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

### Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 51.2 Ω - 4.0 jΩ |
| Return Loss | - 27.7 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.125 ns |

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

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

### Additional EUT Data

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

Date: 14.07.2021

Test Laboratory: SPEAG, Zurich, Switzerland

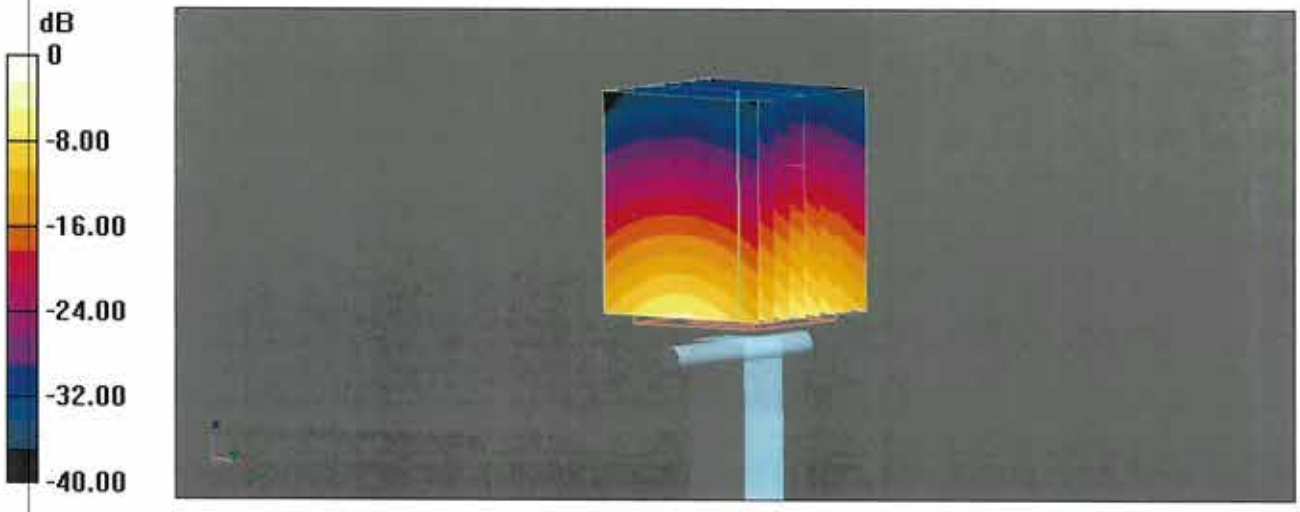
**DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN:1022**

Communication System: UID 0 - CW; Frequency: 3700 MHz
Medium parameters used: f = 3700 MHz; $\sigma$ = 3.12 S/m; $\varepsilon_r$ = 37.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

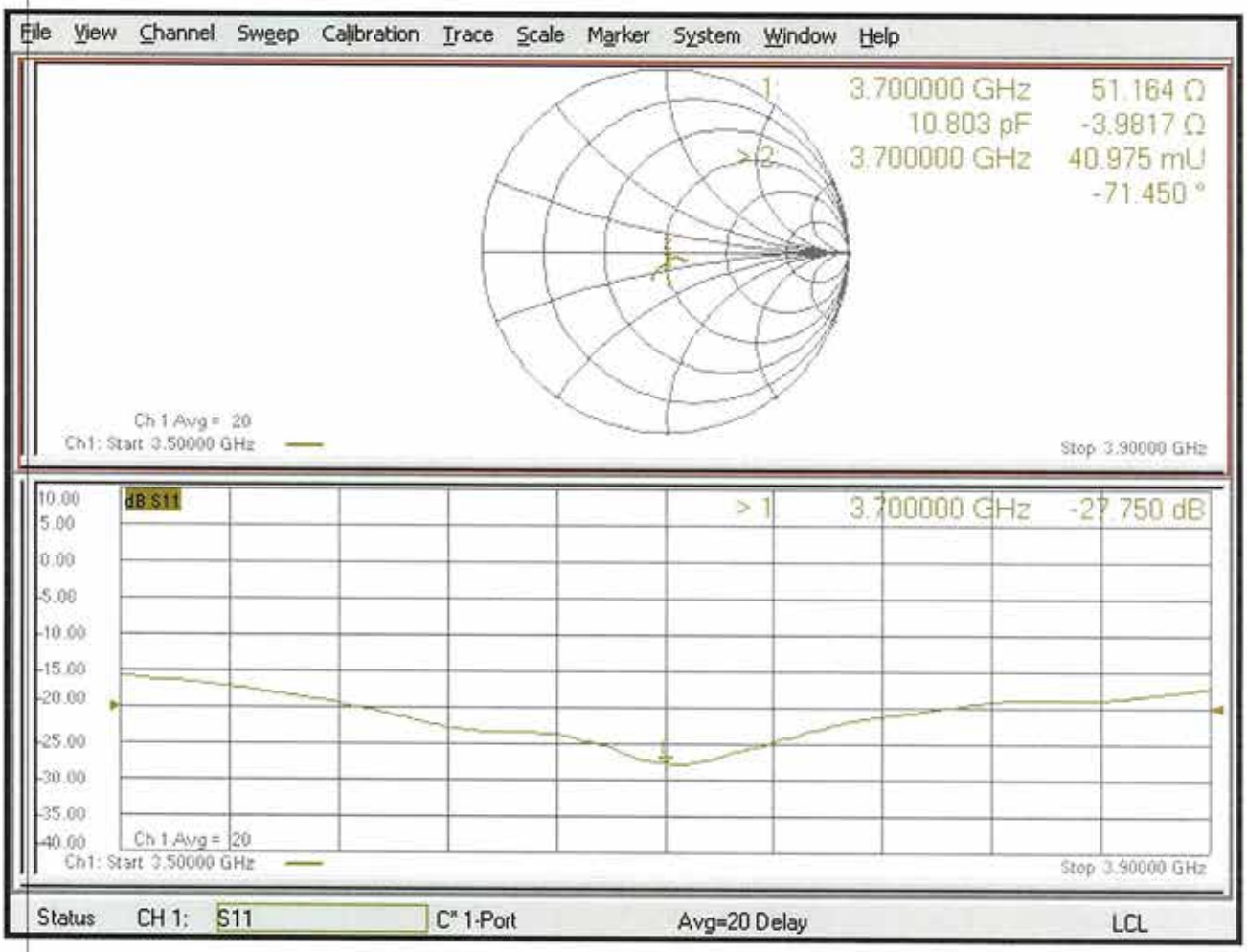
- Probe: EX3DV4 - SN3503; ConvF(7.73, 7.73, 7.73) @ 3700 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

**Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3700MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 72.98 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 19.2 W/kg
**SAR(1 g) = 6.82 W/kg; SAR(10 g) = 2.47 W/kg**
Smallest distance from peaks to all points 3 dB below = 8 mm
Ratio of SAR at M2 to SAR at M1 = 72.8%
Maximum value of SAR (measured) = 13.1 W/kg




0 dB = 13.1 W/kg = 11.16 dBW/kg

## Impedance Measurement Plot for Head TSL



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

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
**S** Servizio svizzero di taratura
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** Sporton

**Certificate No: D3900V2-1017_Apr19**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D3900V2 - SN:1017 |
| Calibration procedure(s) | QA CAL-22.v4<br>Calibration Procedure for SAR Validation Sources between 3-6 GHz |
| Calibration date: | April 29, 2019 |

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 | 03-Apr-19 (No. 217-02892/02893) | Apr-20 |
| Power sensor NRP-Z91 | SN: 103244 | 03-Apr-19 (No. 217-02892) | Apr-20 |
| Power sensor NRP-Z91 | SN: 103245 | 03-Apr-19 (No. 217-02893) | Apr-20 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 04-Apr-19 (No. 217-02894) | Apr-20 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 04-Apr-19 (No. 217-02895) | Apr-20 |
| Reference Probe EX3DV4 | SN: 3503 | 25-Mar-19 (No. EX3-3503_Mar19) | Mar-20 |
| DAE4 | SN: 601 | 04-Oct-18 (No. DAE4-601_Oct18) | Oct-19 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power meter E4419B | SN: GB39512475 | 07-Oct-15 (in house check Feb-19) | In house check: Oct-20 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-18) | In house check: Oct-20 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-18) | In house check: Oct-19 |

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

Issued: April 29, 2019

## 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%.

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.10.2 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy = 4 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| **Frequency** | 3900 MHz ± 1 MHz<br>4100 MHz ± 1 MHz | |

## Head TSL parameters at 3900 MHz

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 37.5 | 3.32 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 36.9 ± 6 % | 3.22 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 3900 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 6.94 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **69.5 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.43 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **24.2 W/kg ± 19.5 % (k=2)** |

## Head TSL parameters at 4100 MHz

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 37.2 | 3.53 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 36.7 ± 6 % | 3.40 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 4100 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 6.62 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **66.3 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.31 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.0 W/kg ± 19.5 % (k=2)** |

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

### Antenna Parameters with Head TSL at 3900 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 51.5 Ω - 7.9 jΩ |
| Return Loss | - 22.0 dB |

### Antenna Parameters with Head TSL at 4100 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 60.6 Ω - 0.8 jΩ |
| Return Loss | - 20.3 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.106 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: 29.04.2019

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 3900 MHz; Type: D3900V2; Serial: D3900V2 - SN:1017**

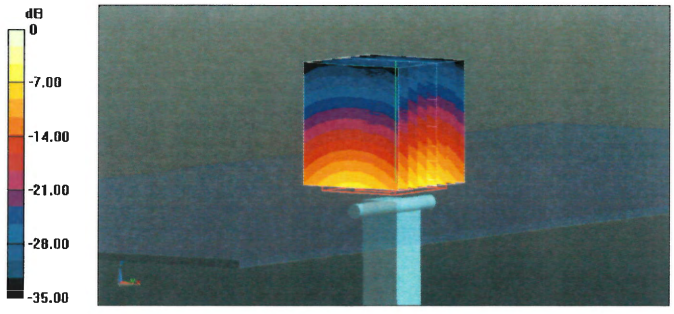
Communication System: UID 0 - CW; Frequency: 3900 MHz, Frequency: 4100 MHz
Medium parameters used: f = 3900 MHz; $\sigma$ = 3.22 S/m; $\varepsilon_r$ = 36.9; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 4100 MHz; $\sigma$ = 3.4 S/m; $\varepsilon_r$ = 36.7; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.25, 7.25, 7.25) @ 3900 MHz, ConvF(7.05, 7.05, 7.05) @ 4100 MHz; Calibrated: 25.03.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

