

Appendix C

Phantom Description

Schmid & Partner Engineering AG

s p e a g

Zeughausstrasse 43, 8004 Zurich, Switzerland
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info@spag.com, <http://www.spag.com>

Certificate of Conformity / First Article Inspection

Item	Oval Flat Phantom EU 5.0
Type No	QD OVA 002 A
Series No	1108 and higher
Manufacturer	Untersee Composites Knebelstrasse 8, CH-8268 Mannenbach, Switzerland

Tests

Complete tests were made on the prototype units QD OVA 001 A, pre-series units QD OVA 001 B as well as on some series units QD OVA 001 B. Some tests are made on all series units QD OVA 002 A.

Test	Requirement	Details	Units tested
Shape	Internal dimensions, depth and sagging are compatible with standards	Bottom elliptical 600 x 400 mm, Depth 190 mm, dimension compliant with [1] for $f > 375$ MHz	Prototypes
Material thickness	Bottom: 2.0mm +/- 0.2mm	dimension compliant with [3] for $f > 800$ MHz	all
Material parameters	rel. permittivity 2 - 5, loss tangent ≤ 0.05 , at $f \leq 6$ GHz	rel. permittivity 3.5 +/- 0.5, loss tangent ≤ 0.05	Material samples
Material resistivity	Compatibility with tissue simulating liquids	Compatible with SPEAG liquids. **	Phantoms, Material sample
Sagging	Sagging of the flat section in tolerance when filled with tissue simulating liquid	within tolerance for filling height up to 155 mm	Prototypes, samples

** Note: Compatibility restrictions apply certain liquid components mentioned in the standard, containing e.g. DGBE, DGMHE or Triton X-100. Observe technical note on material compatibility.

Standards

- [1] OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 01-01
- [2] IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques, December 2003
- [3] IEC 62209-1 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", 2005-02-18
- [4] IEC 62209-2 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices - Human models, instrumentation, and procedures - Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", 2010-03-30

Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of body-worn SAR measurements and system performance checks as specified in [1 - 4] and further standards.

Date 25.7.2011

Signature / Stamp

s p e a g

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Doc No 881 - QD OVA 002 A - A

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System Validation from Original Equipment Supplier

Calibration Laboratory of
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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

Accreditation No.: SCS 0108

Client SGS-TW (Auden)

Certificate No: D2450V2-727_Apr21

CALIBRATION CERTIFICATE

Object D2450V2 - SN:727

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

Calibration date: April 14, 2021

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

All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

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

Calibrated by:	Name Jeffrey Katzman	Function Laboratory Technician	Signature
Approved by:	Katja Pokovic	Technical Manager	

Issued: April 14, 2021

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Certificate No: D2450V2-727_Apr21

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Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	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 $\pm$ 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 $\pm$ 0.2) °C	38.0 $\pm$ 6 %	1.87 mho/m $\pm$ 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	13.8 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.9 W/kg $\pm$ 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.36 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.1 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.4 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.2 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	51.4 W/kg $\pm$ 17.0 % (k=2)
SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.15 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.2 W/kg $\pm$ 16.5 % (k=2)

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

Impedance, transformed to feed point	$56.4 \Omega + 2.9 j\Omega$
Return Loss	- 23.6 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$51.9 \Omega + 4.8 j\Omega$
Return Loss	- 25.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.148 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: 14.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:727

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.87$ S/m; $\epsilon_r = 38.0$; $\rho = 1000$ 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: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

