# Appendix C

## Phantom Description

Schmid & Partner Engineering AG

s p e a g

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Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

### Certificate of Conformity / First Article Inspection

| | |
|---|---|
| Item | Oval Flat Phantom ELI 5.0 |
| Type No | QD OVA 002 A |
| Series No | 1108 and higher |
| Manufacturer | Untersee Composites<br>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 ≤ 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**

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Doc No 881 – QD OVA 002 A - A Page 1 (1)

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# System Validation from Original Equipment Supplier

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

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**S** Swiss Calibration Service

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

**Accreditation No.: SCS 0108**

**Client** **SGS-TW (Auden)** **Certificate No: D2450V2-727_Apr21**

## CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D2450V2 - SN:727 |
| Calibration procedure(s) | QA CAL-05.v11<br>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 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

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

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

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

Issued: April 14, 2021

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

Certificate No: D2450V2-727_Apr21 Page 1 of 8

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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:**

a) 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
b) 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
c) 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
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

e) 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 | |
| **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 | 38.0 ± 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 | 13.8 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **53.9 W/kg ± 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 ± 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 ± 0.2) °C | 51.4 ± 6 % | 2.04 mho/m ± 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 ± 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 ± 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 Ω + 2.9 jΩ |
| Return Loss | - 23.6 dB |

### Antenna Parameters with Body TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.9 Ω + 4.8 jΩ |
| Return Loss | - 25.9 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.148 ns |

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |



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## DASY5 Validation Report for Head TSL

Date: 14.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

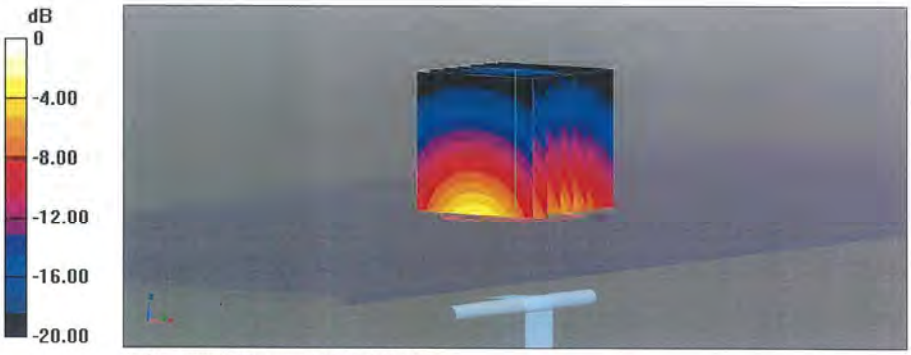
**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:727**

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 1.87 S/m; $\varepsilon_r$ = 38.0; $\rho$ = 1000 kg/m$^3$
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




0 dB = 22.8 W/kg = 13.59 dBW/kg



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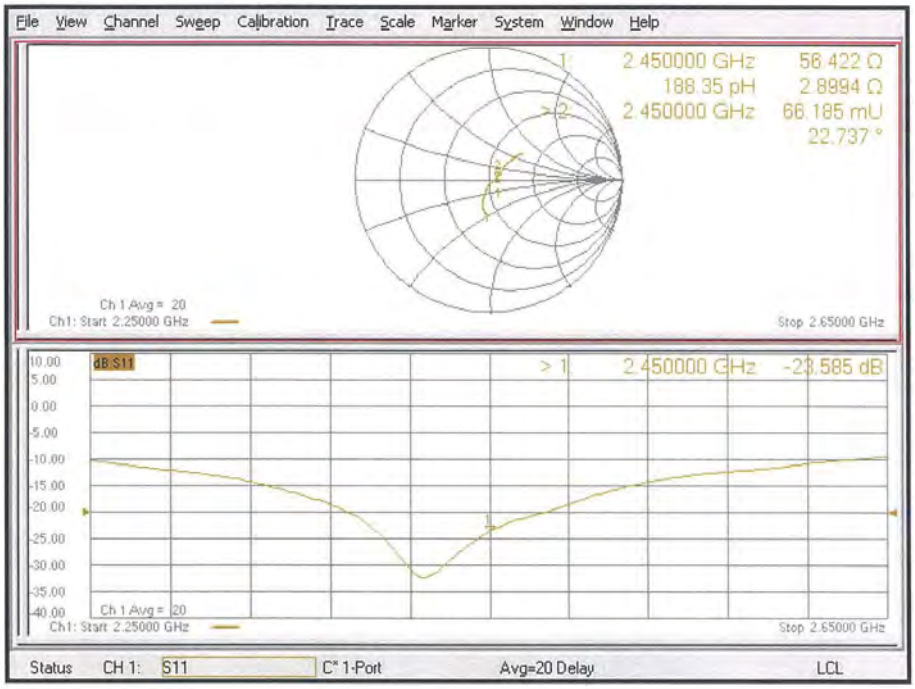
**Impedance Measurement Plot for Head TSL**



