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. 217-03528) 08-Mar-22 (No. EX3-3503_Mar22) 19-Dec-22 (No. DAE4-601_Dec22) Check Date (in house)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Mar-23 Dec-23 Scheduled Check
rimary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter E4419B	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475	Cal Date (Certificate No.) 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) Check Date (in house) 30-Oct-14 (in house check Oct-22)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Mar-23 Dec-23 Scheduled Check
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter E4419B ower sensor HP 8481A	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783	Cal Date (Certificate No.) 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) Check Date (in house) 30-Oct-14 (in house check Oct-22) 07-Oct-15 (in house check Oct-22)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24
rimary Standards ower meter NRP ower sensor NRP-Z91 ower sensor NRP-Z91 eference 20 dB Attenuator ype-N mismatch combination eference Probe EX3DV4 AE4 econdary Standards ower meter E4419B ower sensor HP 8481A ower sensor HP 8481A	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315	Cal Date (Certificate No.) 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) 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)	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 Apr-23 Mar-23 Dec-23 Scheduled Check In house check: Oct-24 In house check: Oct-24 In house check: Oct-24
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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 Recondary Standards ower meter E4419B ower sensor HP 8481A ower sensor HP 8481A F generator R&S SMT-06 etwork Analyzer Agilent E8358A	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41093315 SN: US41080477	Cal Date (Certificate No.) 04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 08-Mar-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 08-Mar-22 (No. 217-03528) 08-Mar-22 (No. 217-03528) 08-Mar-22 (No. 217-03528) 08-Mar-22 (No. 217-03527) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 08-Mar-22 (No. 217-03528) 07-Oct-14 (in house check Oct-22) 07-Oct-15 (in house check Oct-22) 31-Mar-14 (in house check Oct-22) Eunction	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 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
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Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Power meter 20 dB Attenuator System Power Sensor HP 8481A Ower sensor HP 8481A Ower sensor HP 8481A Sower sensor HP 8481A F generator R&S SMT-06 etwork Analyzer Agilent E8358A alibrated by:	ID # SN: 104778 SN: 103244 SN: 103245 SN: BH9394 (20k) SN: 310982 / 06327 SN: 310982 / 06327 SN: 3503 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: 100972 SN: US41080477 Name Paulo Pina	Cal Date (Certificate No.) 04-Apr-22 (No. 217-03525/03524) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03525) 04-Apr-22 (No. 217-03527) 04-Apr-22 (No. 217-03528) 08-Mar-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 Laboratory Technician	Scheduled Calibration Apr-23 Apr-23 Apr-23 Apr-23 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

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

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



Schweizerischer Kalibrierdienst

- Service suisse d'étalonnage
- С Servizio svizzero di taratura S
 - Swiss Calibration Service

S

Accreditation No.: SCS 0108

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

Glossary:

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

Calibration is Performed According to the Following Standards:

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Additional Documentation:

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

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

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

SAR result with Head TSL at 5600 MHz

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

SAR averaged over 10 cm ³ (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 ³ (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 ⁻ (1 g) of nead 15L	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 ³ (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

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/m³ Medium parameters used: f = 5600 MHz; $\sigma = 5.06$ S/m; $\varepsilon_r = 35.9$; $\rho = 1000$ kg/m³ Medium parameters used: f = 5750 MHz; $\sigma = 5.17$ S/m; $\varepsilon_r = 35.7$; $\rho = 1000$ kg/m³ Medium parameters used: f = 5850 MHz; $\sigma = 5.25$ S/m; $\varepsilon_r = 35.4$; $\rho = 1000$ kg/m³ Medium parameters used: f = 5850 MHz; $\sigma = 5.25$ S/m; $\varepsilon_r = 35.4$; $\rho = 1000$ kg/m³

DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(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 j3.740 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 ** 03:00:08 30.01.2024

2) Impedance and Return/Loss

• Return/Loss is greater than the -20 dB cutoff and Impedance is within 5 Ω 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



