



DASY5 Validation Report for Head TSL

Date: 14.12.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1100

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200 \text{ MHz}$; $\sigma = 4.57 \text{ S/m}$; $\epsilon_r = 36.2$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5300 \text{ MHz}$; $\sigma = 4.70 \text{ S/m}$; $\epsilon_r = 36.1$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5500 \text{ MHz}$; $\sigma = 4.92 \text{ S/m}$; $\epsilon_r = 35.8$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5600 \text{ MHz}$; $\sigma = 5.02 \text{ S/m}$; $\epsilon_r = 35.7$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5800 \text{ MHz}$; $\sigma = 5.20 \text{ S/m}$; $\epsilon_r = 35.5$; $\rho = 1000 \text{ kg/m}^3$

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(5.25, 5.25, 5.25) @ 5500 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 07.03.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 03.10.2023
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Head Tissue/Pin=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 = 70.55 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 27.1 W/kg

SAR(1 g) = 7.88 W/kg; SAR(10 g) = 2.26 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 70%

Maximum value of SAR (measured) = 18.3 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 = 72.19 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 27.8 W/kg

SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.32 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 69.9%

Maximum value of SAR (measured) = 18.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.15 V/m; Power Drift = 0.08 dB

Peak SAR (extrapolated) = 31.7 W/kg

SAR(1 g) = 8.45 W/kg; SAR(10 g) = 2.40 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 67.1%

Maximum value of SAR (measured) = 20.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 72.54 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 8.29 W/kg; SAR(10 g) = 2.37 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 68.4%

Maximum value of SAR (measured) = 19.9 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 = 69.47 V/m; Power Drift = 0.08 dB

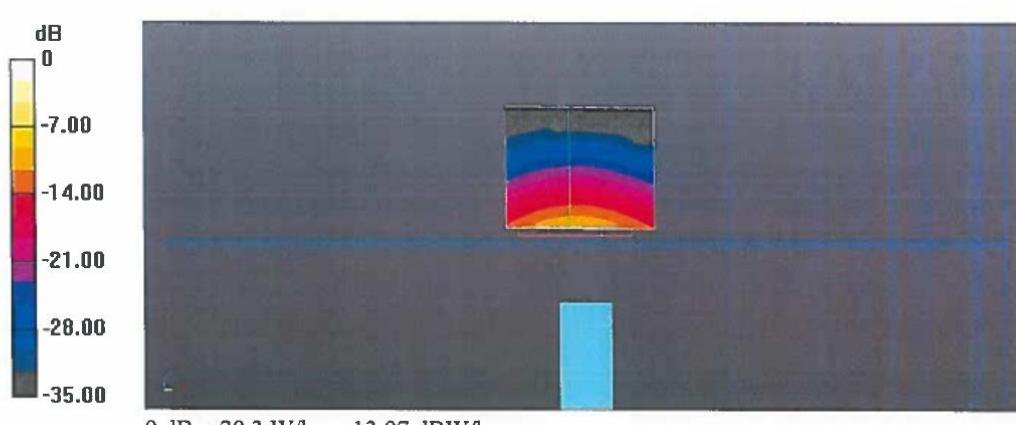
Peak SAR (extrapolated) = 31.6 W/kg

SAR(1 g) = 8.11 W/kg; SAR(10 g) = 2.28 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