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## DASY5 Validation Report for Body TSL

Date: 14.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

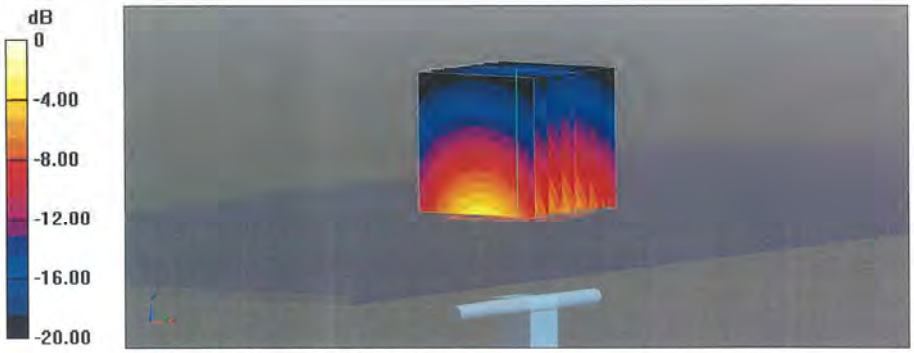
**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:727**

Communication System: UID 0 - CW; Frequency: 2450 MHz
Medium parameters used: f = 2450 MHz; $\sigma$ = 2.04 S/m; $\varepsilon_r$ = 51.4; $\rho$ = 1000 kg/m$^3$
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




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



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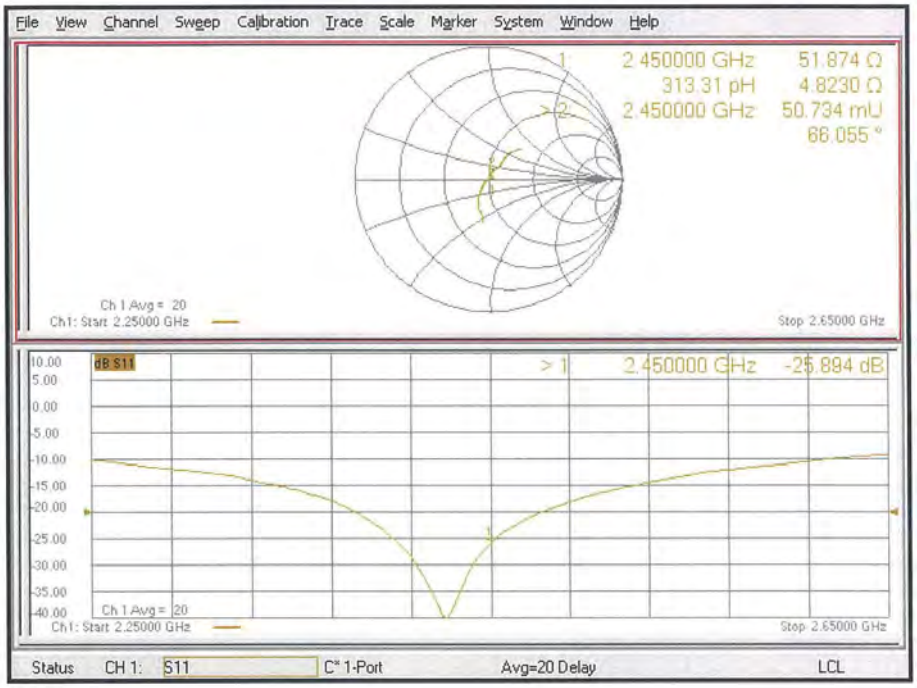
**Impedance Measurement Plot for Body TSL**