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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

Client UL USA Fremont, USA

Certificate No: D6.5GHzV2-1033_Mar23

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CALIBRATION C	ERTIFICAT	E	
Object	D6.5GHzV2 - SN:1033		
Calibration procedure(s)	QA CAL-22.v7 Calibration Procedure for SAR Validation Sources between 3-10 GHz		
Calibration date:	March 15, 2023		
This calibration certificate document The measurements and the uncerta	s the traceability to nat inties with confidence p	ional standards, which realize the physical ur robability are given on the following pages a	nits of measurements (SI). nd are part of the certificate.
All calibrations have been conducted	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
lismatch 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	o 1 21
andrated by.	Con Nyondi	Laboratory recimician	Lef hly
Approved by:	Sven Kühn	Technical Manager	S.C.
			logued: March 16, 2000
This solibration partificate aboll not b	a reproduced except in	full without written approval of the laborator	issued. March 16, 2023

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



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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.

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

mW input power 28.9 W/kg malized to 1W 288 W/kg ± 24.7 % (k=2)
malized to 1W 288 W/kg ± 24.7 % (k=2)
Condition
mW input power 6.48 W/kg
malized to 1W 64.7 W/kg ± 24.4 % (k=2)

SAR averaged over 10 cm ³ (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 ²	Condition	
APD measured	100 mW input power	288 W/m ²
APD measured	normalized to 1W	2880 W/m ² ± 29.2 % (k=2)

APD averaged over 4 cm ²	condition	
APD measured	100 mW input power	130 W/m ²
APD measured	normalized to 1W	1300 W/m ² ± 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

DASY6 Validation Report for Head TSL

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

Device under	Test Properties						
Name, Manuf	acturer D	Dimensions	[mm] IN	/IEI	DUT Typ	e	
D6.5GHz	:	16.0 x 6.0 x	300.0 St	N: 1033			
Exposure Con	ditions						
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 Set	up						
Phantom	T	SL		Probe, Cali	bration Date	DAE, Calib	oration Date
MFP V8.0 Cent	ter - 1182 H	IBBL600-10	000V6	EX3DV4 - SI	N7405, 2022-06-02	DAE4 Sn9	08, 2022-06-27
Scan Setup				Measureme	ent Results		
			Zoom Scan				Zoom Scan
Grid Extents	[mm]		22.0 x 22.0 x 22.0	Date		2	023-03-15, 12:39
Grid Steps [m	ım]		3.4 x 3.4 x 1.4	psSAR1g [\	W/Kg]		28.9
Sensor Surfac	ce [mm]		1.4	psSAR8g [\	W/Kg]		6.48
Graded Grid			Yes	psSAR10g	[W/Kg]		5.31
Grading Ratio)		1.4	Power Drif	ft [dB]		0.01
MAIA			N/A	Power Sca	ling		Disabled
Surface Detec	ction		VMS + 6p	Scaling Fac	ctor [dB]		
Scan Method			Measured	TSL Correc	tion		No correction
				M2/M1 [%	5]		55.2
				Dist 3dB P	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 Ω 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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Swiss Calibration Service