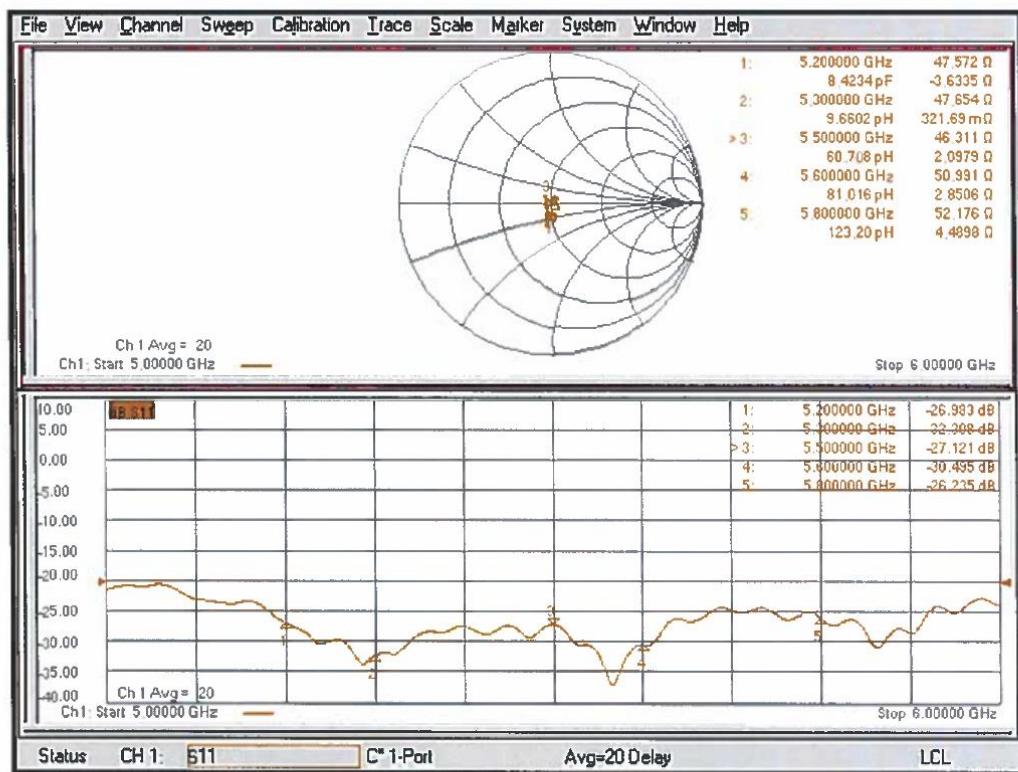
Ratio of SAR at M2 to SAR at M1 = 65.6%

Maximum value of SAR (measured) = 19.8 W/kg





Impedance Measurement Plot for Head TSL





DASY5 Validation Report for Body TSL

Date: 14.12.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1100

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200 \text{ MHz}$; $\sigma = 5.44 \text{ S/m}$; $\epsilon_r = 49.2$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5300 \text{ MHz}$; $\sigma = 5.60 \text{ S/m}$; $\epsilon_r = 49.1$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5500 \text{ MHz}$; $\sigma = 5.88 \text{ S/m}$; $\epsilon_r = 48.8$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5600 \text{ MHz}$; $\sigma = 6.01 \text{ S/m}$; $\epsilon_r = 48.7$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5800 \text{ MHz}$; $\sigma = 6.28 \text{ S/m}$; $\epsilon_r = 48.3$; $\rho = 1000 \text{ kg/m}^3$

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(4.84, 4.84, 4.84) @ 5500 MHz, ConvF(4.79, 4.79, 4.79) @ 5600 MHz, ConvF(4.62, 4.62, 4.62) @ 5800 MHz; Calibrated: 07.03.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 03.10.2023
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Body Tissue/Pin=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 = 65.06 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 26.0 W/kg

SAR(1 g) = 7.31 W/kg; SAR(10 g) = 2.07 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 69.3%

Maximum value of SAR (measured) = 16.5 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 = 64.35 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 27.4 W/kg

SAR(1 g) = 7.33 W/kg; SAR(10 g) = 2.06 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 67.8%

Maximum value of SAR (measured) = 16.9 W/kg



Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 66.02 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 31.2 W/kg

SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.17 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 66%

Maximum value of SAR (measured) = 18.5 W/kg

Dipole Calibration for 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 = 64.95 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 32.2 W/kg

SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.21 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 64.7%

Maximum value of SAR (measured) = 18.8 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 = 63.73 V/m; Power Drift = -0.08 dB

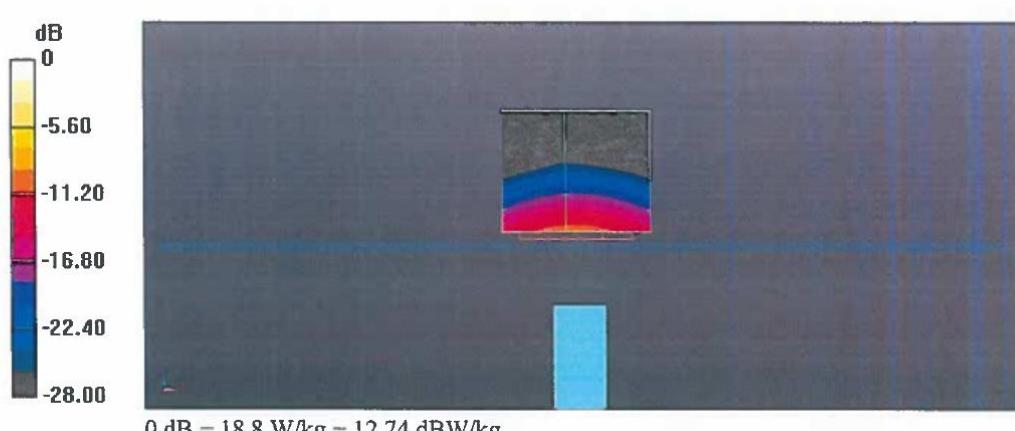
Peak SAR (extrapolated) = 31.2 W/kg

SAR(1 g) = 7.50 W/kg; SAR(10 g) = 2.07 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 64.5%