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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<br>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: 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 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 27, 2021

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

Certificate No: D5GHzV2-1023_Jan21 Page 1 of 15

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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:**

a) 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
b) 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
c) 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
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

e) 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 ± 1 MHz<br>5300 MHz ± 1 MHz<br>5600 MHz ± 1 MHz<br>5800 MHz ± 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 ± 0.2) °C | 35.1 ± 6 % | 4.46 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5200 MHz

| **SAR averaged over 1 cm³ (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 ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (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 ± 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 cm³ (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 cm³ (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 cm³ (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 cm³ (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 cm³ (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 cm³ (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 cm³ (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 cm³ (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 cm³ (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 cm³ (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 jΩ |
| Return Loss | - 23.2 dB |

**Antenna Parameters with Head TSL at 5300 MHz**

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

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

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

**Antenna Parameters with Head TSL at 5800 MHz**

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

**Antenna Parameters with Body TSL at 5200 MHz**

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

**Antenna Parameters with Body TSL at 5300 MHz**

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

**Antenna Parameters with Body TSL at 5600 MHz**

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



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### Antenna Parameters with Body TSL at 5800 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 56.2 Ω + 5.1 jΩ |
| Return Loss | - 22.5 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.199 ns |

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

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.
No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

### Additional EUT Data

| | |
|---|---|
| Manufactured by | SPEAG |



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**DASY5 Validation Report for Head TSL**

Date: 25.01.2021

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; $\varepsilon_r$ = 35.1; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5300 MHz; $\sigma$ = 4.56 S/m; $\varepsilon_r$ = 35; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5600 MHz; $\sigma$ = 4.86 S/m; $\varepsilon_r$ = 34.5; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5800 MHz; $\sigma$ = 5.07 S/m; $\varepsilon_r$ = 34.2; $\rho$ = 1000 kg/m$^3$
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



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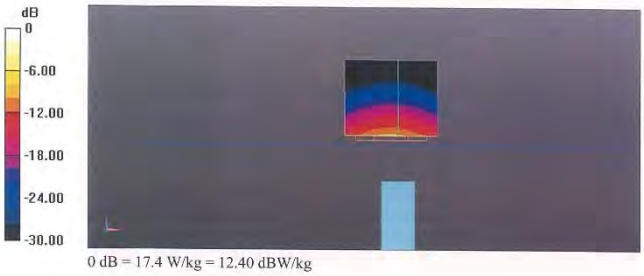
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 78.54 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 31.0 W/kg
**SAR(1 g) = 8.46 W/kg; SAR(10 g) = 2.39 W/kg**
Smallest distance 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



0 dB = 17.4 W/kg = 12.40 dBW/kg



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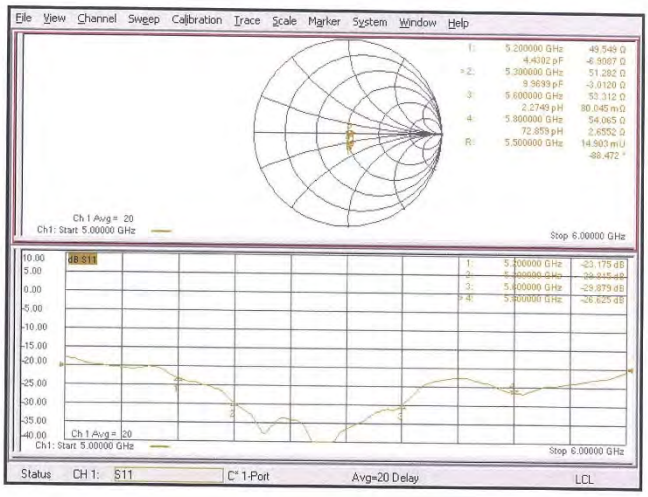
**Impedance Measurement Plot for Head TSL**