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Accreditation No.: SCS 0108

Certificate No. 5G-Veri10-1015_Sep23

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Client	UL	
	Fremont, USA	

CALIBRATION CE	RTIFICAT	E						
Object	5G Verification	Source 10 GHz - SN: 1015						
Calibration procedure(s)	QA CAL-45.v4 Calibration procedure for sources in air above 6 GHz							
Calibration date:	September 05, 2	2023						
This calibration certificate document The measurements and the uncerta All calibrations have been conducted	ts the traceability to nat inties with confidence p d in the closed laborate	ional standards, which realize the physical units probability are given on the following pages and bry facility: environment temperature (22 \pm 3)°C a	s of measurements (SI): are part of the certificate. and humidity < 70%.					
Calibration Equipment used (M&TE	critical for calibration)							
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration					
DAE4ip	SN: 9374 SN: 1602	22-May-23 (No. EUmm-9374_May23) 05-Jul-23 (No. DAE4ip-1602_Jul23)	May-24 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 Network Analyzer Keysight E5063A	SN: 101258 SN: MY54504221	31-May-22 (in house check Nov-22) 31-Oct-19 (in house check Oct-22)	In house check: Nov-23					
	Name	Function	Signature					
Calibrated by	Joanna Lieshaj	Laboratory Tcohnician	Attalling					
Approved by:	Sven Kühn	Technical Manager	5.6					
This calibration certificate shall not be	e reproduced except in	full without written approval of the laboratory	Issued: September 8, 2023					

Calibration Laboratory of

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



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Accreditation No.: SCS 0108

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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 (1cm² and 4cm²) 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/m²) averaged over the surface area of 1 cm² and 4cm² 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 ¹ (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Avg Powe Avg (psPDn+, psl (W	Uncertainty (k = 2)	
				1 cm ²	4 cm ²	
10 mm	93.3	155	1.27 dB	60.5	56.2	1.28 dB

Distance Horn Aperture to Measured Plane	Prad ¹ (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Power psPDn+, psPDt (W	Density ot+, psPDmod+ /m²)	Uncertainty (k = 2)
				1 cm ²	4 cm ²	
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	Prad ¹ (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Avg Powe Avg (psPDn+, psl (W/	Uncertainty (k = 2)	
				1 cm ²	4 cm ²	
10 mm	93.3	155	1.27 dB	60.5	56.1	1.28 dB

Distance Horn Aperture to Measured Plane	Prad ¹ (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Power psPDn+, psPDt (W	Density :ot+, psPDmod+ /m²)	Uncertainty (k = 2)
				1 cm ²	4 cm ²	
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	Prad ^{ri} (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

 $^{^1}$ 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	perties					
Name, Manufacturer	Dimensions [mn	1]	IMEI		DUT Type	
5G Verification Source 10 (GHz 100.0 x 100.0 x	100.0 x 100.0 x 172.0		15	-	
Exposure Conditions						
Phantom Section	Position, Test Distance [mm]	Band	Gro	up,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW		10000.0, 10000	1.0
Hardware Setup						
Phantom	Medium			Probe, Calibration Da	te	DAE. Calibration Date
mmWave Phantom - 1002	Air			EUmmWV3 - SN9374_ 2023-05-22	F1-55GHz,	DAE4ip Sn1602, 2023-07-05
Scan Setup				Measurement Re	sults	
Company Curefords (annual		5G Sc	an			5G Scan
MALA		10	0.0	Date		2023-09-05, 16:21
WAIA		MAIA not us	ed	Avg. Area [cm ²]		1.00
				Avg. Type		Circular Averaging
				psPDn+ [W/m²]		60.3
				psPDtot+[w/m-]		60.5
				Max(Sn) [\//m ²]		60.6
				Max(Stot) [W/m ²]		62.1
				Max(Stot) [W/m ²]		62.1
				E_{max} [V/m]		02.2
				Power Drift [dB]		0.01



Device under Test Pro	perties				
Name, Manufacturer	Dimensions [mm	1]	IMEI	DUT Type	
5G Verification Source 10 (GHz 100.0 x 100.0 x 1	100.0 x 100.0 x 172.0		385	
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
Hardware Setup					
Phantom	Medium		Probe, Calib	ration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air		EUmmWV3 2023-05-22	- SN9374_F1-55GHz,	DAE4ip Sn1602, 2023-07-05
Scan Setup			Measuren	nent Results	
		5G S	an		5G Scan
Sensor Surface [mm]		1	0.0 Date		2023-09-05, 16:21
MAIA		MAIA not us	ed Avg. Area [cm²]	4.00
			Avg. Type		Circular Averaging
			psPDn+ [W	/m²]	56.0
			psPDtot+ [\	W/m²]	56.2
			psPDmod+	[W/m ²]	56.4
			Max(Sn) [W	V/m²]	62.1
			Max(Stot) [W/m²]	62.1
			Max(Stot) [W/m²]	62.2
			E _{max} [V/m]		155
			Power Drift	t [dB]	0.01