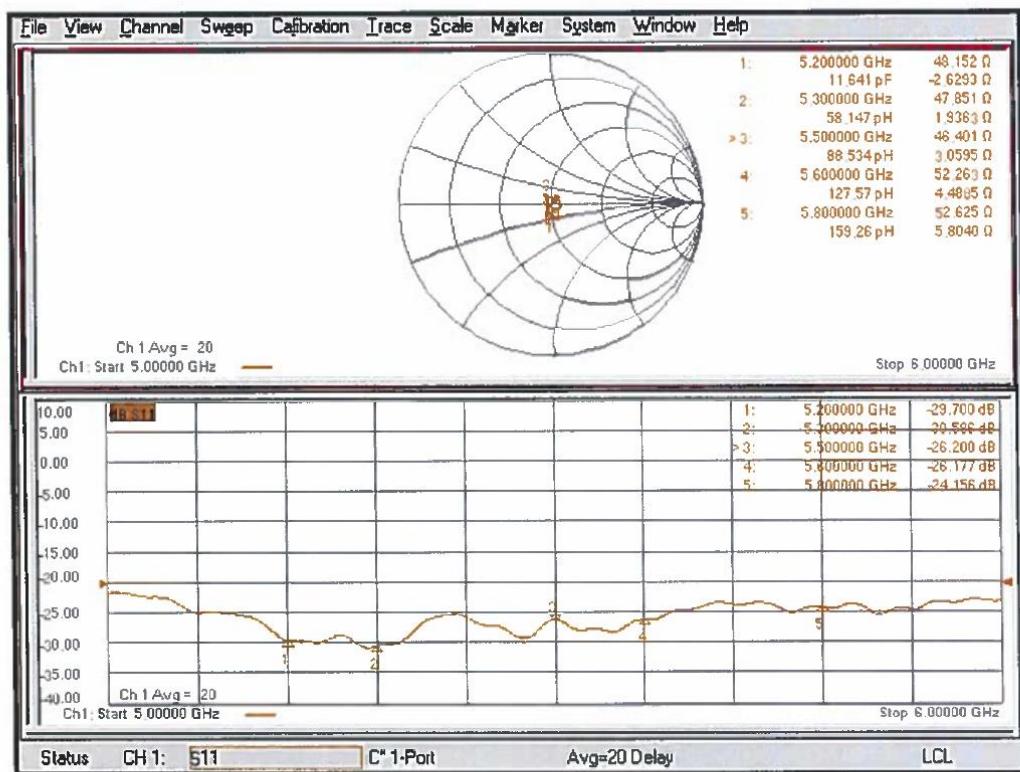
Maximum value of SAR (measured) = 18.0 W/kg



0 dB = 18.8 W/kg = 12.74 dBW/kg



Impedance Measurement Plot for Body TSL





Calibration Laboratory of
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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 **TÜV SÜD**
Fareham, United Kingdom

Certificate No. **P6500-PD_1018_Nov23**

CALIBRATION CERTIFICATE

Object **P6500V2 - SN: 1018**

Calibration procedure(s) **QA CAL-45.v4**
Calibration procedure for sources in air above 6 GHz

Calibration date: **November 07, 2023**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-------------------------|----------|----------------------------------|-----------------------|
| Reference Probe EUmmWV3 | SN: 9374 | 2023-05-22 (No. EUmm-9374_May23) | May-24 |
| DAE4 | SN: 1215 | 2023-06-29 (No. DAE4-1215_Jun23) | Jun-24 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|----------------------------------|----------------|-----------------------------------|------------------------|
| RF generator R&S SMF100A | SN: 100184 | 19-May-22 (in house check Nov-22) | In house check: Nov-23 |
| Power sensor R&S NRP18S-10 | SN: 101258 | 31-May-22 (in house check Nov-22) | In house check: Nov-23 |
| Network Analyzer Keysight E5063A | SN: MY54504221 | 31-Oct-19 (in house check Oct-22) | In house check: Oct-25 |

Calibrated by: **Name: Leif Klysner** **Function: Laboratory Technician** **Signature:**

Approved by: **Name: Sven Kühn** **Function: Technical Manager** **Signature:**

Issued: November 9, 2023

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



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Glossary

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CW Continuous wave

Accreditation No.: SCS 0108

Calibration is Performed According to the Following Standards

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

Methods Applied and Interpretation of Parameters

- Coordinate System:* z-axis orthogonal to the top surface of P6500, y-axis is in the direction of the SMA connector, x-axis normal to y and z.
- Measurement Conditions:* During the measurements, the source is directly connected to the cable and measured without the spacer. Fields are measured at the stated antenna input power. Absorbers are used around the probe cup and at the ceiling to minimize reflections.
- Positioning:* The source is placed on the phantom and measured with the EUmmW probes at the measurement planes stated. The planes are parallel to the phantom and source surfaces. The probe distance is verified using mechanical gauges positioned on the surface of the source.
- E-field distribution:* E field is measured in two x-y-planes with an EUmmW probe. The E-field value stated as calibration value represents the E-field-maxima and the averaged (1cm² and 4cm²) power density values at 2mm and 8mm from top surface of the source or 4mm and 10mm from top surface of the antenna patch.
- Feed Point Impedance and Return Loss:* These parameters are measured with the source radiating into air and absorbers present. The impedance stated is the impedance measured at the SMA connector.

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 source. Both square and circular averaging results are listed.

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



Measurement Conditions

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

| DASY Version | DASY8 Module mmWave | V3.2 |
|---------------------------|----------------------------------|------|
| Phantom | 5G Phantom | |
| Distance patch - plane | 4 mm | |
| Number of measured planes | 2 (4 mm, 4 mm + $\lambda/4$) | |
| Frequency | 6.5 GHz \pm 1 MHz | |

Calibration Parameters, 6.5 GHz

Circular Averaging

| Distance Antenna to Measured Plane | Pin (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Avg Power Density | | Uncertainty (k = 2) |
|------------------------------------|-------------------|-------------------|---------------------|--|------|---------------------|
| | | | | Avg (psPDn+, psPDtot+, psPDmod+) (W/m ²) | | |
| 4 mm | 100 | 453 | 1.27 dB | 232 | 166 | 1.28 dB |
| | 1000 ¹ | 1433 | 1.27 dB | 2317 | 1663 | 1.28 dB |

| Distance Antenna to Measured Plane | Pin (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Power Density | | Uncertainty (k = 2) |
|------------------------------------|-------------------|-------------------|---------------------|--|------------------|---------------------|
| | | | | psPDn+, psPDtot+, psPDmod+ (W/m ²) | | |
| 4 mm | 100 | 453 | 1.27 dB | 201, 219, 275 | 131, 156, 212 | 1.28 dB |
| | 1000 ¹ | 1433 | 1.27 dB | 2010, 2190, 2750 | 1310, 1560, 2120 | 1.28 dB |