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

Reference Value = 118.9 V/m; Power Drift = 0.07 dB

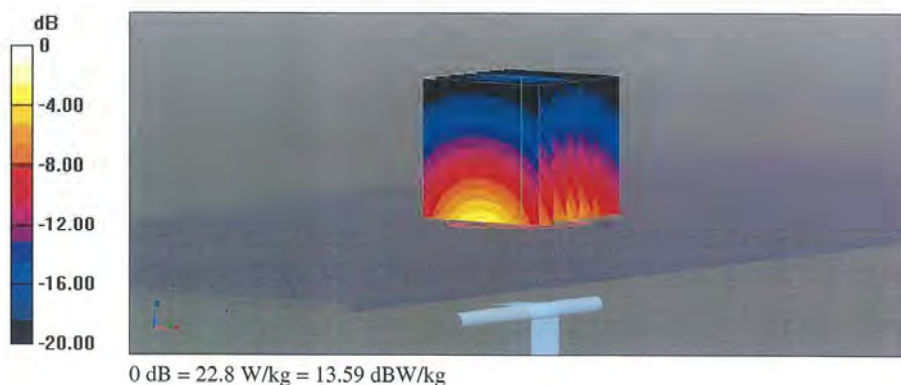
Peak SAR (extrapolated) = 27.6 W/kg

SAR(1 g) = 13.8 W/kg; SAR(10 g) = 6.36 W/kg

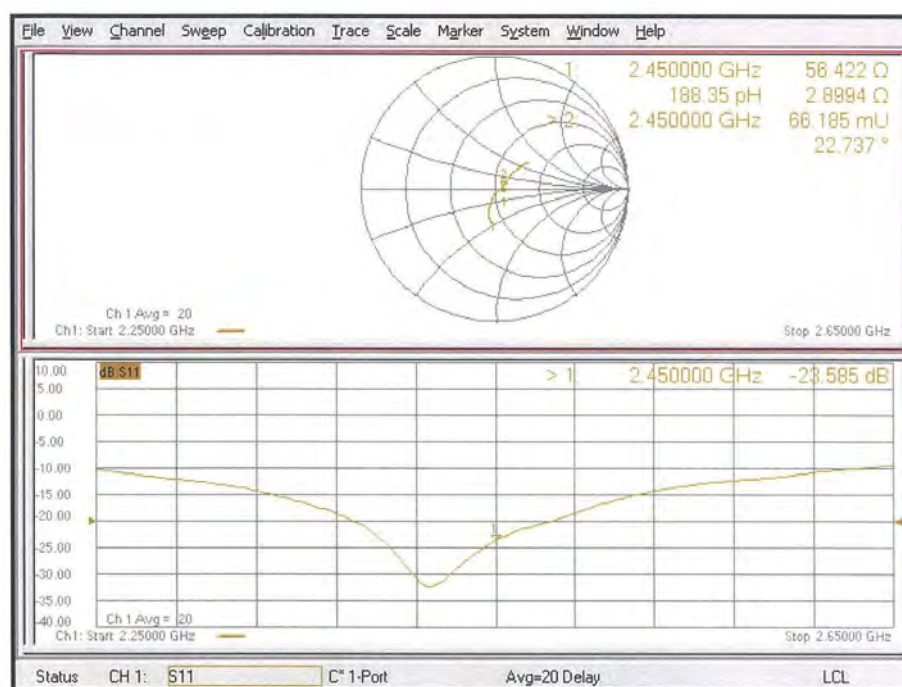
Smallest distance from peaks to all points 3 dB below = 9 mm

Ratio of SAR at M2 to SAR at M1 = 49.9%

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



Impedance Measurement Plot for Head TSL



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DASY5 Validation Report for Body TSL

Date: 14.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:727

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 51.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.12, 8.12, 8.12) @ 2450 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