Device under Test Prop Name, Manufacturer	perties Dimensions Imm	1	IMEI		DUT Type	
5G Verification Source 10 G	GHz 100.0 x 100.0 x 1	.72.0	SN: 1015		*	
Exposure Conditions Phantom Section	Position, Test Distance [mm]	Band	Gro	up,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW		10000.0, 10000	1.0
Hardware Setup Phantom	Medium			Probe, Calibration Da	te	DAE, Calibration Date
mmWave Phantom - 1002	Air			EUmmWV3 - SN9374_ 2023-05-22	_F1-55GHz,	DAE4ip Sn1602, 2023-07-05
Scan Setup		56 5	ner	Measurement Re	sults	50 5
Sensor Surface [mm] MAIA		1 MAIA not us	0.0 sed	Date Avg. Area [cm ²] Avg. Type psPDn+ [W/m ²] psPDtot+ [W/m ²] Max(Sn) [W/m ²] Max(Sn) [W/m ²] Max(Stot) [W/m ²] Max(Stot) [W/m ²] E _{max} [V/m] Power Drift [dB]		2023-09-05, 16:21 1.00 Square Averaging 60.4 60.5 60.6 62.1 62.1 62.2 155 0.01



Device under Test Pro	perties	-1	INACI			
5G Verification Source 10	GHz 100.0 x 100.0 x	100.0 x 100.0 x 172.0		15	DUT Type	
	10010 x 10010 x	272.0	314. 10	10		
Exposure Conditions Phantom Section	Position, Test Distance [mm]	Band	Gro	up,	Frequency [MHz],	Conversion Factor
5G -	10.0 mm	Validation band	CW		10000.0, 10000	1.0
Hardware Setup	Medium					
mmWave Phantom - 1002	Air			Probe, Calibration Da	te	DAE, Calibration Date
initiate Francin - 1002	All			2023-05-22	F1-55GHz,	DAE4ip Sn1602, 2023-07-05
Scan Setup				Measurement Re	sults	
		5G Sc	an			5G Scan
Sensor Surface [mm]		10	0.0	Date		2023-09-05, 16:21
MAIA		MAIA not us	ed	Avg. Area [cm ²]		4.00
				Avg. Type		Square Averaging
				psPDn+ [W/m²]		55.9
				psPDtot+ [W/m²]		56.1
				psPDmod+ [W/m²]		56.4
				Max(Sn) [W/m²]		62.1
				Max(Stot) [W/m ²]		62.1
				Max(Stot) [W/m ²]		62.2
				E _{max} [V/m]		155
				Power Drift [dB]		0.01



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

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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 Fremont, USA	Certificate No.	5G-Veri30-1117_Sep23
CAL	IBBATION CERTIFICATE		

Object	5G Verification Source 30 GHz - SN: 1117									
Calibration procedure(s)	QA CAL-45.v4 Calibration procedure for sources in air above 6 GHz									
Calibration date:	September 20, 2023									
This calibration certificate documer The measurements and the uncert	nts the traceability to natio ainties with confidence pro	nal standards, which realize the physical units o obability are given on the following pages and ar	f measurements (SI). e part of the certificate.							
All calibrations have been conducte	ed in the closed laboratory	r facility: environment temperature (22 ± 3)°C an	d humidity < 70%.							
Calibration Equipment used (M&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	1602 05-Jul-23 (No. DAE4ip-1602 Jul23) Jul-24								
Secondary Standards	ID #	Check Date (in house)	Scheduled Check							
	Name	Function	Signature							
Calibrated by:	Joanna Lloohaj	Laboratory Technician	Applesy-							
Approved by:	Sven Kühn	Technical Manager	S.Ca							
This calibration certificate shall not b	be reproduced except in fr	ill without written approval of the laboratory	Issued: September 21, 2023							
the subration continents shall not t	to reproduced except in it	an without written approval of the laboratory.								