Square Averaging

| Distance Antenna to Measured Plane | Pin (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Avg Power Density | | Uncertainty (k = 2) |
|------------------------------------|-------------------|-------------------|---------------------|--|------|---------------------|
| | | | | Avg (psPDn+, psPDtot+, psPDmod+) (W/m ²) | | |
| 4 mm | 100 | 453 | 1.27 dB | 233 | 167 | 1.28 dB |
| | 1000 ¹ | 1433 | 1.27 dB | 2330 | 1670 | 1.28 dB |

| Distance Antenna to Measured Plane | Pin (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Power Density | | Uncertainty (k = 2) |
|------------------------------------|-------------------|-------------------|---------------------|--|------------------|---------------------|
| | | | | psPDn+, psPDtot+, psPDmod+ (W/m ²) | | |
| 4 mm | 100 | 453 | 1.27 dB | 202, 220, 277 | 132, 156, 213 | 1.28 dB |
| | 1000 ¹ | 1433 | 1.27 dB | 2020, 2200, 2770 | 1320, 1560, 2130 | 1.28 dB |

¹ Measured result normalized to 1W input power.



Max Power Density

| Distance Antenna to Measured Plane | <i>P_{in}</i> (mW) | Max E-field (V/m) | Uncertainty (k = 2) | Max Power Density S _n , S _{tot} , S _{tot} (W/m ²) | Uncertainty (k = 2) |
|------------------------------------|----------------------------|-------------------|---------------------|---|---------------------|
| 4 mm | 100 | 453 | 1.27 dB | 257, 278, 348 | 1.28 dB |
| | 1000 ¹ | 1433 | 1.27 dB | 2570, 2780, 3480 | 1.28 dB |

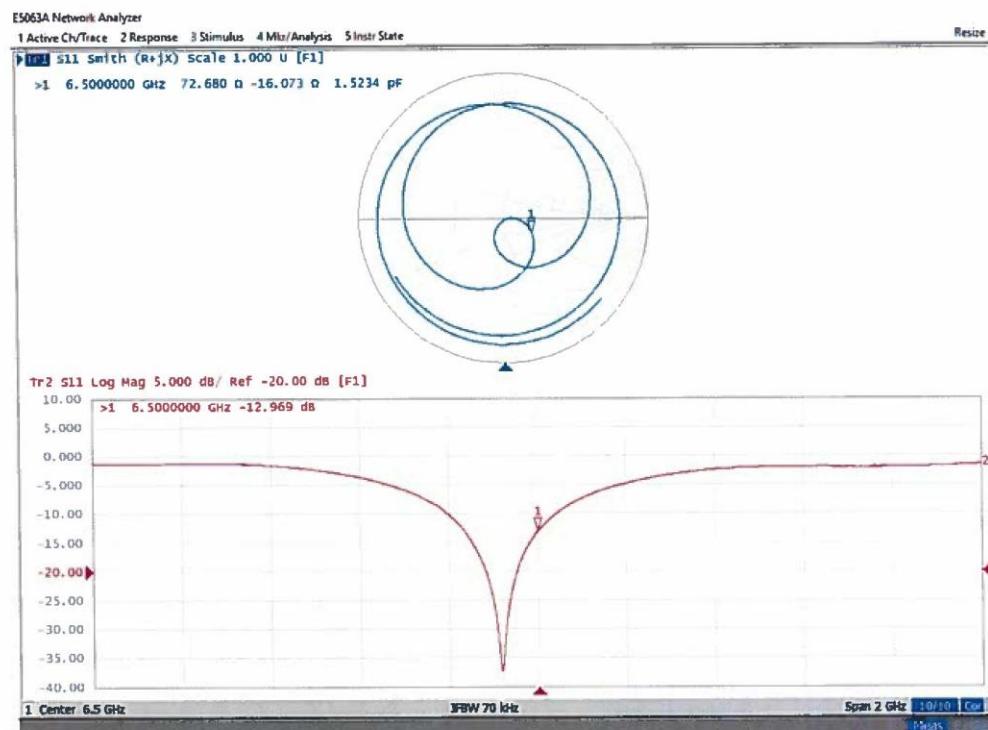


Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 72.7 Ω - 16.1 $j\Omega$ |
| Return Loss | - 13.0 dB |

Impedance Measurement Plot





DASY Report

Measurement Report for P6500V2, UID 0 -, Channel 6500 (6500.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|--------------------|-----------------------|----------|----------|
| P6500V2 | 100.0 x 100.0 x 100.0 | SN: 1018 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| SG + | 2.0 mm | Validation band | CW | 6500.0, 6500 | 1.0 |

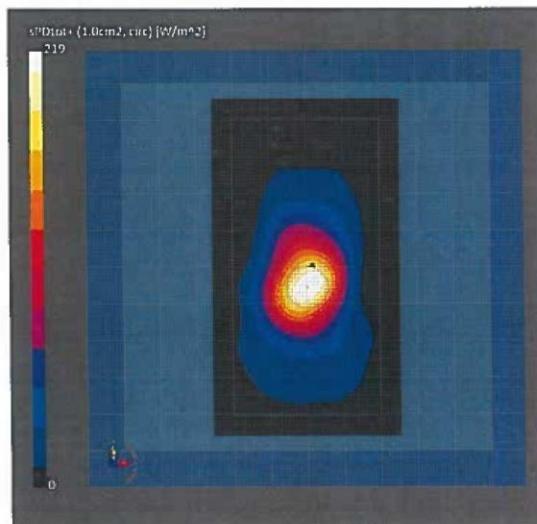
Hardware Setup

| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|-------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV4 - SN9374_F1-55GHz, 2023-05-22 | DAE4 Sn1215, 2023-06-29 |