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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; $\varepsilon_r$ = 49.4; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5300 MHz; $\sigma$ = 5.57 S/m; $\varepsilon_r$ = 49.2; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5600 MHz; $\sigma$ = 5.99 S/m; $\varepsilon_r$ = 48.7; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5800 MHz; $\sigma$ = 6.27 S/m; $\varepsilon_r$ = 48.3; $\rho$ = 1000 kg/m$^3$
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



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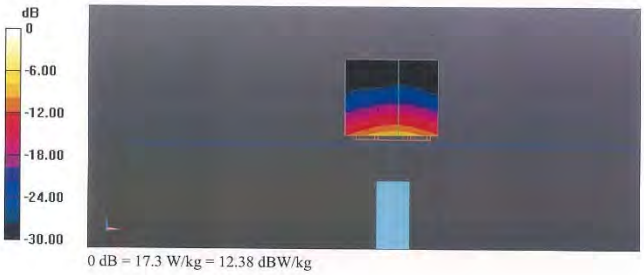
**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.51 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 33.7 W/kg
**SAR(1 g) = 7.79 W/kg; SAR(10 g) = 2.13 W/kg**
Smallest distance 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



0 dB = 17.3 W/kg = 12.38 dBW/kg



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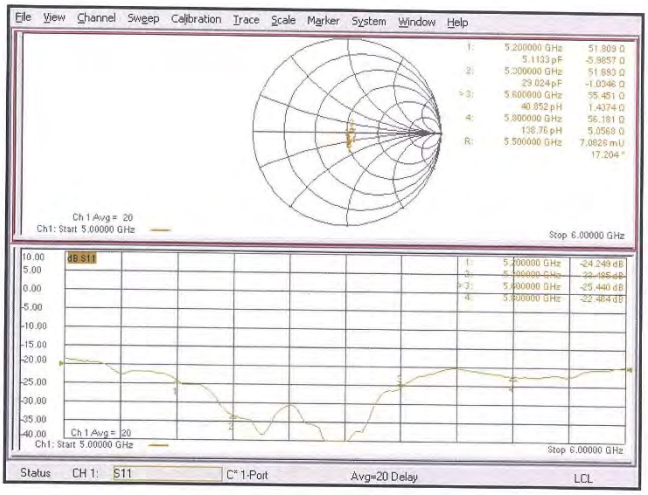
**Impedance Measurement Plot for Body TSL**



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

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**C** Service suisse d'étalonnage
Servizio svizzero di taratura
**S** Swiss Calibration Service

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

**Accreditation No.: SCS 0108**

**Client** SGS (Auden)

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

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D6.5GHzV2 - SN:1006 |
| Calibration procedure(s) | QA CAL-22.v6<br>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: 101093 | 10-May-12 (in house check Dec-18) | In house check: Dec-21 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: August 27, 2021

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**S** Swiss Calibration Service

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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:**

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** | 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 | 33.6 ± 6 % | 6.11 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 29.3 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **291 W/kg ± 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 ± 24.4 % (k=2)** |