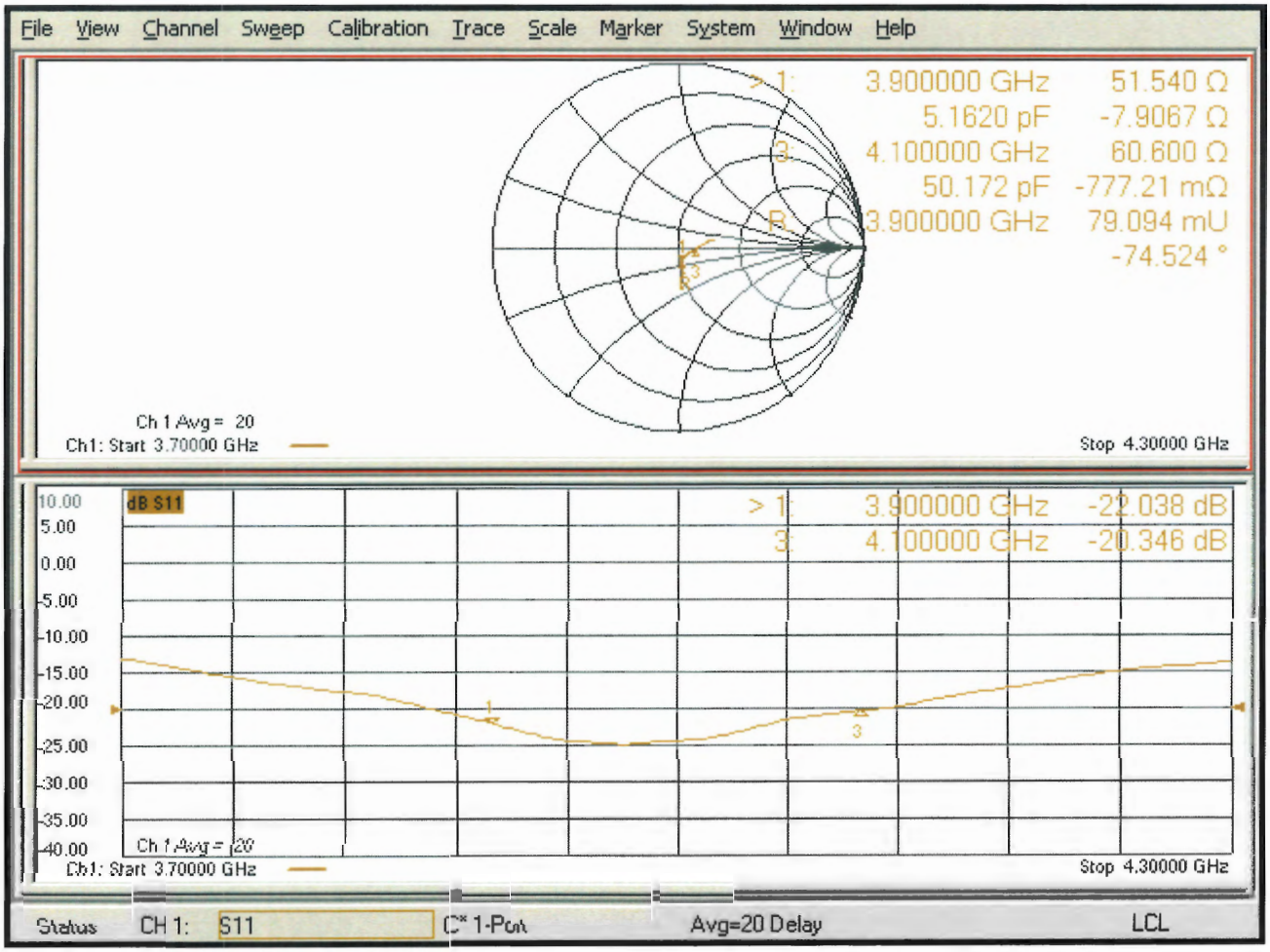
**Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3900MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 72.14 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 20.0 W/kg
**SAR(1 g) = 6.94 W/kg; SAR(10 g) = 2.43 W/kg**
Maximum value of SAR (measured) = 13.8 W/kg

**Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=4100MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 69.50 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 19.1 W/kg
**SAR(1 g) = 6.62 W/kg; SAR(10 g) = 2.31 W/kg**
Maximum value of SAR (measured) = 13.2 W/kg




0 dB = 13.2 W/kg = 11.21 dBW/kg

## Impedance Measurement Plot for Head TSL



## D3900V2, serial no. 1017 Extended Dipole Calibrations

Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

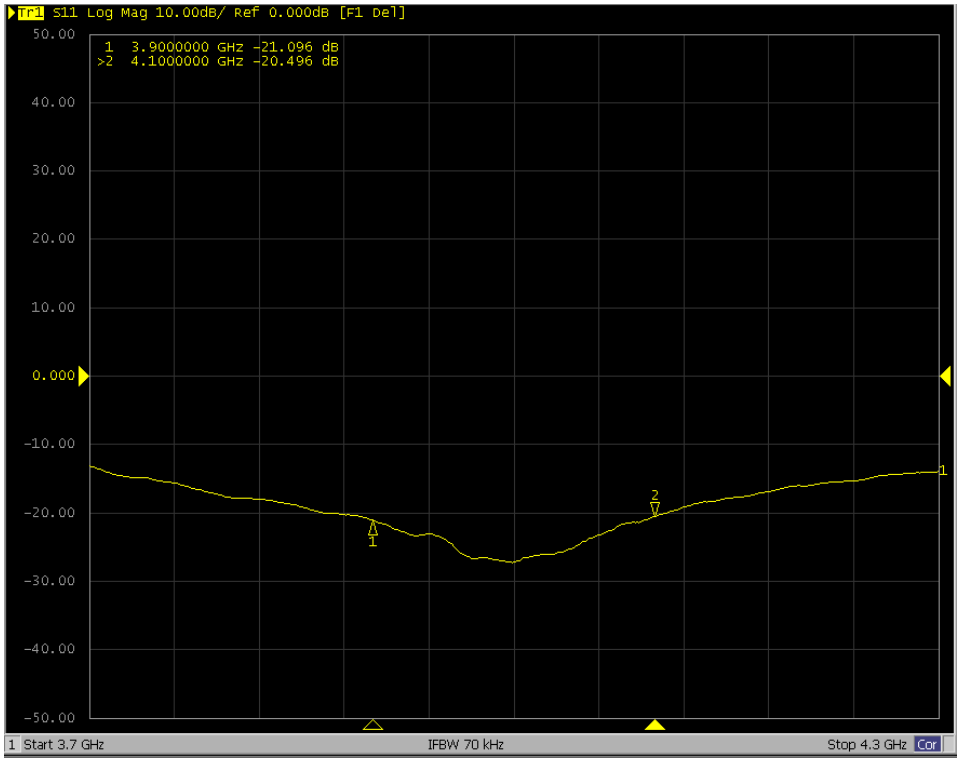
**<Justification of the extended calibration>**

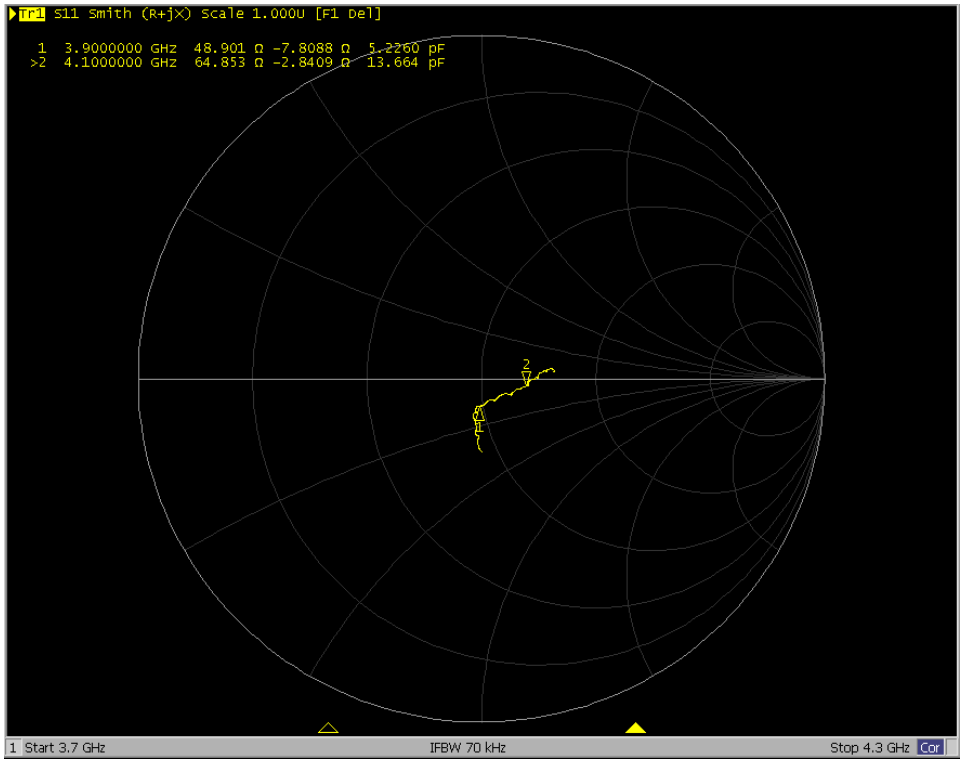
| D**3900**V2 – serial no. **1017** | | | | | | |
|---|---|---|---|---|---|---|
| | **3900MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 04.29.2019 (Cal. Report) | -22.038 | | 51.540 | | -7.9067 | |
| 04.28.2020 (extended) | -21.096 | -4.274 | 48.901 | 2.639 | -7.8088 | -0.0979 |
| 04.27.2021 (extended) | -22.203 | 0.749 | 51.008 | 0.532 | -7.5215 | -0.3852 |
| | **4100MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 04.29.2019 (Cal. Report) | -20.346 | | 60.600 | | -0.77721 | |
| 04.28.2020 (extended) | -20.496 | 0.737 | 64.853 | -4.253 | -2.8409 | 2.06369 |
| 04.27.2021 (extended) | -20.128 | -1.071 | 61.940 | -1.340 | -1.6549 | 0.87769 |