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

Reference Value = 111.4 V/m; Power Drift = -0.00 dB

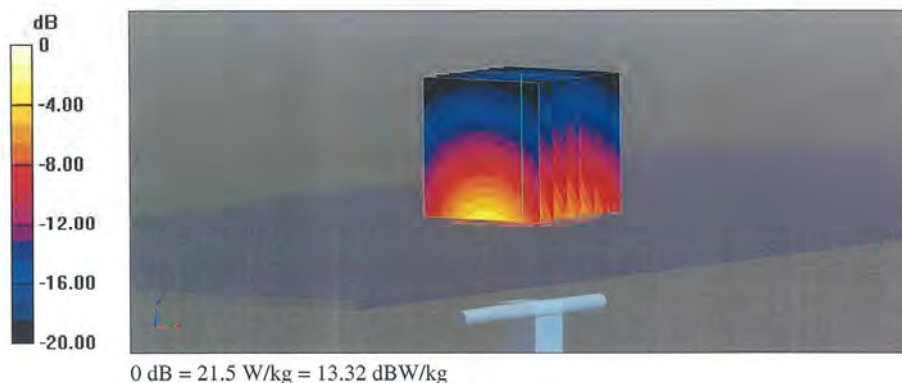
Peak SAR (extrapolated) = 25.2 W/kg

SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.15 W/kg

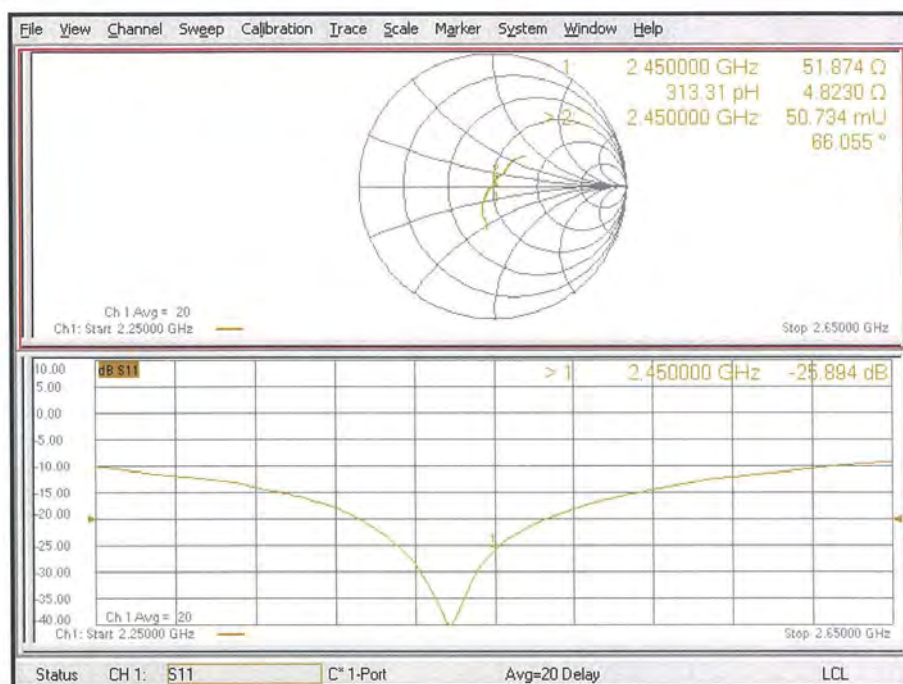
Smallest distance from peaks to all points 3 dB below = 8 mm

Ratio of SAR at M2 to SAR at M1 = 53.1%

Maximum value of SAR (measured) = 21.5 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: SCS 0108

Client SGS-TW (Auden)

Certificate No: D5GHzV2-1023_Jan21

CALIBRATION CERTIFICATE

Object D5GHzV2 - SN:1023

Calibration procedure(s) QA CAL-22.v5
Calibration Procedure for SAR Validation Sources between 3-10 GHz

Calibration date: January 26, 2021

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	01-Apr-20 (No. 217-03100/03101)	Apr-21
Power sensor NRP-Z91	SN: 103244	01-Apr-20 (No. 217-03100)	Apr-21
Power sensor NRP-Z91	SN: 103245	01-Apr-20 (No. 217-03101)	Apr-21
Reference 20 dB Attenuator	SN: BH9394 (20k)	31-Mar-20 (No. 217-03106)	Apr-21
Type-N mismatch combination	SN: 310982 / 06327	31-Mar-20 (No. 217-03104)	Apr-21
Reference Probe EX3DV4	SN: 3503	30-Dec-20 (No. EX3-3503_Dec20)	Dec-21
DAE4	SN: 601	02-Nov-20 (No. DAE4-601_Nov20)	Nov-21
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: G839512475	30-Oct-14 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-20)	In house check: Oct-22
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-20)	In house check: Oct-22
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-20)	In house check: Oct-21

Calibrated by: Name Leif Klysner Function Laboratory Technician Signature

Approved by: Name Kaja Polovic Function Technical Manager Signature

Issued: January 27, 2021

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

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Measurement Conditions

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

DASY Version	DASY5	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 = 10.0 mm, dz = 10.0 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz $\pm$ 1 MHz 5300 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	35.1 $\pm$ 6 %	4.46 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	---	---

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm ³ (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/	77.9 W/kg $\pm$ 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/	22.2 W/kg $\pm$ 19.5 % (k=2)

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Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.0 ± 6 %	4.56 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.8 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	34.5 ± 6 %	4.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	—	—

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.46 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.6 W/kg ± 19.5 % (k=2)

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Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.2 ± 6 %	5.07 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.6 W/kg ± 19.5 % (k=2)

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Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.4 ± 6 %	5.44 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.37 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.04 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.5 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.2 ± 6 %	5.57 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.32 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.02 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.3 W/kg ± 19.5 % (k=2)

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Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.7 ± 6 %	5.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.79 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	78.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.13 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.4 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.3 ± 6 %	6.27 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	—	—

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.36 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.00 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.0 W/kg ± 19.5 % (k=2)

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Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	49.5 Ω - 6.9 j Ω
Return Loss	- 23.2 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	51.3 Ω - 3.0 j Ω
Return Loss	- 29.8 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	53.3 Ω + 0.1 j Ω
Return Loss	- 29.9 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	54.1 Ω + 2.7 j Ω
Return Loss	- 26.6 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.8 Ω - 6.0 j Ω
Return Loss	- 24.2 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	51.9 Ω - 1.0 j Ω
Return Loss	- 33.5 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	55.5 Ω + 1.4 j Ω
Return Loss	- 25.4 dB

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Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	$56.2 \Omega + 5.1 j\Omega$
Return Loss	-22.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.199 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: 25.01.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1023