Scan Setup

| | 5G Scan | 5G Scan |
|---------------------------------|---------------|--------------------|
| Grid Extents (auto extend) [mm] | 50.0 x 90.0 | 2023-11-07, 11:45 |
| Grid Steps (automatic) [lambda] | 0.044 x 0.044 | 1.00 |
| Sensor Surface [mm] | 2.0 | Circular Averaging |
| MAIA | MAIA not used | 201 |
| | | 219 |
| | | 275 |
| | | 257 |
| | | 278 |
| | | 348 |
| | | 453 |
| | | 0.01 |

Measurement Results





DASY Report

Measurement Report for P6500V2, UID 0 -, Channel 6500 (6500.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|--------------------|-----------------------|----------|----------|
| P6500V2 | 100.0 x 100.0 x 100.0 | SN: 1018 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G - | 2.0 mm | Validation band | CW | 6500.0, 6500 | 1.0 |

Hardware Setup

| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|-------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV4 - SN9374_F1-55GHz, 2023-05-22 | DAE4 Sn1215, 2023-06-29 |

Scan Setup

| | 5G Scan | 5G Scan | |
|---------------------------------|---------------|---------------------------------|--------------------|
| Grid Extents (auto extend) [mm] | 50.0 x 90.0 | Date | 2023-11-07, 11:45 |
| Grid Steps (automatic) [lambda] | 0.044 x 0.044 | Avg. Area [cm ²] | 4.00 |
| Sensor Surface [mm] | 2.0 | Avg. Type | Circular Averaging |
| MAIA | MAIA not used | psPDo+ [W/m ²] | 131 |
| | | psPDo+ [W/m ²] | 156 |
| | | psPDo+ [W/m ²] | 212 |
| | | Max(Sn) [W/m ²] | 257 |
| | | Max(Stot) [W/m ²] | 278 |
| | | Max(Stot) [W/m ²] | 348 |
| | | E _{max} [V/m] | 453 |
| | | Power Drift [dB] | 0.01 |





DASY Report

Measurement Report for P6500V2, UID 0 -, Channel 6500 (6500.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|--------------------|-----------------------|----------|----------|
| P6500V2 | 100.0 x 100.0 x 100.0 | SN: 1018 | - |

Exposure Conditions

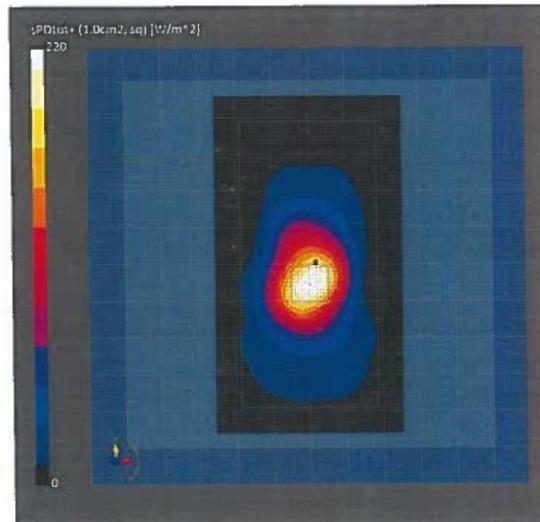
| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| SG - | 2.0 mm | Validation band | CW | 6500.0, 6500 | 1.0 |

Hardware Setup

| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|-------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV4 - SN9374_F1-55GHz, 2023-05-22 | DAE4 Sn1215, 2023-06-29 |

Scan Setup

| | 5G Scan | 5G Scan |
|---------------------------------|---------------|---------------------------------|
| Grid Extents (auto extend) [mm] | 50.0 x 90.0 | 2023-11-07, 11:45 |
| Grid Steps (automatic) [lambda] | 0.044 x 0.044 | 1.00 |
| Sensor Surface [mm] | 2.0 | Square Averaging |
| MAIA | MAIA not used | 202 |
| | | psPDo+ [W/m ²] |
| | | psPDo+ [W/m ²] |
| | | psPDo+ [W/m ²] |
| | | 277 |
| | | Max(Sn) [W/m ²] |
| | | 257 |
| | | Max(Stot) [W/m ²] |
| | | 278 |
| | | Max(Stot) [W/m ²] |
| | | 348 |
| | | E _{max} [V/m] |
| | | 453 |
| | | Power Drift [dB] |
| | | 0.01 |





DASY Report

Measurement Report for P6500V2, UID 0 -, Channel 6500 (6500.0MHz)

Device under Test Properties

| Name, Manufacturer | Dimensions [mm] | IMEI | DUT Type |
|--------------------|-----------------------|----------|----------|
| P6500V2 | 100.0 x 100.0 x 100.0 | SN: 1018 | - |

Exposure Conditions

| Phantom Section | Position, Test Distance [mm] | Band | Group, | Frequency [MHz], Channel Number | Conversion Factor |
|-----------------|------------------------------|-----------------|--------|---------------------------------|-------------------|
| 5G + | 2.0 mm | Validation band | CW | 6500.0, 6500 | 1.0 |