The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

**<Dipole Verification Data> - D3900 V2, serial no. 1017 (Data of Measurement : 04.28.2020)**

**3900 MHz - Head**

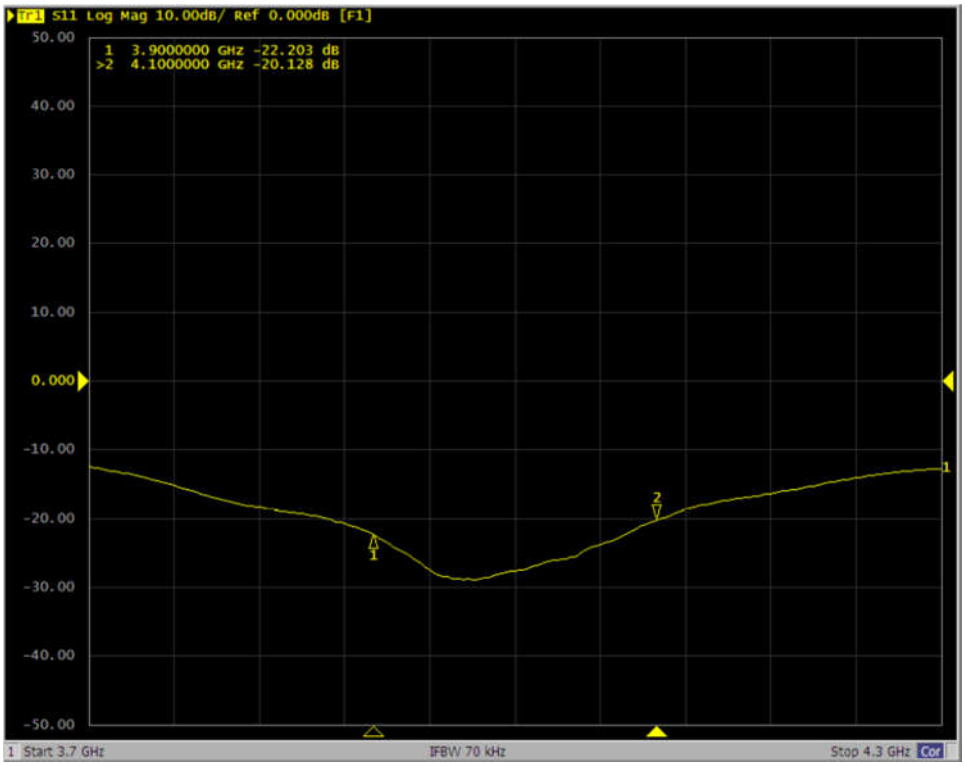


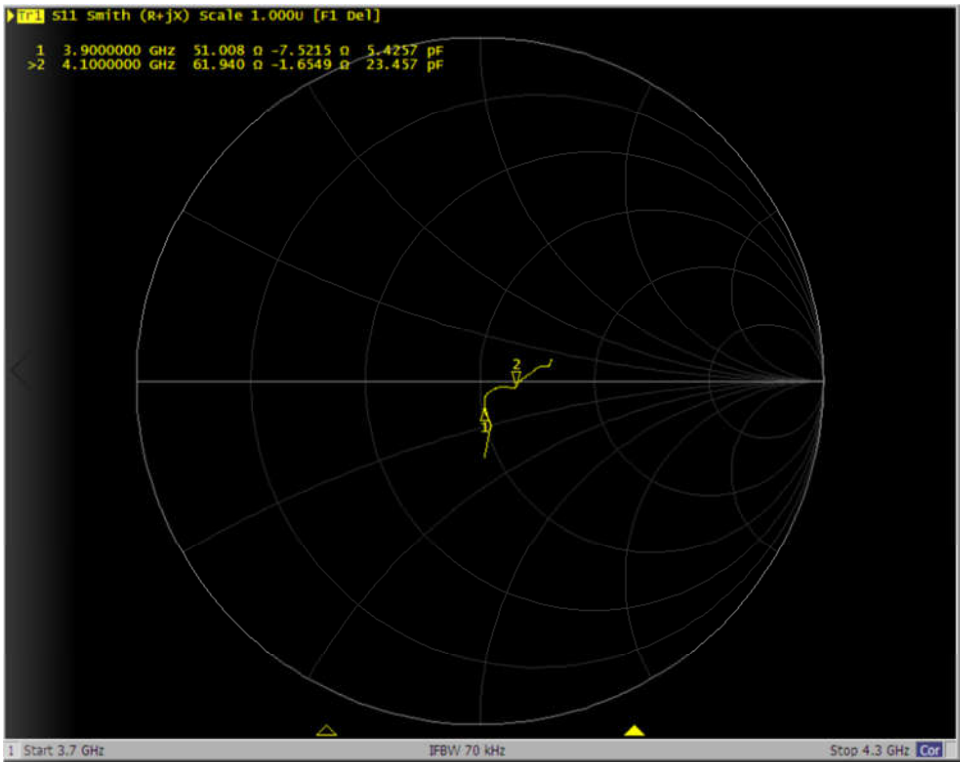




**SPORTON INTERNATIONAL INC.**
TEL : 886-3-327-3456
FAX : 886-3-328-4978

**<Dipole Verification Data> - D3900 V2, serial no. 1017 (Data of Measurement : 04.27.2021)**

**3900 MHz - Head**

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

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**Accreditation No.: SCS 0108**

**Client** Sporton

**Certificate No: D5GHzV2-1128_Dec19**

# CALIBRATION CERTIFICATE

Object: D5GHzV2 - SN:1128

Calibration procedure(s): QA CAL-22.v4
Calibration Procedure for SAR Validation Sources between 3-6 GHz

Calibration date: December 16, 2019

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 | 03-Apr-19 (No. 217-02892/02893) | Apr-20 |
| Power sensor NRP-Z91 | SN: 103244 | 03-Apr-19 (No. 217-02892) | Apr-20 |
| Power sensor NRP-Z91 | SN: 103245 | 03-Apr-19 (No. 217-02893) | Apr-20 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 04-Apr-19 (No. 217-02894) | Apr-20 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 04-Apr-19 (No. 217-02895) | Apr-20 |
| Reference Probe EX3DV4 | SN: 3503 | 25-Mar-19 (No. EX3-3503_Mar19) | Mar-20 |
| DAE4 | SN: 601 | 30-Apr-19 (No. DAE4-601_Apr19) | Apr-20 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power meter E4419B | SN: GB39512475 | 30-Oct-14 (in house check Feb-19) | In house check: Oct-20 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-18) | In house check: Oct-20 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-19) | In house check: Oct-20 |

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

Issued: December 17, 2019

## 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%.

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.10.3 |
| **Extrapolation** | Advanced Extrapolation | |
| **Phantom** | Modular Flat Phantom V5.0 | |
| **Distance Dipole Center - TSL** | 10 mm | with Spacer |
| **Zoom Scan Resolution** | dx, dy = 4.0 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| **Frequency** | 5250 MHz ± 1 MHz<br>5600 MHz ± 1 MHz<br>5750 MHz ± 1 MHz | |

## Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.9 | 4.71 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.8 ± 6 % | 4.48 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5250 MHz

| **SAR averaged over 1 cm$^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.06 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **80.0 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm$^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.32 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.9 W/kg ± 19.5 % (k=2)** |

## Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.5 | 5.07 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.3 ± 6 % | 4.83 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5600 MHz

| **SAR averaged over 1 cm$^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.32 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **82.4 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm$^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.39 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.6 W/kg ± 19.5 % (k=2)** |

## Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.4 | 5.22 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.1 ± 6 % | 4.98 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5750 MHz

| **SAR averaged over 1 cm$^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 7.99 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **79.1 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm$^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.29 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **22.6 W/kg ± 19.5 % (k=2)** |

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

### Antenna Parameters with Head TSL at 5250 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 47.7 Ω - 6.4 jΩ |
| Return Loss | - 23.1 dB |

### Antenna Parameters with Head TSL at 5600 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 53.6 Ω - 3.5 jΩ |
| Return Loss | - 26.3 dB |

### Antenna Parameters with Head TSL at 5750 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 51.3 Ω - 3.5 jΩ |
| Return Loss | - 28.6 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.208 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: 16.12.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1128

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz
Medium parameters used: f = 5250 MHz; $\sigma$ = 4.48 S/m; $\varepsilon_r$ = 34.8; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5600 MHz; $\sigma$ = 4.83 S/m; $\varepsilon_r$ = 34.3; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5750 MHz; $\sigma$ = 4.98 S/m; $\varepsilon_r$ = 34.1; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

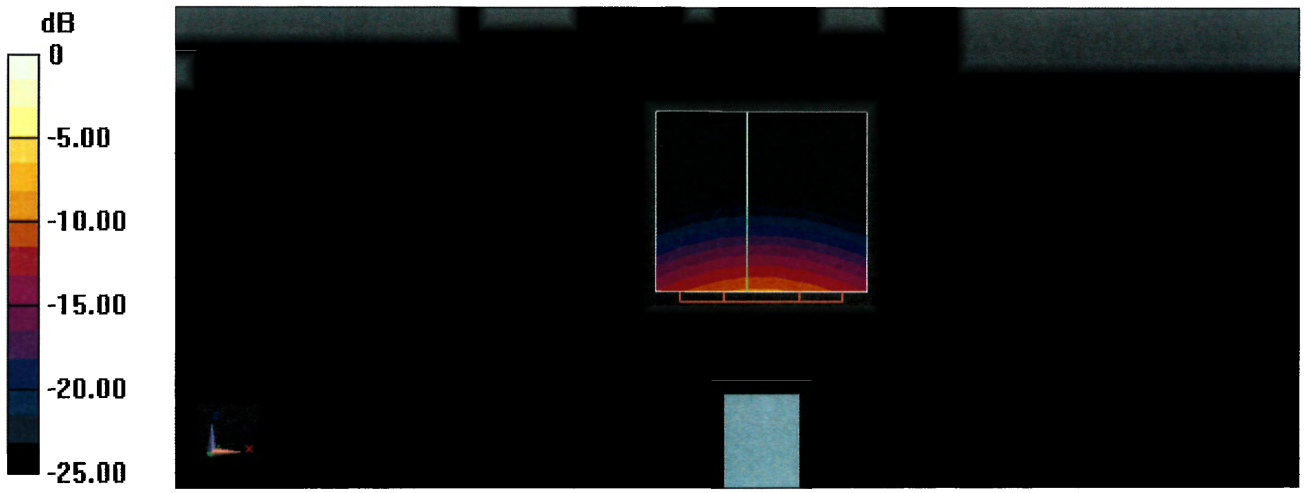
DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.4, 5.4, 5.4) @ 5250 MHz,
  ConvF(4.95, 4.95, 4.95) @ 5600 MHz, ConvF(4.98, 4.98, 4.98) @ 5750 MHz; Calibrated: 25.03.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.3(1513); SEMCAD X 14.6.13(7474)