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.46$ S/m; $\epsilon_r = 35.1$; $\rho = 1000$ kg/m³,
Medium parameters used: $f = 5300$ MHz; $\sigma = 4.56$ S/m; $\epsilon_r = 35$; $\rho = 1000$ kg/m³,
Medium parameters used: $f = 5600$ MHz; $\sigma = 4.86$ S/m; $\epsilon_r = 34.5$; $\rho = 1000$ kg/m³,
Medium parameters used: $f = 5800$ MHz; $\sigma = 5.07$ S/m; $\epsilon_r = 34.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.8, 5.8, 5.8) @ 5200 MHz, ConvF(5.49, 5.49, 5.49) @ 5300 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 78.88 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 27.4 W/kg

SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.24 W/kg

Smallest distance from peaks to all points 3 dB below = 6.9 mm

Ratio of SAR at M2 to SAR at M1 = 69.2%

Maximum value of SAR (measured) = 17.4 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 77.25 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 28.6 W/kg

SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.3 W/kg

Smallest distance from peaks to all points 3 dB below = 6.9 mm

Ratio of SAR at M2 to SAR at M1 = 68.9%

Maximum value of SAR (measured) = 18.1 W/kg

Certificate No: D5GHzV2-1023_Jan21

Page 10 of 15

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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 = 78.54 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 31.0 W/kg
SAR(1 g) = 8.46 W/kg; SAR(10 g) = 2.39 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 67.5%
Maximum value of SAR (measured) = 19.4 W/kg

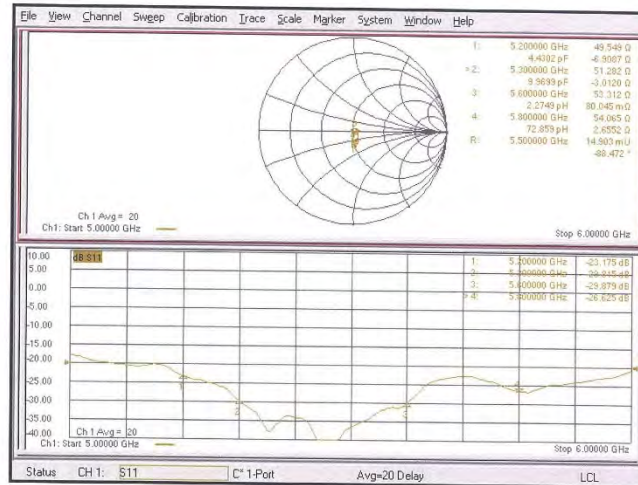
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 75.89 V/m; Power Drift = 0.08 dB
Peak SAR (extrapolated) = 32.1 W/kg
SAR(1 g) = 8.16 W/kg; SAR(10 g) = 2.28 W/kg
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 65.2%
Maximum value of SAR (measured) = 19.1 W/kg



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Impedance Measurement Plot for Head TSL



Certificate No: D5GHzV2-1023_Jan21

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DASY5 Validation Report for Body TSL

Date: 26.01.2021

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1023

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 5.44$ S/m; $\epsilon_r = 49.4$; $\rho = 1000$ kg/m³ ,Medium parameters used: $f = 5300$ MHz; $\sigma = 5.57$ S/m; $\epsilon_r = 49.2$; $\rho = 1000$ kg/m³ ,Medium parameters used: $f = 5600$ MHz; $\sigma = 5.99$ S/m; $\epsilon_r = 48.7$; $\rho = 1000$ kg/m³ ,Medium parameters used: $f = 5800$ MHz; $\sigma = 6.27$ S/m; $\epsilon_r = 48.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.29, 5.29, 5.29) @ 5200 MHz, ConvF(5.23, 5.23, 5.23) @ 5300 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.62, 4.62, 4.62) @ 5800 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 67.79 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 28.2 W/kg

SAR(1 g) = 7.37 W/kg; SAR(10 g) = 2.04 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%

Maximum value of SAR (measured) = 17.3 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 66.64 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 29.2 W/kg

SAR(1 g) = 7.32 W/kg; SAR(10 g) = 2.02 W/kg

Smallest distance from peaks to all points 3 dB below = 6.8 mm

Ratio of SAR at M2 to SAR at M1 = 65.4%

Maximum value of SAR (measured) = 17.7 W/kg

Certificate No: D5GHzV2-1023_Jan21

Page 13 of 15

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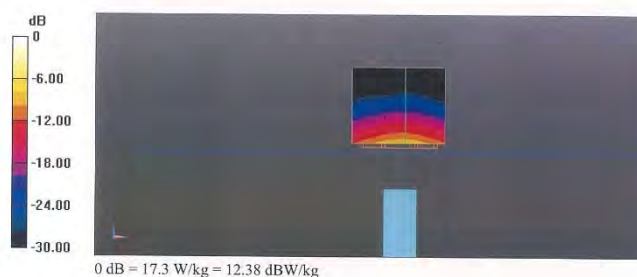
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Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.51 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 33.7 W/kg
SAR(1 g) = 7.79 W/kg; SAR(10 g) = 2.13 W/kg
Smallest distance from peaks to all points 3 dB below = 6.8 mm
Ratio of SAR at M2 to SAR at M1 = 62.8%
Maximum value of SAR (measured) = 19.3 W/kg