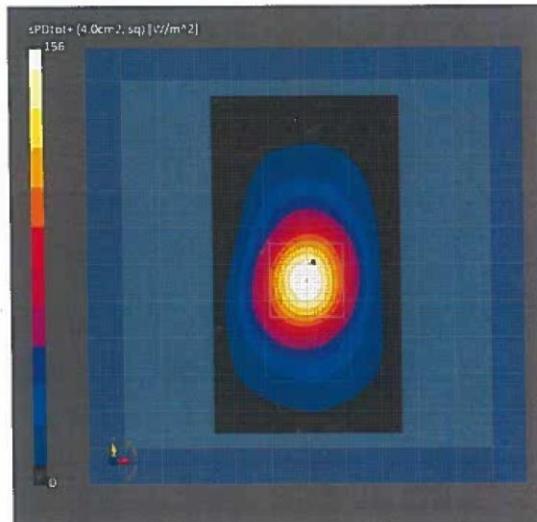
Hardware Setup

| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|-----------------------|--------|---------------------------------------|-------------------------|
| mmWave Phantom - 1002 | Air | EUmmWV4 - SN9374_F1-55GHz, 2023-05-22 | DAE4 Sn1215, 2023-06-29 |

Scan Setup

| | 5G Scan | 5G Scan |
|---------------------------------|---------------|-------------------|
| Grid Extents (auto extend) [mm] | 50.0 x 90.0 | 2023-11-07, 11:45 |
| Grid Steps (automatic) [lambda] | 0.044 x 0.044 | 4.00 |
| Sensor Surface [mm] | 2.0 | Square Averaging |
| MAIA | MAIA not used | 132 |
| | | 156 |
| | | 156 |
| | | 156 |
| | | 213 |
| | | 257 |
| | | 278 |
| | | 348 |
| | | 453 |
| | | 0.01 |

Measurement Results





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

Accreditation No.: SCS 0108

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Client **TÜV SÜD**
Fareham, United Kingdom

Certificate No. **D2450V2-715_Dec23**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:715**

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

Calibration date: **December 07, 2023**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---------------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP2 | SN: 104778 | 30-Mar-23 (No. 217-03804/03805) | Mar-24 |
| Power sensor NRP-Z91 | SN: 103244 | 30-Mar-23 (No. 217-03804) | Mar-24 |
| Power sensor NRP-Z91 | SN: 103245 | 30-Mar-23 (No. 217-03805) | Mar-24 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 30-Mar-23 (No. 217-03809) | Mar-24 |
| Type-N mismatch combination | SN: 310982 / 06327 | 30-Mar-23 (No. 217-03810) | Mar-24 |
| Reference Probe EX3DV4 | SN: 7349 | 03-Nov-23 (No. EX3-7349_Nov23) | Nov-24 |
| DAE4 | SN: 601 | 03-Oct-23 (No. DAE4-601_Oct23) | Oct-24 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB39512475 | 30-Oct-14 (in house check Oct-22) | In house check: Oct-24 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-22) | In house check: Oct-24 |
| Power sensor HP 8481A | SN: MY41093315 | 07-Oct-15 (in house check Oct-22) | In house check: Oct-24 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-22) | In house check: Oct-24 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-22) | In house check: Oct-24 |

| Calibrated by: | Name | Function | Signature |
|----------------|------------|-----------------------|-----------|
| | Paulo Pina | Laboratory Technician | |

| Approved by: | Name | Function | Signature |
|--------------|-----------|-------------------|-----------|
| | Sven Kühn | Technical Manager | |

Issued: December 8, 2023

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Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY System Handbook

Methods Applied and Interpretation of Parameters:

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

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



Measurement Conditions

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

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

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 39.2 | 1.80 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 38.3 ± 6 % | 1.85 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | --- | --- |

SAR result with Head TSL

| | | |
|---|--------------------|--------------------------|
| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
| SAR measured | 250 mW input power | 13.4 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 52.6 W/kg ± 17.0 % (k=2) |

| | | |
|---|--------------------|--------------------------|
| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
| SAR measured | 250 mW input power | 6.21 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.6 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 | 53.0 ± 6 % | 2.01 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 | 12.5 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 49.3 W/kg ± 17.0 % (k=2) |

| | | |
|---|--------------------|--------------------------|
| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
| SAR measured | 250 mW input power | 5.93 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 23.6 W/kg ± 16.5 % (k=2) |



Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 51.7 Ω + 2.1 $j\Omega$ |
| Return Loss | - 31.6 dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 49.4 Ω + 2.5 $j\Omega$ |
| Return Loss | - 31.8 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.157 ns |
|----------------------------------|----------|

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

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

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

Additional EUT Data

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



DASY5 Validation Report for Head TSL

Date: 07.12.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:715

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.85$ S/m; $\epsilon_r = 38.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 03.11.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 03.10.2023
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 116.1 V/m; Power Drift = 0.03 dB