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 77.60 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 27.9 W/kg
**SAR(1 g) = 8.06 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) = 18.2 W/kg

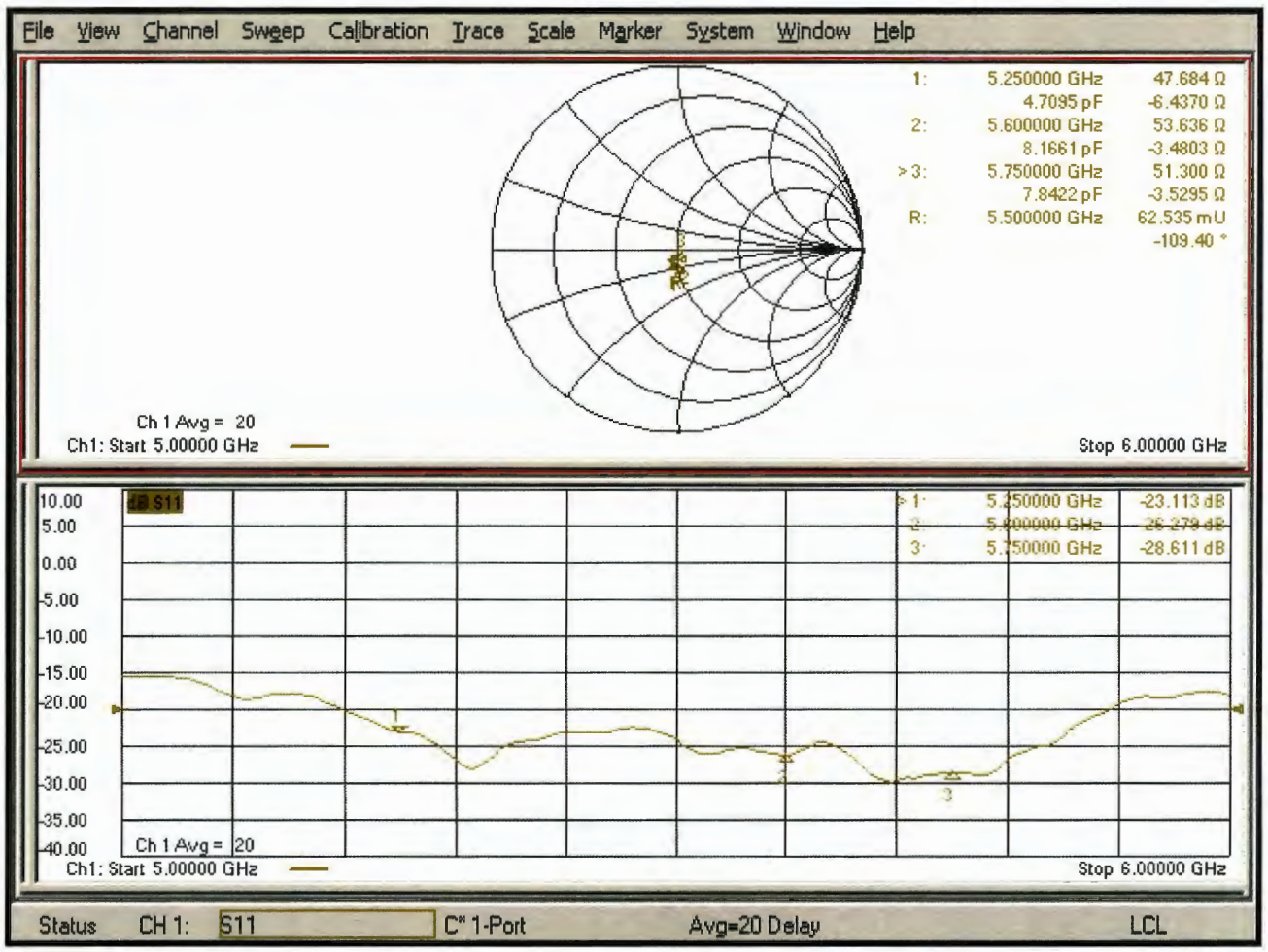
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 77.23 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 31.2 W/kg
**SAR(1 g) = 8.32 W/kg; SAR(10 g) = 2.39 W/kg**
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 67.1%
Maximum value of SAR (measured) = 19.3 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 74.23 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 31.3 W/kg
**SAR(1 g) = 7.99 W/kg; SAR(10 g) = 2.29 W/kg**
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 65.7%
Maximum value of SAR (measured) = 18.9 W/kg




0 dB = 18.9 W/kg = 12.77 dBW/kg

## Impedance Measurement Plot for Head TSL



## D5000V2, serial no. 1128 Extended Dipole Calibrations

Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

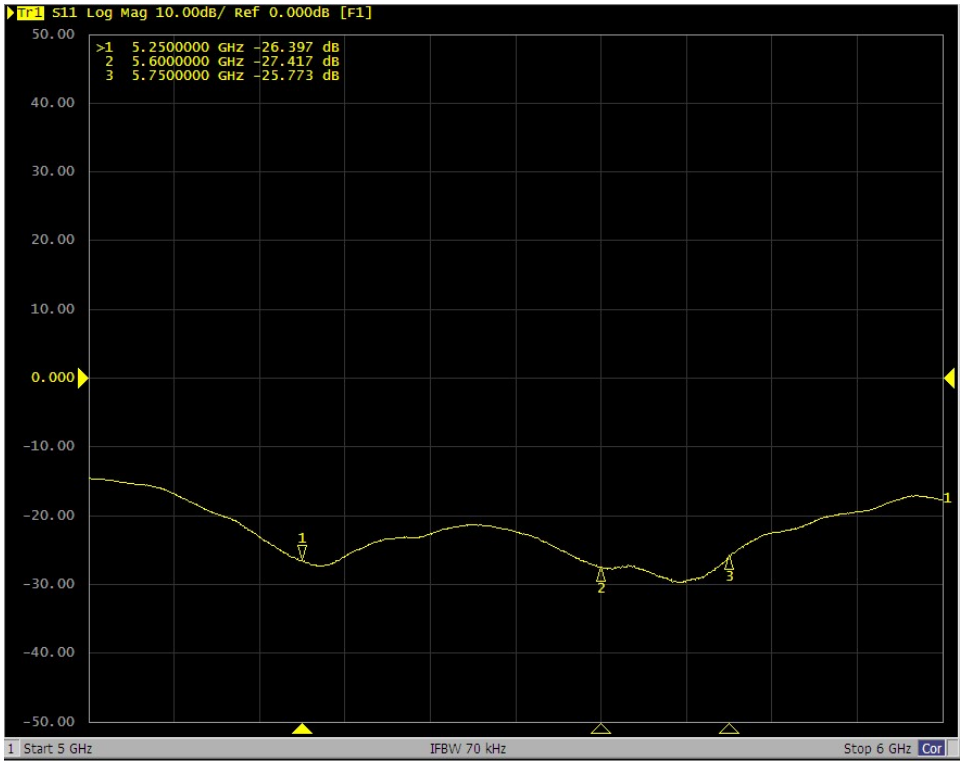
**<Justification of the extended calibration>**

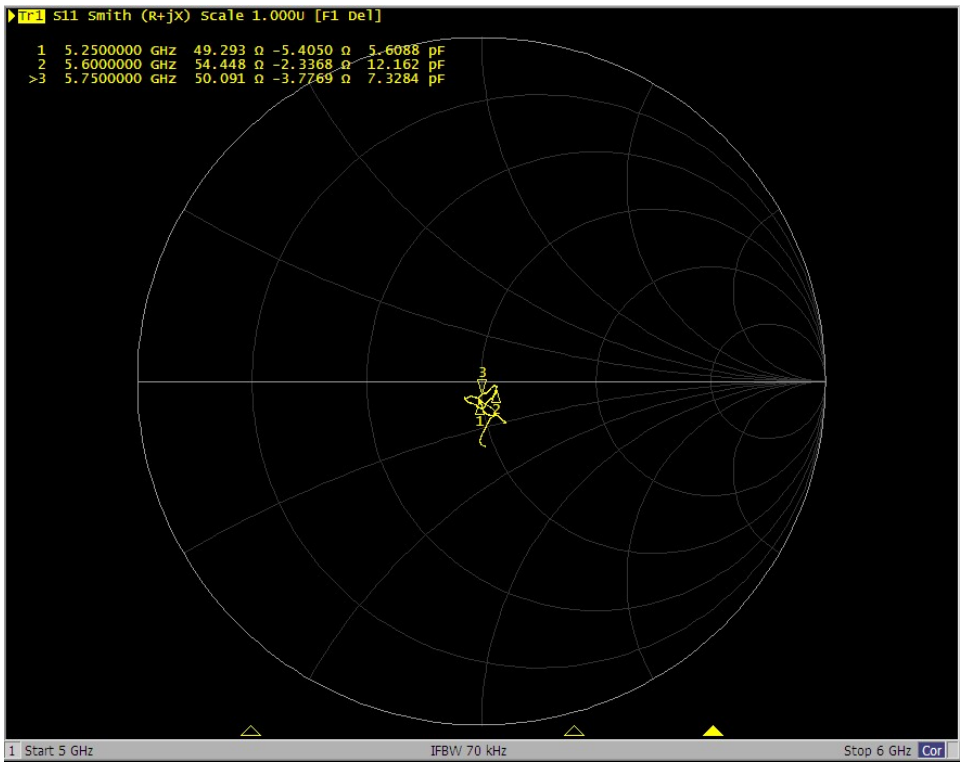
| D**5000**V2 – serial no. **1128** | | | | | | |
|---|---|---|---|---|---|---|
| | **5250MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 12.16.2019 (Cal. Report) | -23.113 | | 47.684 | | -6.437 | |
| 12.15.2020 (extended) | -26.397 | 14.2 | 49.293 | 1.609 | -5.405 | 1.032 |
| 12.14.2021 (extended) | -25.566 | 10.61 | 48.461 | 0.777 | -4.9046 | 1.5324 |
| | **5600MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 12.16.2019 (Cal. Report) | -26.278 | | 53.636 | | -3.4803 | |
| 12.15.2020 (extended) | -27.417 | 4.33 | 54.448 | 0.812 | -2.3368 | 1.1435 |
| 12.14.2021 (extended) | -28.562 | 8.69 | 54.259 | 0.623 | 0.72734 | 4.20764 |
| | **5750MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 12.16.2019 (Cal. Report) | -28.611 | | 51.3 | | -3.5295 | |
| 12.15.2020 (extended) | -25.773 | -9.91 | 50.091 | -1.209 | -3.7769 | -0.2474 |
| 12.14.2021 (extended) | -27.023 | -5.55 | 48.393 | -2.907 | -4.6333 | -1.1038 |