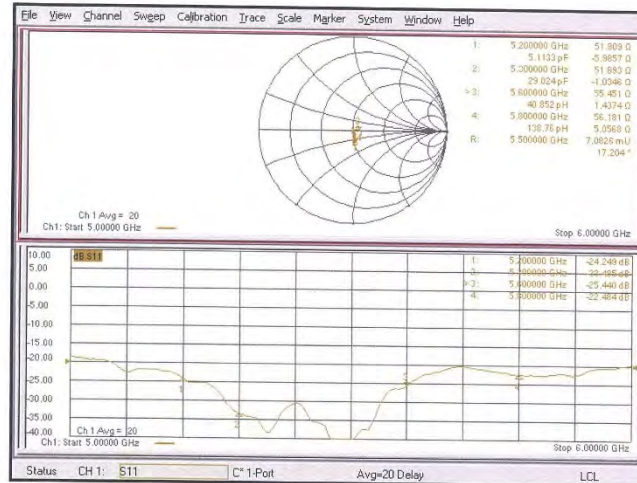
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.18 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 32.5 W/kg
SAR(1 g) = 7.36 W/kg; SAR(10 g) = 2 W/kg
Smallest distance from peaks to all points 3 dB below = 6.8 mm
Ratio of SAR at M2 to SAR at M1 = 62.2%
Maximum value of SAR (measured) = 18.4 W/kg



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Impedance Measurement Plot for Body TSL



Certificate No: D5GHzV2-1023_Jan21

Page 15 of 15

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **SGS (Auden)**

Certificate No: **D6.5GHzV2-1006_Aug21**

CALIBRATION CERTIFICATE

Object **D6.5GHzV2 - SN:1006**

Calibration procedure(s) **QA CAL-22.v6
Calibration Procedure for SAR Validation Sources between 3-10 GHz**

Calibration date: **August 26, 2021**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	09-Apr-21 (No. 217-03291/03292)	Apr-22
Power sensor NRP-Z91	SN: 103244	09-Apr-21 (No. 217-03291)	Apr-22
Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Power sensor R&S NRP33T	SN: 100967	08-Apr-21 (No. 217-03293)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7405	30-Dec-20 (No. EX3-7405_Dec20)	Dec-21
DAE4	SN: 908	24-Jun-21 (No. DAE4-908_Jun21)	Jun-22
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator Anapico APSIN20G	SN: 669	28-Mar-17 (in house check Dec-18)	In house check: Dec-21
Network Analyzer R&S ZVL13	SN: 101083	10-May-12 (in house check Dec-18)	In house check: Dec-21

Calibrated by: **Name** **Function** **Signature**
Jeton Kastrati **Laboratory Technician**

Approved by: **Katja Pokovic** **Technical Manager**

Issued: August 27, 2021

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

Certificate No: D6.5GHzV2-1006_Aug21

Page 1 of 6

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Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The 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	V16.0
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 $\pm$ 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 $\pm$ 0.2) °C	33.6 $\pm$ 6 %	6.11 mho/m $\pm$ 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	29.3 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	291 W/kg $\pm$ 24.7 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	5.39 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.5 W/kg $\pm$ 24.4 % (k=2)

Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	45.7 Ω - 6.6 j Ω
Return Loss	- 21.7 dB

APD (Absorbed Power Density)

APD averaged over 1 cm ²	Condition	
APD measured	100 mW input power	291 W/m ²
APD measured	normalized to 1W	2910 W/m ² $\pm$ 29.2 % (k=2)

APD averaged over 4 cm ²	condition	
APD measured	100 mW input power	132 W/m ²
APD measured	normalized to 1W	1320 W/m ² $\pm$ 28.9 % (k=2)

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-1006, UID 0 -, Channel 6500 (6500.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
D6.5GHz	16.0 x 6.0 x 300.0	SN: 1006	-

Exposure Conditions

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	5.75	6.11	33.6

Hardware Setup

Phantom	TSL	Probe, Calibration Date	DAE, Calibration Date
MFP V8.0 Center - 1182	HBBL600-10000V6	EX3DV4 - SN7405, 2020-12-30	DAE4 Sn908, 2021-06-24

Scan Setup

	Zoom Scan
Grid Extents [mm]	22.0 x 22.0 x 22.0
Grid Steps [mm]	3.4 x 3.4 x 1.4
Sensor Surface [mm]	1.4
Graded Grid	Yes
Grading Ratio	1.4
MAIA	N/A
Surface Detection	VMS + 6p
Scan Method	Measured