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Glossary

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. During the measurements, the horn is directly connected to the cable and the antenna ohmic and mismatch losses are determined by farfield 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 (1cm² and 4cm²) 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/m²) averaged over the surface area of 1 cm² and 4cm² 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	30 GHz ± 10 MHz	

Calibration Parameters, 30 GHz

Circular Averaging

Distance Horn Aperture to Measured Plane	Prad ^r Max E-fieldUncertain(mW)(V/m)(k = 2)		rad ^r Max E-fieldUncertaintynW)(V/m)(k = 2)		Avg Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m ²)	
				1 cm ²	4 cm ²	
10 mm	74.1	201	1.27 dB	92.3	80.4	1.28 dB

Distance Horn	Prad	Max E-field	Uncertainty	Power Density		Uncertainty
Aperture to	(mW)	(V/m)	(k = 2)	psPDn+, psPDtot+, psPDmod+		(k = 2)
Measured Plane				(W/m²)		
				1 cm ²	4 cm ²	
10 mm	74.1	201	1.27 dB	91.5, 92.6, 92.8	79.4, 80.7, 81.0	1.28 dB

Square Averaging

Distance Horn	Prad	Max E-field	Uncertainty	Avg Power Density		Uncertainty
Aperture to	(mW)	(V/m)	(k = 2)	Avg (psPDn+, psPDtot+, psPDmod+)		(k = 2)
Measured Plane	11	10	1	(W/m²)		1
				1 cm ²	4 cm ²	
10 mm	74.1	201	1.27 dB	92.5	80.1	1.28 dB

Distance Horn Aperture to Measured Plane	Prad ^r (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Power Density psPDn+, psPDtot+, psPDmod+ (W/m²)		Uncertainty (k = 2)
	1.17			1 cm ²	4 cm ²	
10 mm	74.1	201	1.27 dB	91.7, 92.8, 93.0	79.1, 80.5, 80.7	1.28 dB

Max Power Density

Distance Horn Aperture to Measured Plane	Prad ^{ri} (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Max Power Density Sn, Stot, Stot (W/m²)	Uncertainty (k = 2)
10 mm	74.1	201	1.27 dB	105, 106, 106	1.28 dB

¹ Derived from far-field data

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Proj	perties					
Name, Manufacturer	Dimensions (mm	1]	IMEI		DUT Type	
5G Verification Source 30 G	GHz 100.0 x 100.0 x 1	100.0	SN: 111	17	÷.	
Exposure Conditions						
Phantom Section	Position, Test Distance [mm]	Band	Grou	ıp,	Frequency [MHz], Channel Number	Conversion Factor
5G -	5.55 mm	Validation band	CW		30000.0, 30000	1.0
Hardware Setup						
Phantom	Medium			Probe. Calibration Dat	te	DAE. Calibration Date
mmWave Phantom - 1002	Air			EUmmWV3 - SN9374_ 2023-05-22	F30GHz,	DAE4ip Sn1602, 2023-07-05
Scan Setup				Measurement Re	sults	
		5G Sc	can			5G Scan
Sensor Surface [mm]		5	.55	Date		2023-09-20, 16:02
MAIA		MAIA not us	sed	Avg. Area [cm ²]		1.00
				Avg. Type		Circular Averaging
				psPDn+ [W/m ²]		91.5
				psPDtot+ [W/m²]		92.6
				pspbmod+ [w/m-]		92.8
				Max(Stot) [W/m²]		105
				Max(1Stot1) [W/m ²]		106
				F _{max} [V/m]		201
				Power Drift [dB]		-0.04