The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

**<Dipole Verification Data> - D5000 V2, serial no. 1128 (Data of Measurement : 12.15.2020)**

**5000 MHz - Head**

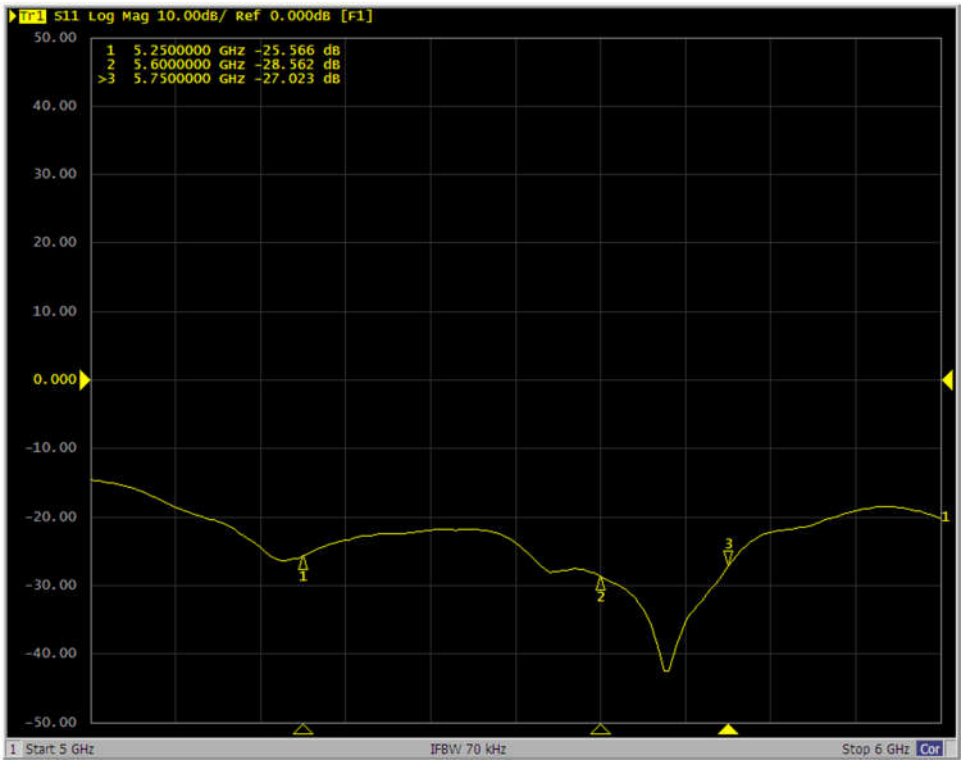


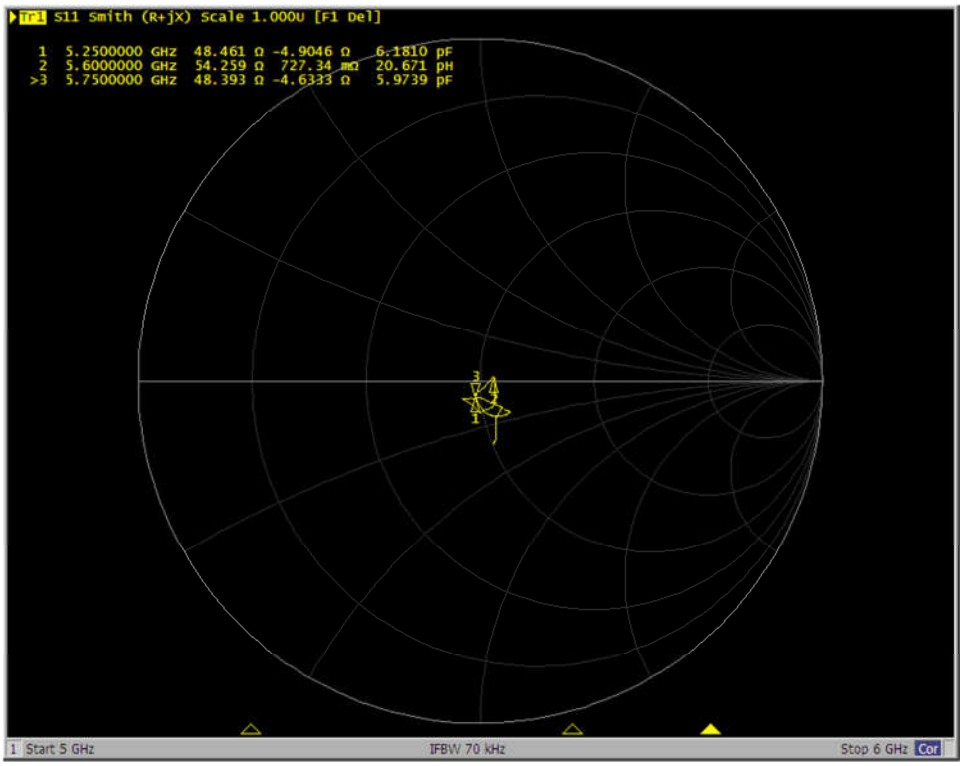




**SPORTON INTERNATIONAL INC.**
TEL : 886-3-327-3456
FAX : 886-3-328-4978

**<Dipole Verification Data> - D5000 V2, serial no. 1128 (Data of Measurement : 12.14.2021)**

**5000 MHz - Head**

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**C** Service suisse d'étalonnage
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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** **Sporton**

**Certificate No: D5GHzV2-1171_Apr21**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | D5GHzV2 - SN:1171 |
| Calibration procedure(s) | QA CAL-22.v6<br>Calibration Procedure for SAR Validation Sources between 3-10 GHz |
| Calibration date: | April 20, 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: 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: | Michael Weber | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: April 20, 2021

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

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

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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**

**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%.

## 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 = 4.0 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| **Frequency** | 5250 MHz ± 1 MHz<br>5600 MHz ± 1 MHz<br>5750 MHz ± 1 MHz<br>5850 MHz ± 1 MHz | |

## Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

| | **Temperature** | **Permittivity** | **Conductivity** |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.9 | 4.71 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.9 ± 6 % | 4.57 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5250 MHz

| **SAR averaged over 1 $cm^3$ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.08 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **80.3 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 $cm^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.32 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.0 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 | 34.4 ± 6 % | 4.93 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 | 8.41 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **83.4 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.39 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.7 W/kg ± 19.5 % (k=2)** |

## Head TSL parameters at 5750 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.4 | 5.22 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.1 ± 6 % | 5.09 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5750 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.11 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 5850 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|---|---|---|
| **Nominal Head TSL parameters** | 22.0 °C | 35.2 | 5.32 mho/m |
| **Measured Head TSL parameters** | (22.0 ± 0.2) °C | 34.0 ± 6 % | 5.19 mho/m ± 6 % |
| **Head TSL temperature change during test** | < 0.5 °C | ---- | ---- |

## SAR result with Head TSL at 5850 MHz

| **SAR averaged over 1 cm³ (1 g) of Head TSL** | Condition | |
|---|---|---|
| SAR measured | 100 mW input power | 8.29 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **82.3 W/kg ± 19.9 % (k=2)** |

| **SAR averaged over 10 cm³ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 2.34 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **23.1 W/kg ± 19.5 % (k=2)** |

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

### Antenna Parameters with Head TSL at 5250 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 50.4 Ω - 9.7 jΩ |
| Return Loss | - 20.3 dB |

### Antenna Parameters with Head TSL at 5600 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 55.5 Ω - 4.5 jΩ |
| Return Loss | - 23.5 dB |

### Antenna Parameters with Head TSL at 5750 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 55.9 Ω - 5.8 jΩ |
| Return Loss | - 22.1 dB |

### Antenna Parameters with Head TSL at 5850 MHz

| | |
|---|---|
| Impedance, transformed to feed point | 57.7 Ω - 6.6 jΩ |
| Return Loss | - 20.5 dB |

### General Antenna Parameters and Design

| | |
|---|---|
| Electrical Delay (one direction) | 1.206 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: 20.04.2021

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1171**

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5750 MHz, Frequency: 5850 MHz
Medium parameters used: f = 5250 MHz; $\sigma$ = 4.57 S/m; $\varepsilon_r$ = 34.9; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5600 MHz; $\sigma$ = 4.93 S/m; $\varepsilon_r$ = 34.4; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5750 MHz; $\sigma$ = 5.09 S/m; $\varepsilon_r$ = 34.1; $\rho$ = 1000 kg/m$^3$ ,
Medium parameters used: f = 5850 MHz; $\sigma$ = 5.19 S/m; $\varepsilon_r$ = 34; $\rho$ = 1000 kg/m$^3$
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

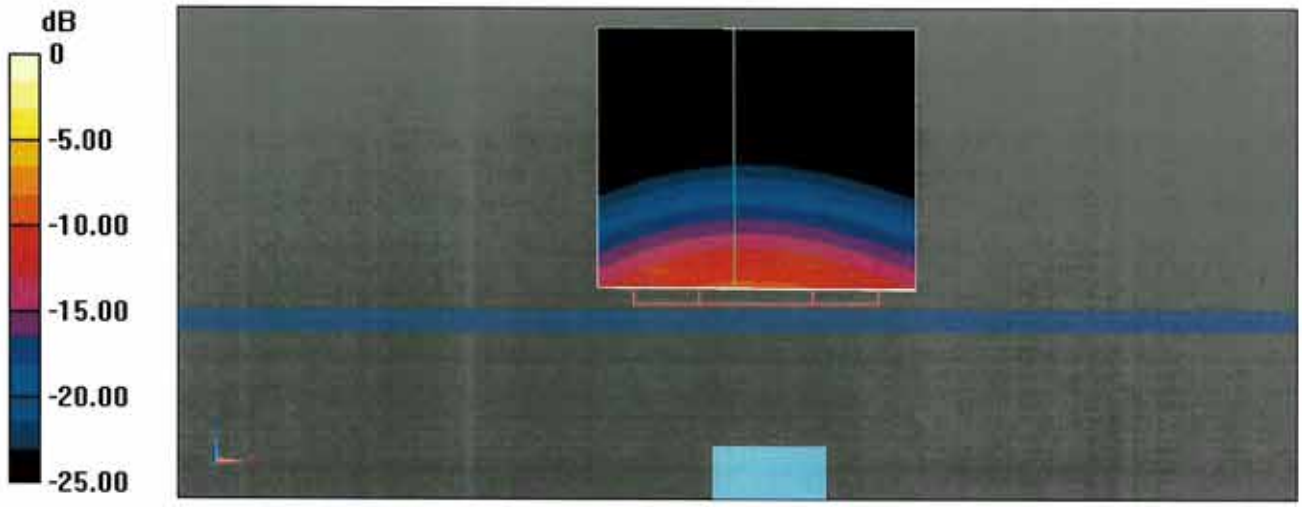
- Probe: EX3DV4 - SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.08, 5.08, 5.08) @ 5750 MHz, ConvF(4.99, 4.99, 4.99) @ 5850 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: 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=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 76.43 V/m; Power Drift = 0.08 dB
Peak SAR (extrapolated) = 27.7 W/kg
**SAR(1 g) = 8.08 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 = 71.2%
Maximum value of SAR (measured) = 18.2 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 = 77.80 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 31.0 W/kg
**SAR(1 g) = 8.41 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 = 68.6%
Maximum value of SAR (measured) = 19.6 W/kg