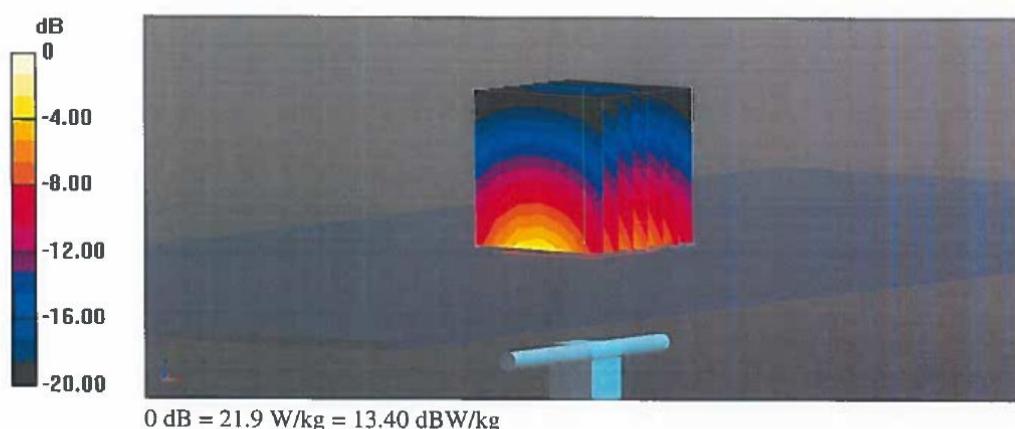
Peak SAR (extrapolated) = 26.5 W/kg

SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.21 W/kg

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

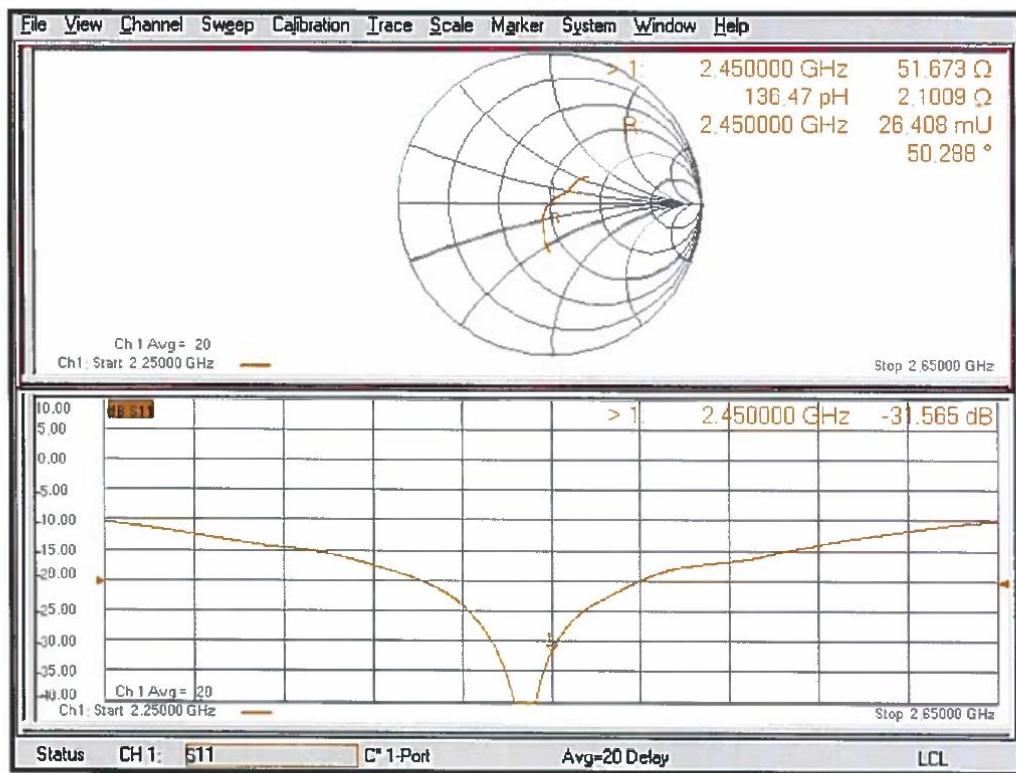
Ratio of SAR at M2 to SAR at M1 = 50.6%

Maximum value of SAR (measured) = 21.9 W/kg





Impedance Measurement Plot for Head TSL





DASY5 Validation Report for Body TSL

Date: 06.12.2023

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:715

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

Medium parameters used: $f = 2450 \text{ MHz}$; $\sigma = 2.01 \text{ S/m}$; $\epsilon_r = 53$; $\rho = 1000 \text{ kg/m}^3$

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: 03.11.2023
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 03.10.2023
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 107.3 V/m; Power Drift = 0.08 dB