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## Appendix

### Antenna Parameters with Head TSL

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

### APD (Absorbed Power Density)

| **APD averaged over 1 cm²** | Condition | |
|---|---|---|
| APD measured | 100 mW input power | 291 W/m² |
| APD measured | normalized to 1W | **2910 W/m² ± 29.2 % (k=2)** |

| **APD averaged over 4 cm²** | condition | |
|---|---|---|
| APD measured | 100 mW input power | 132 W/m² |
| APD measured | normalized to 1W | **1320 W/m² ± 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 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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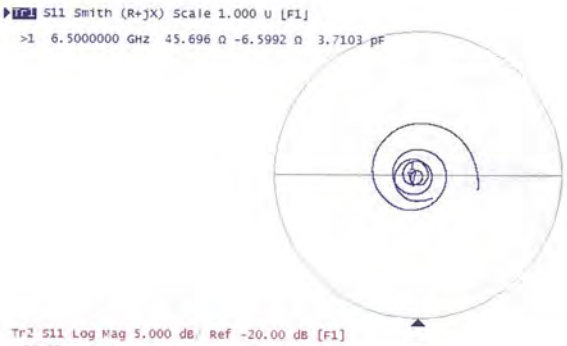
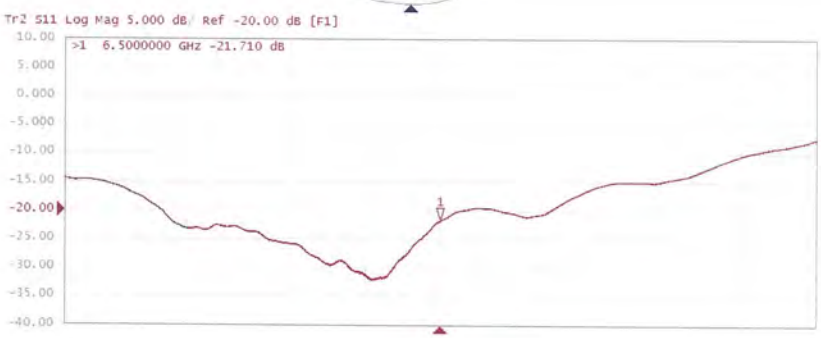
## Impedance Measurement Plot for Head TSL



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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<br>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%.

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| Power sensor R&S NRP33T | SN: 100967 | 08-Apr-21 (No. 217-03293) | Apr-22 |
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| Type-N mismatch combination | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344) | Apr-22 |
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| RF generator Anapico APSIN20G | SN: 669 | 28-Mar-17 (in house check Dec-18) | In house check: Dec-21 |
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| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: August 27, 2021

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- *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.

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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 ± 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 ± 0.2) °C | 32.7 ± 6 % | 6.71 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 27.7 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **275 W/kg ± 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 ± 24.4 % (k=2)** |



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## Appendix

### Antenna Parameters with Head TSL

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

### APD (Absorbed Power Density)

| **APD averaged over 1 cm²** | Condition | |
|---|---|---|
| APD measured | 100 mW input power | 274 W/m² |
| APD measured | normalized to 1W | **2740 W/m² ± 29.2 % (k=2)** |

| **APD averaged over 4 cm²** | condition | |
|---|---|---|
| APD measured | 100 mW input power | 119 W/m² |
| APD measured | normalized to 1W | **1190 W/m² ± 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**

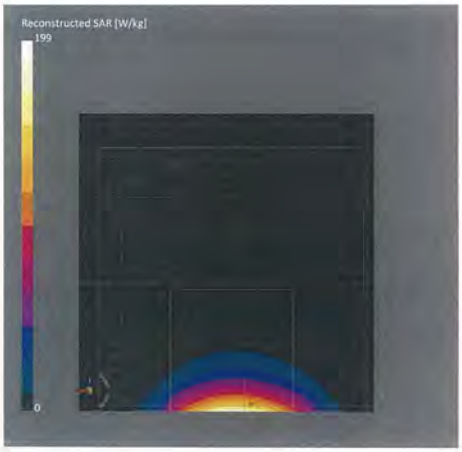
| Phantom | TSL | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| MFP V8.0 Center - 1182 | HBBL600-10000V6 | EX3DV4 - SN7405, 2020-12-30 | DAE4 Sn908, 2021-06-24 |