Measurement Results

	Zoom Scan
Date	2021-08-26, 10:54
psSAR1g [W/Kg]	29.3
psSAR10g [W/Kg]	5.39
Power Drift [dB]	0.03
Power Scaling	Disabled
Scaling Factor [dB]	
TSL Correction	No correction
M2/M1 [%]	50.3
Dist 3dB Peak [mm]	4.8



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Impedance Measurement Plot for Head TSL

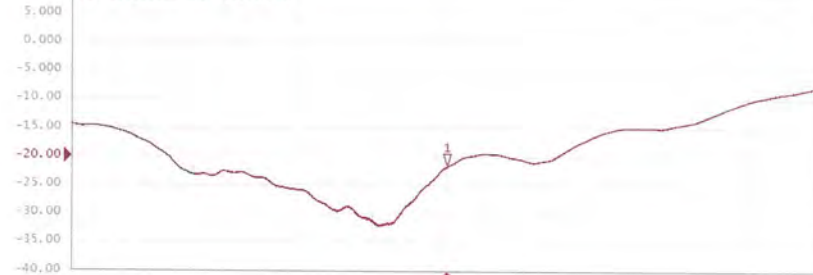
► F1 S11 Smith (R+jX) Scale 1.000 U [F1]

>1 6.5000000 GHz 45.696 Ω -6.5992 Ω 3.7103 pF



Tr2 S11 Log Mag 5.000 dB/ Ref -20.00 dB [F1]

>1 6.5000000 GHz -21.710 dB



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Accreditation No.: SCS 0108

Client **SGS (Auden)**

Certificate No: D7GHZV2-1007_Aug21

CALIBRATION CERTIFICATE

Object **D7GHZV2 - SN:1007**

Calibration procedure(s) **QA CAL-22.v6**
Calibration Procedure for SAR Validation Sources between 3-10 GHz

Calibration date: **August 26, 2021**

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Power sensor NRP-Z91	SN: 103245	09-Apr-21 (No. 217-03292)	Apr-22
Power sensor R&S NRP33T	SN: 100967	08-Apr-21 (No. 217-03293)	Apr-22
Reference 20 dB Attenuator	SN: BH9394 (20k)	09-Apr-21 (No. 217-03343)	Apr-22
Type-N mismatch combination	SN: 310982 / 06327	09-Apr-21 (No. 217-03344)	Apr-22
Reference Probe EX3DV4	SN: 7405	30-Dec-20 (No. EX3-7405_Dec20)	Dec-21
DAE4	SN: 908	24-Jun-21 (No. DAE4-908_Jun21)	Jun-22
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator Anapico APSIN20G	SN: 669	28-Mar-17 (in house check Dec-18)	In house check: Dec-21
Network Analyzer R&S ZVL13	SN: 101093	10-May-12 (in house check Dec-18)	In house check: Dec-21

Calibrated by: **Name** Jeton Kastrati **Function** Laboratory Technician **Signature**

Approved by: **Name** Katja Pokovic **Function** Technical Manager

Issued: August 27, 2021

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Certificate No: D7GHZV2-1007_Aug21

Page 1 of 6

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

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%.

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Measurement Conditions

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

DASY Version	DASY6	V16.0
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	7000 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	33.9	6.65 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	32.7 $\pm$ 6 %	6.71 mho/m $\pm$ 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	27.7 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	275 W/kg $\pm$ 24.7 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	4.78 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	47.4 W/kg $\pm$ 24.4 % (k=2)

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Appendix

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.9 Ω - 3.8 j Ω
Return Loss	- 26.6 dB

APD (Absorbed Power Density)

APD averaged over 1 cm ²	Condition	
APD measured	100 mW input power	274 W/m ²
APD measured	normalized to 1W	2740 W/m ² $\pm$ 29.2 % (k=2)

APD averaged over 4 cm ²	condition	
APD measured	100 mW input power	119 W/m ²
APD measured	normalized to 1W	1190 W/m ² $\pm$ 28.9 % (k=2)

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 D7GHz-1007, UID 0 -, Channel 7000 (7000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
D7GHz	14.0 x 6.0 x 297.0	SN: 1007	-

Exposure Conditions

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,	7000	6.09	6.71	32.7

Hardware Setup

Phantom	TSL	Probe, Calibration Date	DAE, Calibration Date
MFP V8.0 Center - 1182	HBBL600-1000V6	EX3DV4 - SN7405, 2020-12-30	DAE4 Sn908, 2021-06-24