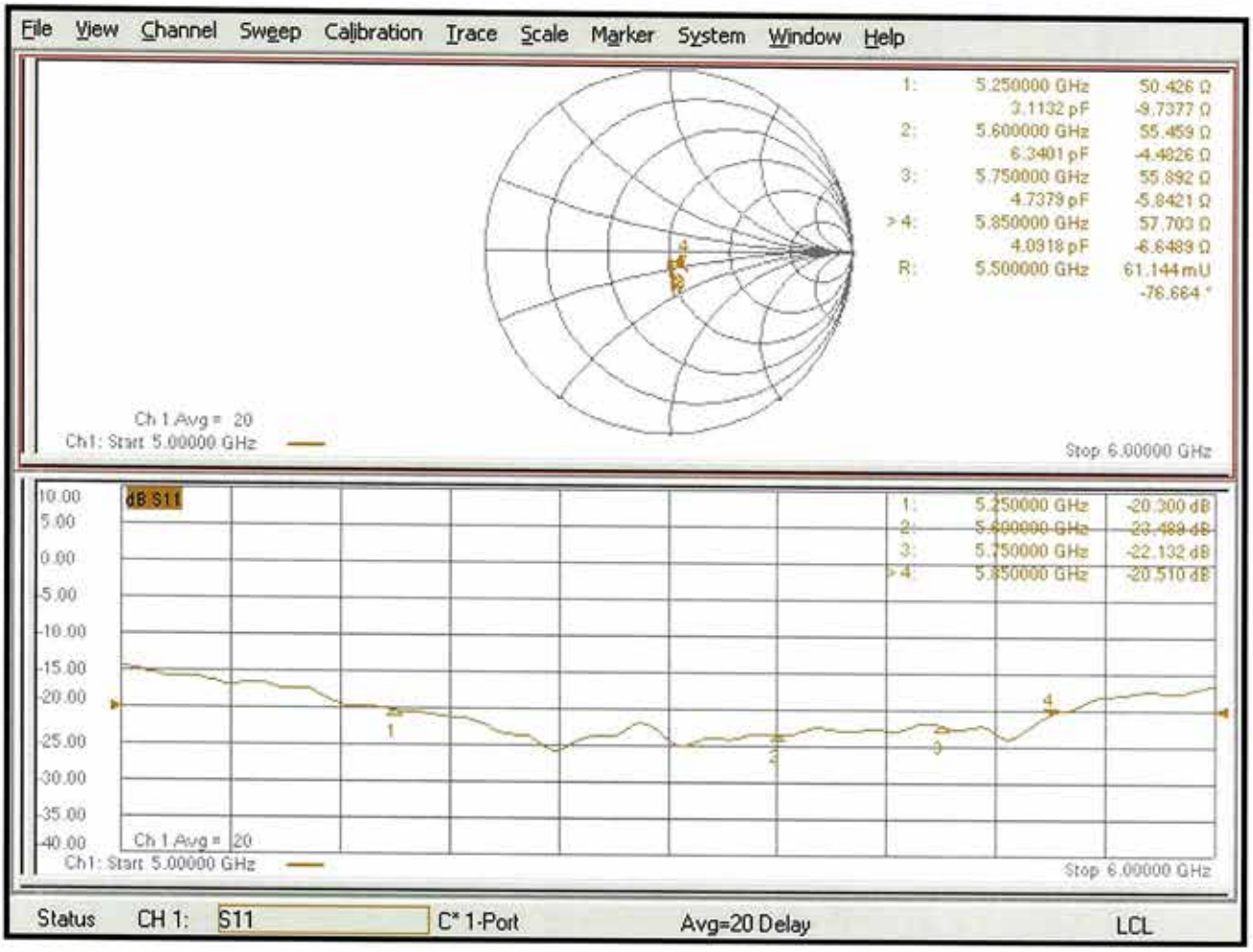
**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5750 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 75.01 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 31.5 W/kg
**SAR(1 g) = 8.11 W/kg; SAR(10 g) = 2.30 W/kg**
Smallest distance from peaks to all points 3 dB below = 7.4 mm
Ratio of SAR at M2 to SAR at M1 = 66.9%
Maximum value of SAR (measured) = 19.2 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5850 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 76.40 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 33.2 W/kg
**SAR(1 g) = 8.29 W/kg; SAR(10 g) = 2.34 W/kg**
Smallest distance from peaks to all points 3 dB below = 7.2 mm
Ratio of SAR at M2 to SAR at M1 = 65.7%
Maximum value of SAR (measured) = 20.0 W/kg




0 dB = 20.0 W/kg = 13.00 dBW/kg

## Impedance Measurement Plot for Head TSL



## D5000V2, serial no. 1171 Extended Dipole Calibrations

Referring to KDB 450824, if dipoles are verified in return loss (<-20dB, within 20% of prior calibration), and in impedance (within 5 ohm of prior calibration), the annual calibration is not necessary and the calibration interval can be extended.

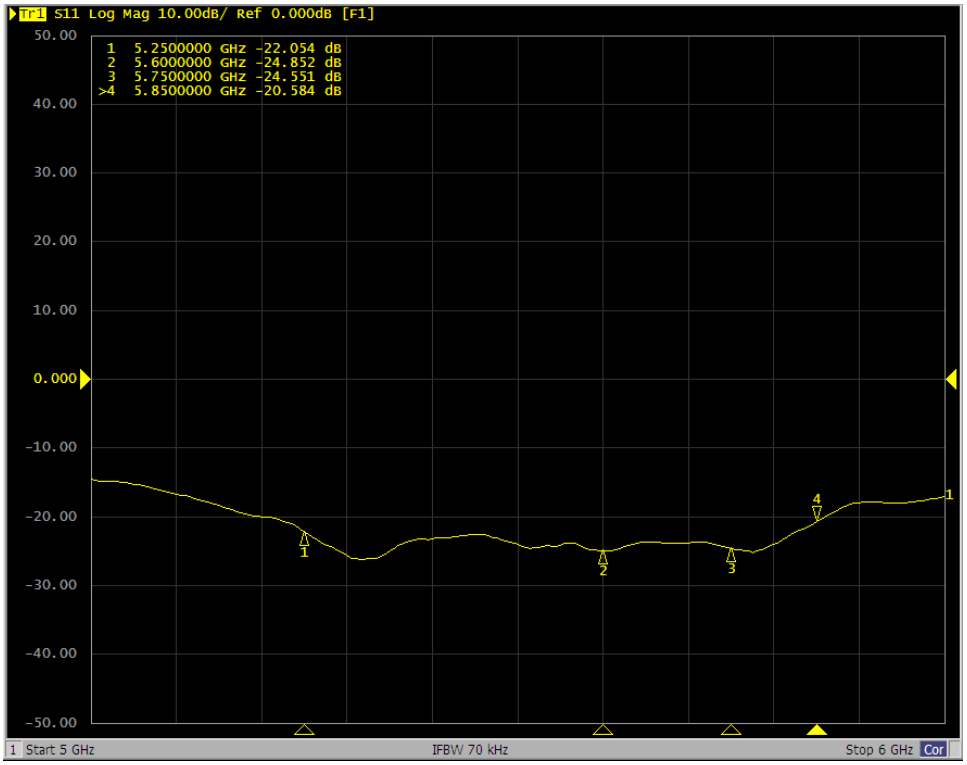
**<Justification of the extended calibration>**

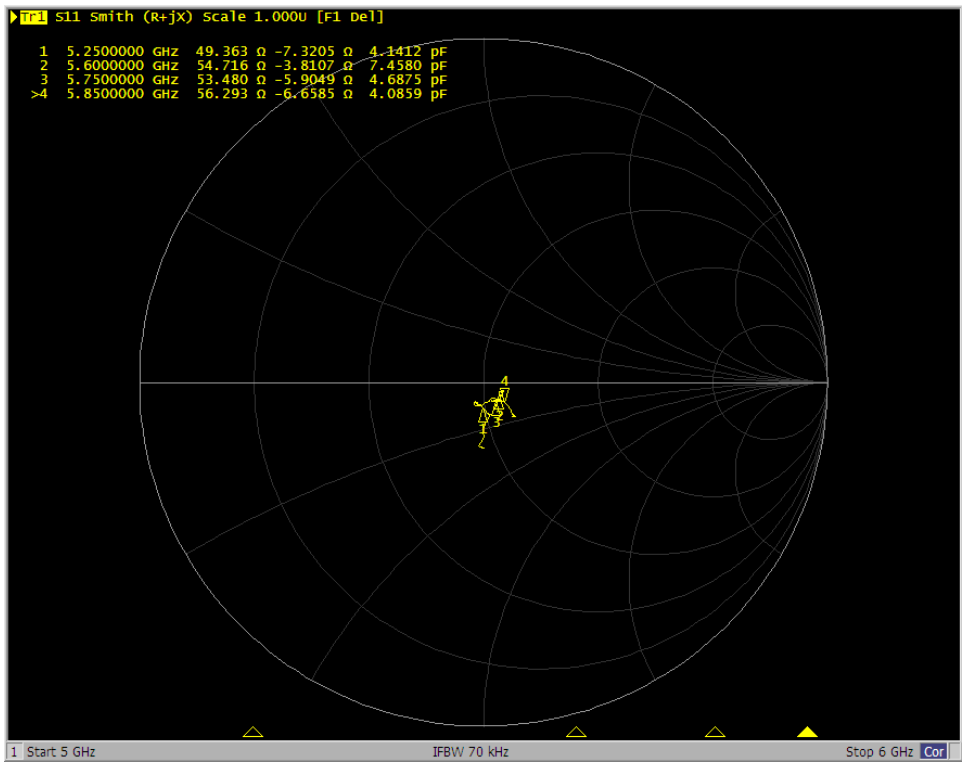
| D**5000**V2 – serial no. **1171** | | | | | | |
|---|---|---|---|---|---|---|
| | **5250MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 04.20.2021 (Cal. Report) | -20.3 | | 50.4 | | -9.7 | |
| 04.19.2022 (extended) | -22.054 | 8.6 | 49.363 | 1.037 | -7.3205 | -2.3795 |
| | **5600MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 04.20.2021 (Cal. Report) | -23.5 | | 55.5 | | -4.5 | |
| 04.19.2022 (extended) | -24.852 | 5.8 | 54.716 | 0.784 | -3.8107 | -0.6893 |
| | **5750MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 04.20.2021 (Cal. Report) | -22.1 | | 55.9 | | -5.8 | |
| 04.19.2022 (extended) | -24.551 | 11.1 | 53.48 | 2.42 | -5.9049 | 0.1049 |
| | **5850MHZ** | | | | | |
| Date of Measurement | Return-Loss (dB) | Delta (%) | Real Impedance (ohm) | Delta (ohm) | Imaginary Impedance (ohm) | Delta (ohm) |
| 04.20.2021 (Cal. Report) | -20.5 | | 57.7 | | -6.6 | |
| 04.19.2022 (extended) | -20.584 | 0.4 | 56.293 | 1.407 | -6.6585 | 0.0585 |

The return loss is < -20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification result should support extended calibration.