**Scan Setup**

| | Zoom Scan |
|---|---|
| Grid Extents [mm] | 22.0 x 22.0 x 22.0 |
| Grid Steps [mm] | 3.0 x 3.0 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, 14:14 |
| psSAR1g [W/Kg] | 27.7 |
| psSAR10g [W/Kg] | 4.78 |
| Power Drift [dB] | 0.05 |
| Power Scaling | Disabled |
| Scaling Factor [dB] | |
| TSL Correction | No correction |
| M2/M1 [%] | 46.9 |
| Dist 3dB Peak [mm] | 4.6 |



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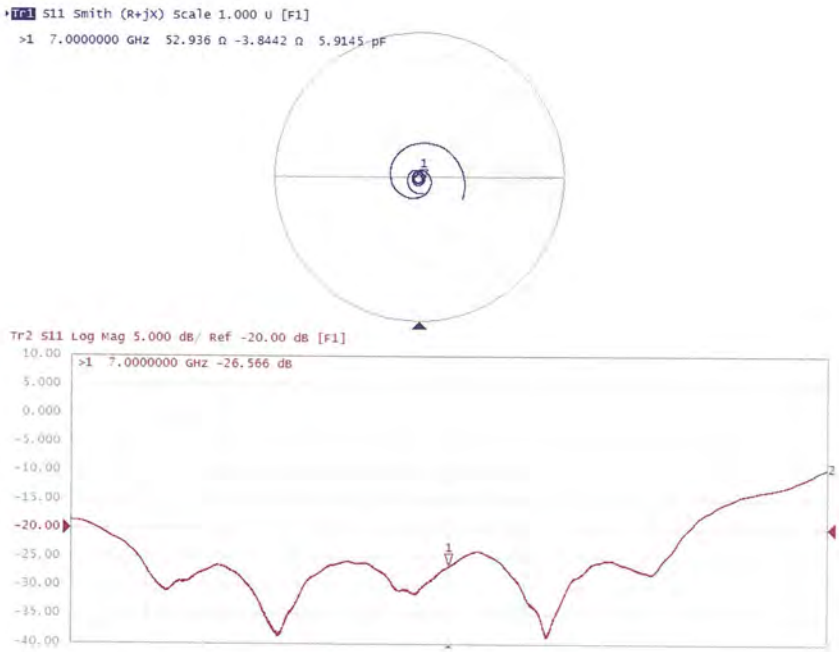
## Impedance Measurement Plot for Head TSL



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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<br>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 EummWV3 | 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 |
|---|---|---|---|
| | | | |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M. Weber |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 25, 2021

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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 + λ/4) with a vectorial E-field probe. The E-field value stated as calibration value represents the E-field-maxima and the averaged (1cm$^2$ and 4cm$^2$) power density values at 10mm in front of the horn.
- *Field polarization:* Above the open horn, linear polarization of the field is expected. This is verified graphically in the field representation.

## Calibrated Quantity

- Local peak E-field (V/m) and average of peak spatial components of the poynting vector (W/m$^2$) averaged over the surface area of 1 cm$^2$ and 4cm$^2$ 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%.



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## 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 + 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 Power Density Avg (psPDn+, psPDtot+, psPDmod+) (W/m²) | | Uncertainty (k = 2) |
|---|---|---|---|---|---|---|
| | | | | 1 cm² | 4 cm² | |
| 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/m²) | | Uncertainty (k = 2) |
|---|---|---|---|---|---|---|
| | | | | 1 cm² | 4 cm² | |
| 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

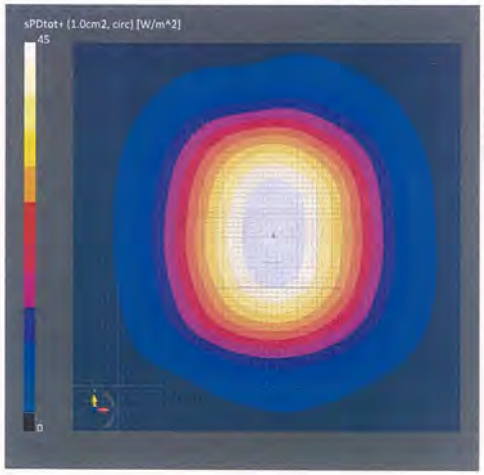
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