Scan Setup

Zoom Scan		Measurement Results	
Grid Extents [mm]	22.0 x 22.0 x 22.0	Date	2021-08-26, 14:14
Grid Steps [mm]	3.0 x 3.0 x 1.4	psSAR1g [W/Kg]	27.7
Sensor Surface [mm]	1.4	psSAR10g [W/Kg]	4.78
Graded Grid	Yes	Power Drift [dB]	0.05
Grading Ratio	1.4	Power Scaling	Disabled
MAIA	N/A	Scaling Factor [dB]	
Surface Detection	VMS + 6p	TSL Correction	No correction
Scan Method	Measured	M2/M1 [%]	46.9
		Dist 3dB Peak [mm]	4.6



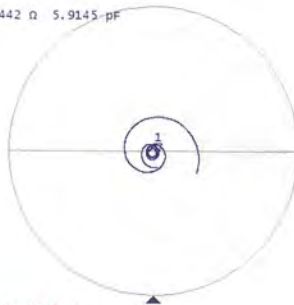
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Impedance Measurement Plot for Head TSL

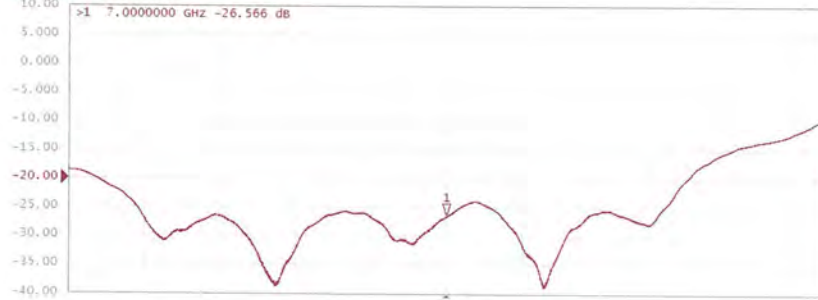
Tr1 S11 Smith (R+jX) Scale 1.000 u [F1]

>1 7.0000000 GHz 52.936 Ω -3.8442 Ω 5.9145-pF



Tr2 S11 Log Mag 5.000 dB/ Ref -20.00 dB [F1]

>1 7.0000000 GHz -26.566 dB



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Accreditation No.: **SCS 0108**

Client **SGS-TW (Auden)**

Certificate No: **5G-Veri10-1021_Jan21**

CALIBRATION CERTIFICATE

Object **5G Verification Source 10 GHz - SN: 1021**

Calibration procedure(s) **QA CAL-45.v3
Calibration procedure for sources in air above 6 GHz**

Calibration date: **January 18, 2021**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Reference Probe EumWV3	SN: 9374	30-Dec-20 (No. EUmmWV3-9374_Dec20)	Dec-21
DAE4ip	SN: 1602	11-Aug-20 (No. DAE4ip-1602_Aug20)	Aug-21

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
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Calibrated by: **Name** Michael Weber **Function** Laboratory Technician **Signature** *N. Weber*

Approved by: **Name** Katja Pokovic **Function** Technical Manager **Signature** *K. Pokovic*

Issued: January 25, 2021

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Certificate No: 5G-Veri10-1021_Jan21

Page 1 of 7

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Accreditation No.: **SCS 0108**

Glossary

CW Continuous wave

Calibration is Performed According to the Following Standards

- Internal procedure QA CAL-45-5Gsources
- IEC TR 63170 ED1, "Measurement procedure for the evaluation of power density related to human exposure to radio frequency fields from wireless communication devices operating between 6 GHz and 100 GHz", January 2018

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 forward power to the horn antenna 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 + $\lambda/4$) 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	cDASY6 Module mmWave	V2.2
Phantom	5G Phantom	
Distance Horn Aperture - plane	10 mm	
XY Scan Resolution	dx, dy = 7.5 mm	
Number of measured planes	2 (10mm, 10mm + $\lambda/4$)	
Frequency	10 GHz $\pm$ 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 Power Density Avg ($psPDn+$, $psPDtot+$, $psPDmod+$) (W/m ²)		Uncertainty (k = 2)
				1 cm ²	4 cm ²	
10 mm	74.0	134	1.27 dB	45.0	42.3	1.28 dB

Square Averaging

Distance Horn Aperture to Measured Plane	$Prad^1$ (mW)	Max E-field (V/m)	Uncertainty (k = 2)	Avg Power Density Avg ($psPDn+$, $psPDtot+$, $psPDmod+$) (W/m ²)		Uncertainty (k = 2)
				1 cm ²	4 cm ²	
10 mm	74.0	134	1.27 dB	45.1	42.2	1.28 dB