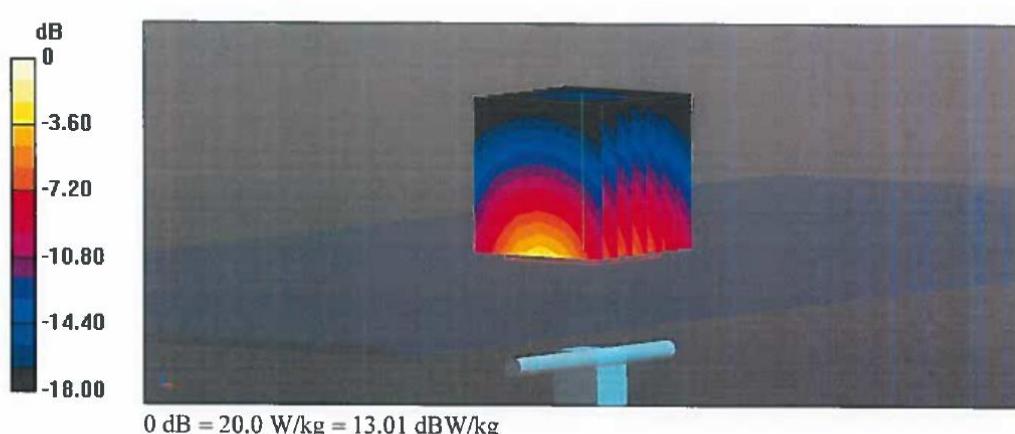
Peak SAR (extrapolated) = 23.3 W/kg

SAR(1 g) = 12.5 W/kg; SAR(10 g) = 5.93 W/kg

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

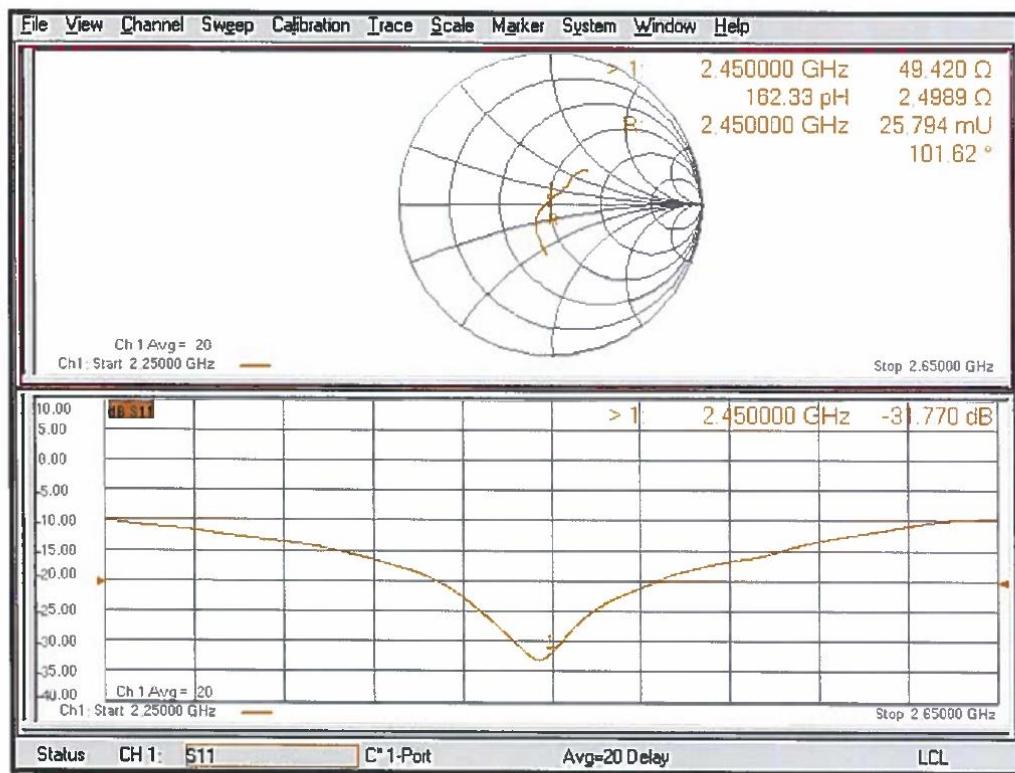
Ratio of SAR at M2 to SAR at M1 = 54.6%

Maximum value of SAR (measured) = 20.0 W/kg





Impedance Measurement Plot for Body TSL





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Accreditation No.: SCS 0108

Client **TÜV SÜD**
Fareham, United Kingdom

Certificate No. **D6.5GHzV2-1070_Nov23**

CALIBRATION CERTIFICATE

Object **D6.5GHzV2 - SN:1070**

Calibration procedure(s) **QA CAL-22.v7**
Calibration Procedure for SAR Validation Sources between 3-10 GHz

Calibration date: **November 02, 2023**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|----------------------------|------------------|--------------------------------|-----------------------|
| Power sensor R&S NRP33T | SN: 100967 | 03-Apr-23 (No. 217-03806) | Apr-24 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 30-Mar-23 (No. 217-03809) | Mar-24 |
| Mismatch combination | SN: 84224 / 360D | 03-Apr-23 (No. 217-03812) | Apr-24 |
| Reference Probe EX3DV4 | SN: 7405 | 12-Jun-23 (No. EX3-7405_Jun23) | Jun-24 |
| DAE4 | SN: 908 | 03-Jul-23 (No. DAE4-908_Jul23) | Jul-24 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|----------------------------------|----------------|-----------------------------------|------------------------|
| RF generator Anapico APSIN20G | SN: 827 | 18-Dec-18 (in house check Dec-21) | In house check: Dec-23 |
| Power sensor NRP-Z23 | SN: 100169 | 10-Jan-19 (in house check Nov-22) | In house check: Nov-23 |
| Power sensor NRP-1BT | SN: 100950 | 28-Sep-22 (in house check Nov-22) | In house check: Nov-23 |
| Network Analyzer Keysight E5063A | SN: MY54504221 | 31-Oct-19 (in house check Oct-22) | In house check: Oct-25 |

| Calibrated by: | Name | Function | Signature |
|----------------|--------------------|-----------------------|-----------|
| | Aldonia Georgiadou | Laboratory Technician | |

| Approved by: | Name | Function | Signature |
|--------------|-----------|-------------------|-----------|
| | Sven Kühn | Technical Manager | |

Issued: November 2, 2023

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