### 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 [cm²] | 1.00 |
| psPDn+ [W/m²] | 44.9 |
| psPDtot+ [W/m²] | 45.0 |
| psPDmod+ [W/m²] | 45.2 |
| $E_{max}$ [V/m] | 134 |
| Power Drift [dB] | 0.04 |



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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

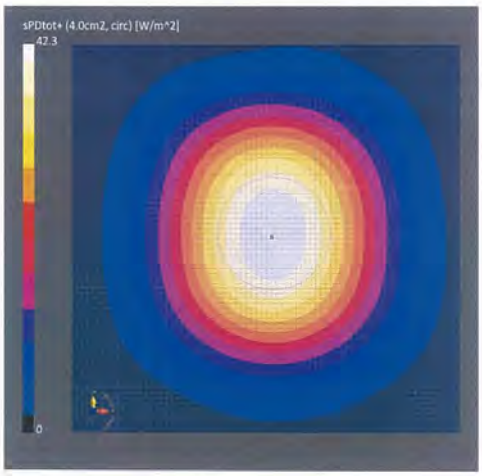
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

### 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 [cm²] | 4.00 |
| psPDn+ [W/m²] | 42.2 |
| psPDtot+ [W/m²] | 42.3 |
| psPDmod+ [W/m²] | 42.5 |
| $E_{max}$ [V/m] | 134 |
| Power Drift [dB] | 0.04 |



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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

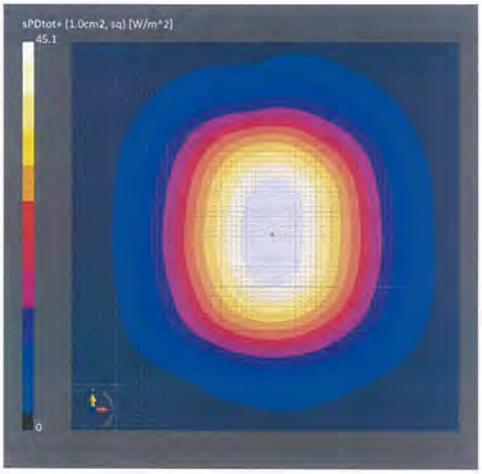
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

### 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 [cm²] | 1.00 |
| psPDn+ [W/m²] | 44.9 |
| psPDtot+ [W/m²] | 45.1 |
| psPDmod+ [W/m²] | 45.2 |
| $E_{max}$ [V/m] | 134 |
| Power Drift [dB] | 0.04 |



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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

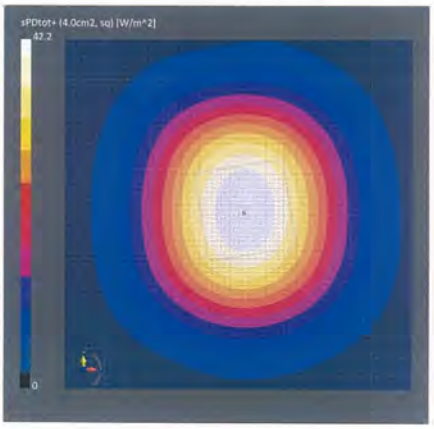
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-78GHz, 2020-12-30 | DAE4ip Sn1602, 2020-08-11 |

### 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 [cm²] | 4.00 |
| psPDn+ [W/m²] | 42.1 |
| psPDtot+ [W/m²] | 42.2 |
| psPDmod+ [W/m²] | 42.4 |
| $E_{max}$ [V/m] | 134 |
| Power Drift [dB] | 0.04 |

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**- End of report -**

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