**<Dipole Verification Data> - D5000 V2, serial no. 1171 (Data of Measurement : 04.19.2022)**

**5000 MHz - Head**

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**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
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Swiss Calibration Service

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

**Accreditation No.: SCS 0108**

**Client** Sporton

**Certificate No: D6.5GHzV2-1003_Sep21**

# CALIBRATION CERTIFICATE

Object: D6.5GHzV2 - SN:1003

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

Calibration date: September 24, 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 Keysight E5063A | SN:MY54504221 | 31-Oct-19 (in house check Oct-19) | In house check: Oct-22 |

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

Issued: September 27, 2021

## Glossary:

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

## Calibration is Performed According to the Following Standards:

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

## Additional Documentation:

b) DASY System Handbook

## Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.
- *The absorbed power density (APD):* The absorbed power density is evaluated according to Samaras T, Christ A, Kuster N, "*Compliance assessment of the epithelial or absorbed power density above 6 GHz using SAR measurement systems",* Bioelectromagnetics, 2021 (submitted). The additional evaluation uncertainty of 0.55 dB (rectangular distribution) is considered.

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

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | DASY6 | V16.0 |
| **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 | 29.4 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **292 W/kg ± 24.7 % (k=2)** |

| **SAR averaged over 10 cm$^3$ (10 g) of Head TSL** | condition | |
|---|---|---|
| SAR measured | 100 mW input power | 5.42 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | **53.8 W/kg ± 24.4 % (k=2)** |

## Appendix

## Antenna Parameters with Head TSL

| | |
|---|---|
| Impedance, transformed to feed point | 54.4 Ω - 1.9 jΩ |
| Return Loss | - 26.8 dB |

## APD (Absorbed Power Density)

| **APD averaged over 1 cm$^2$** | Condition | |
|---|---|---|
| APD measured | 100 mW input power | 292 W/m$^2$ |
| APD measured | normalized to 1W | **2920 W/m$^2$ ± 29.2 % (k=2)** |

| **APD averaged over 4 cm$^2$** | condition | |
|---|---|---|
| APD measured | 100 mW input power | 132 W/m$^2$ |
| APD measured | normalized to 1W | **1320 W/m$^2$ ± 28.9 % (k=2)** |

## General Antenna Parameters and Design

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

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

## Additional EUT Data

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

# DASY6 Validation Report for Head TSL

**Measurement Report for D6.5GHz-1003, 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: 1003 | - |

**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**

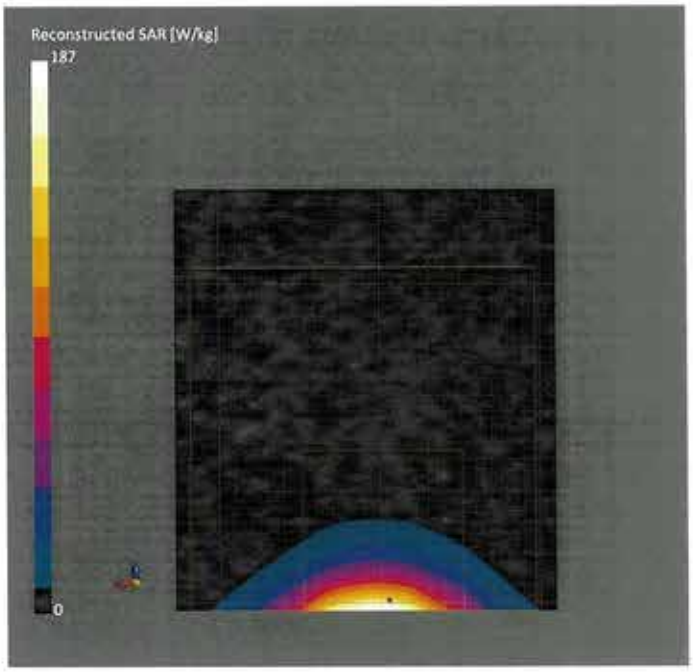
| Phantom | TSL | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| MFP V8.0 Center - 1182 | HBBL600-10000V6 | EX3DV4 - SN7405, 2020-12-30 | DAE4 Sn908, 2021-06-24 |

**Scan Setup**

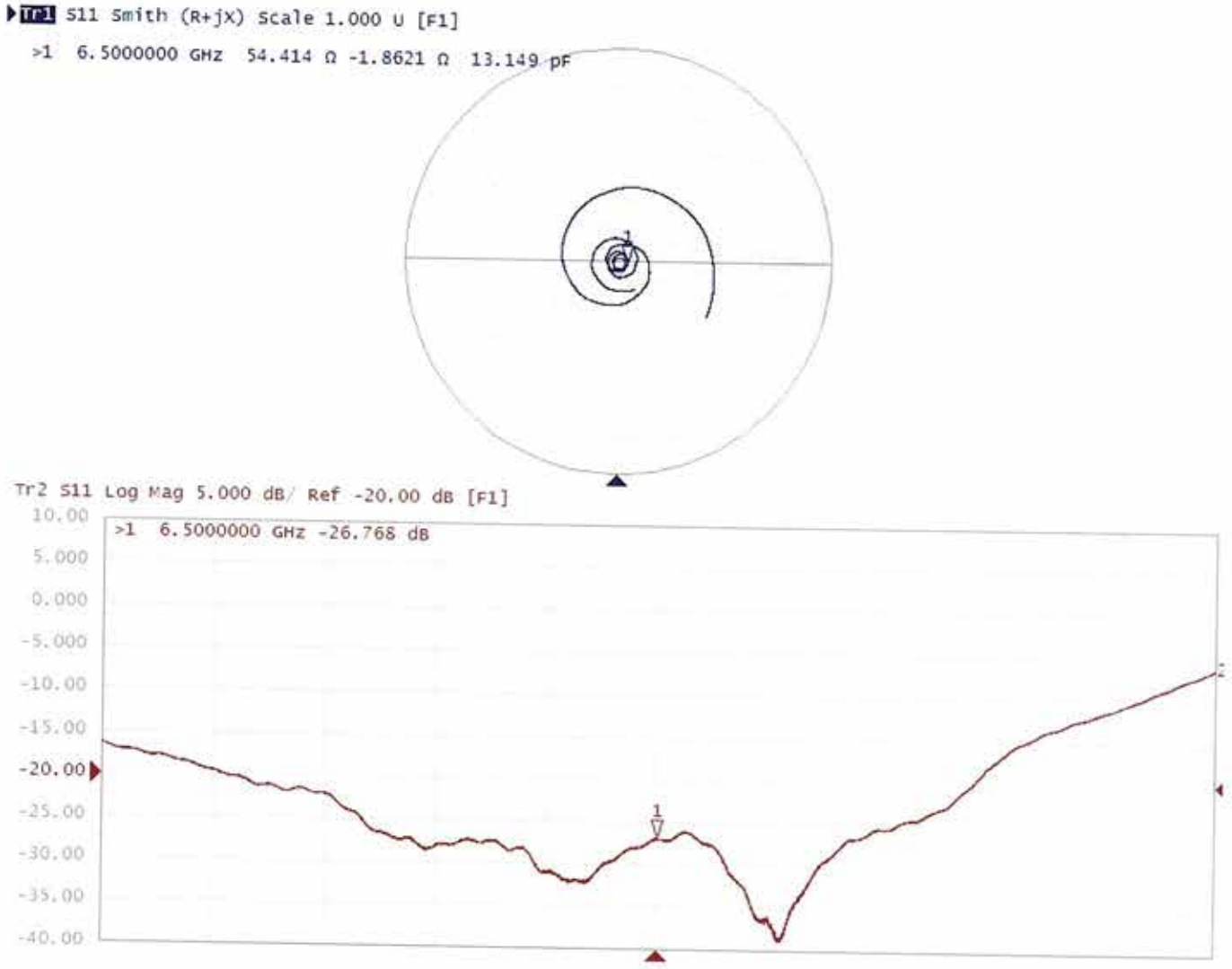
| | Zoom Scan |
|---|---|
| Grid Extents [mm] | 22.0 x 22.0 x 22.0 |
| Grid Steps [mm] | 3.4 x 3.4 x 1.4 |
| Sensor Surface [mm] | 1.4 |
| Graded Grid | Yes |
| Grading Ratio | 1.4 |
| MAIA | N/A |
| Surface Detection | VMS + 6p |
| Scan Method | Measured |

**Measurement Results**

| | Zoom Scan |
|---|---|
| Date | 2021-09-24, 9:30 |
| psSAR1g [W/Kg] | 29.4 |
| psSAR10g [W/Kg] | 5.42 |
| Power Drift [dB] | -0.02 |
| Power Scaling | Disabled |
| Scaling Factor [dB] | |
| TSL Correction | No correction |
| M2/M1 [%] | 55.6 |
| Dist 3dB Peak [mm] | 4.6 |



## Impedance Measurement Plot for Head TSL



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**Accreditation No.: SCS 0108**

**Client** **Sporton**

**Certificate No: 5G-Veri10-1020_Jan22**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | 5G Verification Source 10 GHz - SN: 1020 |
| Calibration procedure(s) | QA CAL-45.v3<br>Calibration procedure for sources in air above 6 GHz |
| Calibration date: | January 18, 2022 |

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 | 2021-12-21(No. EUmmWV3-9374_Dec21) | Dec-22 |
| DAE4ip | SN: 1602 | 2021-06-25 (No. DAE4ip-1602_Jun21) | Jun-22 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| | | | |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Sven Kühn | Deputy Manager | |

Issued: January 26, 2022

## 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 radiated power is the forward power to the horn antenna minus ohmic and mismatch loss. The forward power is measured prior and after the measurement with a power sensor. During the measurements, the horn is directly connected to the cable and the antenna ohmic and mismatch losses are determined by far-field measurements. *(2) 30, 45, 60 and 90 GHz*: The verification sources are switched on for at least 30 minutes. Absorbers are used around the probe cub and at the ceiling to minimize reflections.
- *Horn Positioning:* The waveguide horn is mounted vertically on the flange of the waveguide source to allow vertical positioning of the EUmmW probe during the scan. The plane is parallel to the phantom surface. Probe distance is verified using mechanical gauges positioned on the flare of the horn.
- *E- field distribution:* E field is measured in two x-y-plane (10mm, 10mm + λ/4) with a vectorial E-field probe. The E-field value stated as calibration value represents the E-field-maxima and the averaged (1cm$^2$ 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%.