Certificate No: 5G-Veri30-1117_Sep23

Device under Test Prog Name, Manufacturer	perties Dimensions (mm	1	IMEI		DUT Type	
5G Verification Source 30 G	GHz 100.0 x 100.0 x 1	100.0	SN: 11:	17	-	
Exposure Conditions Phantom Section	Position, Test Distance [mm]	Band	Gro	,qι	Frequency [MHz], Channel Number	Conversion Factor
5G -	5.55 mm	Validation band	CW		30000.0, 30000	1.0
Hardware Setup Phantom	Medium			Probe, Calibration Da	te	DAE, Calibration Date
mmWave Phantom - 1002	Air			EUmmWV3 - SN9374_ 2023-05-22	_F30GHz,	DAE4ip Sn1602, 2023-07-05
Scan Setup		5G Si	can	Measurement Re	sults	5G Scan
Sensor Surface [mm] MAIA		5 MAIA not u	.55 sed	Date Avg. Area [cm ²] Avg. Type psPDn+ [W/m ²] psPDtot+ [W/m ²] Max(Sn) [W/m ²] Max(Stot) [W/m ²] Max(Stot) [W/m ²] E _{max} [V/m] Power Drift [dB]		2023-09-20, 16:02 4.00 Circular Averaging 79.4 80.7 81.0 105 106 106 201 -0.04



Device under Test Pro	perties			0.07	
Name, Manufacturer				DUT Type	
SO Vermication Source SO C	JHZ 100.0 X 100.0 X 1	.00.0	511.1117		
Exposure Conditions Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	5.55 mm	Validation band	CW	30000.0, 30000	1.0
Hardware Setup Phantom	Medium		Probe, Calibra	ation Date	DAE, Calibration Date
mmWave Phantom - 1002	Air		EUmmWV3 - 5 2023-05-22	SN9374_F30GHz,	DAE4ip Sn1602, 2023-07-05
Scan Setup			Measurem	ent Results	
Conney Surface Imm]		5G Sca	an Data		5G Scan
MAIA		5.5 MAIA not use	ed Avg. Area [ci Avg. Type psPDn+ [W/i psPDtot+ [W psPDmod+ [' Max(Sn) [W/ Max(Stot) [V Max(]Stot]) E _{max} [V/m] Power Drift [m²] m²] W/m²] (m²] V/m²] [W/m²] [W/m²]	2023-09-20, 16:02 1.00 Square Averaging 91.7 92.8 93.0 105 106 106 201 -0.04


DASY Report

Measurement Report for 5G Verification Source 30 GHz, UID 0 -, Channel 30000 (30000.0MHz)

Device under Test Prop	perties Dimensions Imm	1	IMEL	DUTTuro	
5G Verification Source 30 G	GHz 100.0 x 100.0 x 1	100.0 x 100.0 x 100.0		-	
Exposure Conditions Phantom Section	Position, Test Distance	Band	Group,	Frequency [MHz]	, Conversion Factor
	[mm]			Channel Number	
5G -	5.55 mm	Validation band	CW	30000.0, 30000	1.0
Hardware Setup	Madium		Deales	allegation Date	DAT Collinguise Date
mmWave Phantom - 1002	Air		EUmmV 2023-0	-andration Date VV3 - SN9374_F30GHz, 5-22	DAE4ip Sn1602, 2023-07-05
Scan Setup			Measu	irement Results	
Sancar Surface [mm]		5G Sc	an Data		5G Scan
MAIA		MAIA not us	ed Avg. A Avg. Ty psPDn psPDtc psPDtr Max(Si Max() E _{max} [V, Power	rea [cm²] ype + [W/m²] od+ [W/m²] n) [W/m²] tot) [W/m²] Stot) [W/m²] /m] Drift [dB]	4.00 Square Averaging 79.1 80.5 80.7 105 106 106 201 -0.04