¹ Assessed ohmic and mismatch loss: 0.45 dB

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DASY Report

Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 172.0	SN: 1021	-

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

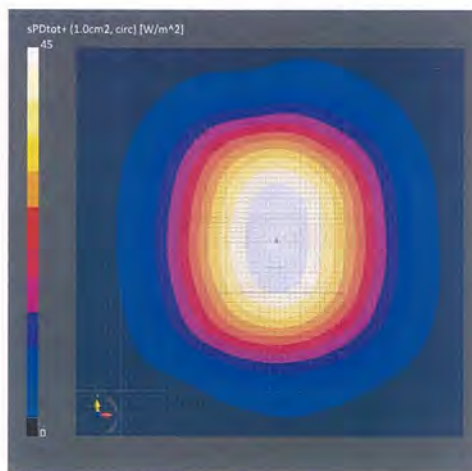
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUMmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan
Grid Extents [mm]	120.0 x 120.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	10.0
MAIA	MAIA not used

Measurement Results

	5G Scan
Date	2021-01-18, 16:23
Avg. Area [cm ²]	1.00
psPDn+ [W/m ²]	44.9
psPDtot+ [W/m ²]	45.0
psPDmod+ [W/m ²]	45.2
E _{max} [V/m]	134
Power Drift [dB]	0.04



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Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 172.0	SN: 1021	-

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

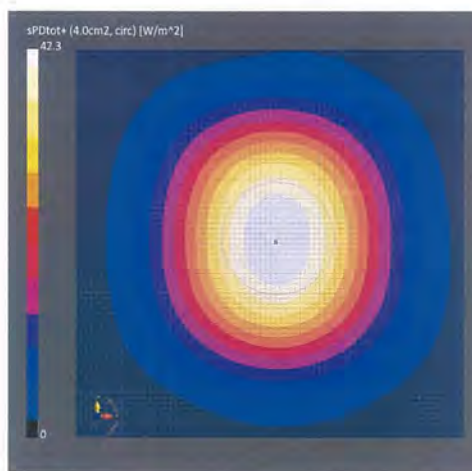
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan
Grid Extents [mm]	120.0 x 120.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	10.0
MAIA	MAIA not used

Measurement Results

	5G Scan
Date	2021-01-18, 16:23
Avg. Area [cm ²]	4.00
psPDn+ [W/m ²]	42.2
psPDtot+ [W/m ²]	42.3
psPDmod+ [W/m ²]	42.5
E _{max} [V/m]	134
Power Drift [dB]	0.04



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Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 172.0	SN: 1021	-

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, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUMmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan
Grid Extents [mm]	120.0 x 120.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	10.0
MAIA	MAIA not used

Measurement Results

	5G Scan
Date	2021-01-18, 16:23
Avg. Area [cm ²]	1.00
psPDn+ [W/m ²]	44.9
psPDtot+ [W/m ²]	45.1
psPDmod+ [W/m ²]	45.2
E _{max} [V/m]	134
Power Drift [dB]	0.04



DASY Report

Measurement Report for 5G Verification Source 10 GHz, UID 0 -, Channel 10000 (10000.0MHz)

Device under Test Properties

Name, Manufacturer	Dimensions [mm]	IMEI	DUT Type
5G Verification Source 10 GHz	100.0 x 100.0 x 172.0	SN: 1021	-

Exposure Conditions

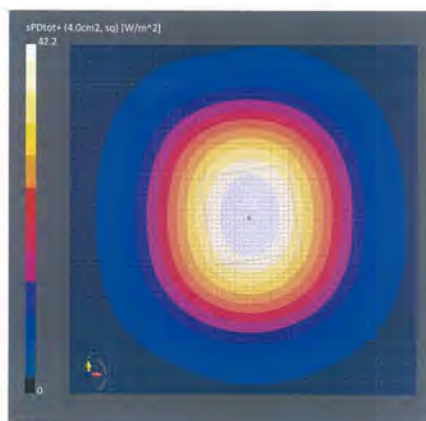
Phantom Section	Position, Test Distance [mm]	Band	Group,	Frequency [MHz], Channel Number	Conversion Factor
5G -	10.0 mm	Validation band	CW	10000.0, 10000	1.0

Hardware Setup

Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave Phantom - 1002	Air	EUmmWV3 - SN9374_F1-78GHz, 2020-12-30	DAE4ip Sn1602, 2020-08-11

Scan Setup

	5G Scan	Measurement Results	5G Scan
Grid Extents [mm]	120.0 x 120.0	Date	2021-01-18, 16:23
Grid Steps [lambda]	0.25 x 0.25	Avg. Area [cm ²]	4.00
Sensor Surface [mm]	10.0	psPDn+ [W/m ²]	42.1
MAIA	MAIA not used	psPDtot+ [W/m ²]	42.2
		psPDmod+ [W/m ²]	42.4
		E _{max} [V/m]	134
		Power Drift [dB]	0.04

**- End of report -**

Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 90 days only.
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