## Measurement Conditions

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

| | | |
|---|---|---|
| **DASY Version** | cDASY6 Module mmWave | V2.4 |
| **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 | 86.1 | **149** | 1.27 dB | **55.0** | **51.7** | 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 | 86.1 | **149** | 1.27 dB | **55.0** | **51.5** | 1.28 dB |

[1] Assessed ohmic and mismatch loss plus numerical offset: 0.55 dB

# 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: 1020 | - |

### 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

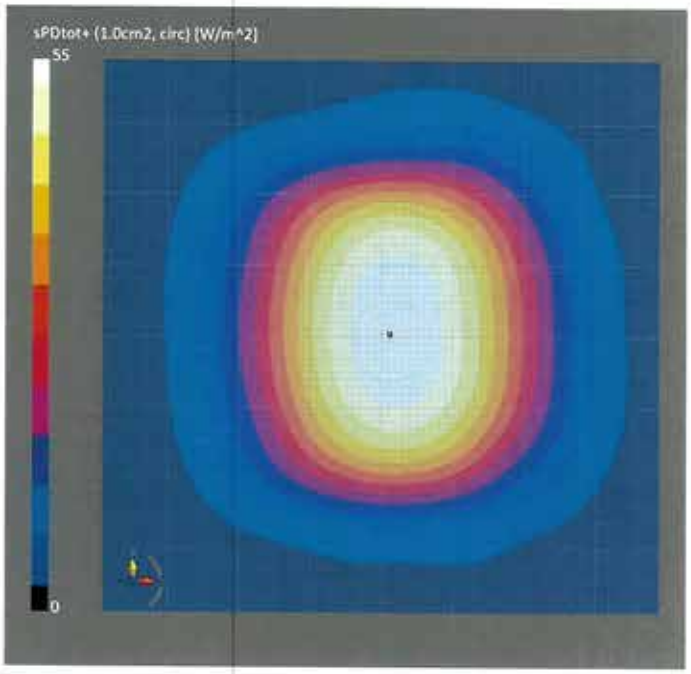
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-55GHz, 2021-12-21 | DAE4ip Sn1602, 2021-06-25 |

### 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 | 2022-01-18, 16:30 |
| Avg. Area [cm²] | 1.00 |
| psPDn+ [W/m²] | 54.8 |
| psPDtot+ [W/m²] | 55.0 |
| psPDmod+ [W/m²] | 55.2 |
| $E_{max}$ [V/m] | 149 |
| Power Drift [dB] | 0.02 |



# 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: 1020 | - |

### 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

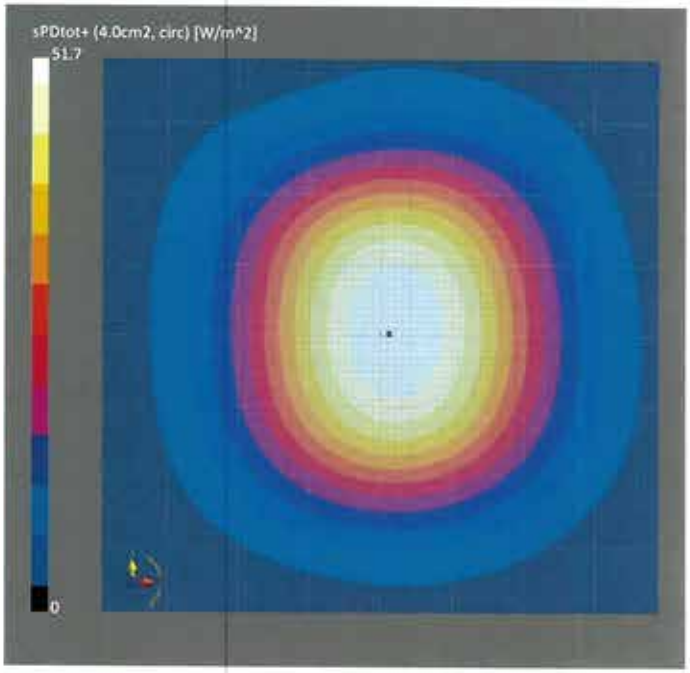
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-55GHz, 2021-12-21 | DAE4ip Sn1602, 2021-06-25 |

### 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 | 2022-01-18, 16:30 |
| Avg. Area [cm²] | 4.00 |
| psPDn+ [W/m²] | 51.5 |
| psPDtot+ [W/m²] | 51.7 |
| psPDmod+ [W/m²] | 51.9 |
| $E_{max}$ [V/m] | 149 |
| Power Drift [dB] | 0.02 |



# 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: 1020 | - |

### 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

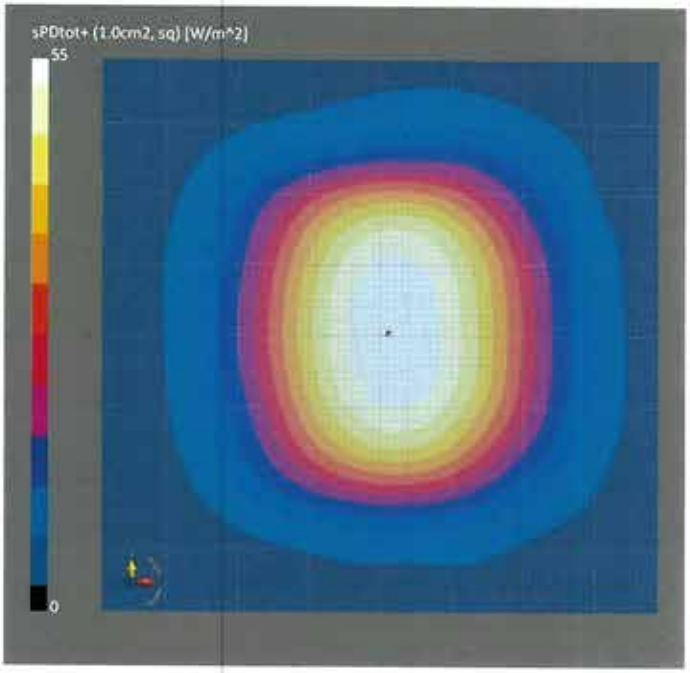
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-55GHz, 2021-12-21 | DAE4ip Sn1602, 2021-06-25 |

### 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 | 2022-01-18, 16:30 |
| Avg. Area [cm²] | 1.00 |
| psPDn+ [W/m²] | 54.8 |
| psPDtot+ [W/m²] | 55.0 |
| psPDmod+ [W/m²] | 55.2 |
| $E_{max}$ [V/m] | 149 |
| Power Drift [dB] | 0.02 |



# 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: 1020 | - |

### 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

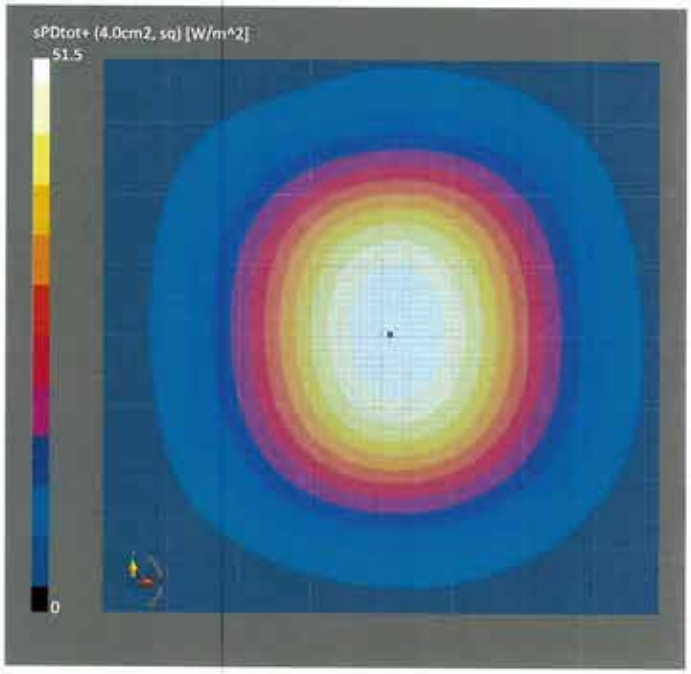
| Phantom | Medium | Probe, Calibration Date | DAE, Calibration Date |
|---|---|---|---|
| mmWave Phantom - 1002 | Air | EUmmWV3 - SN9374_F1-55GHz, 2021-12-21 | DAE4ip Sn1602, 2021-06-25 |

### 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 | 2022-01-18, 16:30 |
| Avg. Area [cm²] | 4.00 |
| psPDn+ [W/m²] | 51.3 |
| psPDtot+ [W/m²] | 51.5 |
| psPDmod+ [W/m²] | 51.7 |
| $E_{max}$ [V/m] | 149 |
| Power Drift [dB] | 0.02 |



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

**Accreditation No.: SCS 0108**

**Client** Sporton

**Certificate No: DAE4-316_Jan22**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE4 - SD 000 D04 BM - SN: 316 |
| Calibration procedure(s) | QA CAL-06.v30<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | January 26, 2022 |

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 |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 31-Aug-21 (No:31368) | Aug-22 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 24-Jan-22 (in house check) | In house check: Jan-23 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 24-Jan-22 (in house check) | In house check: Jan-23 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Dominique Steffen | Laboratory Technician | |
| Approved by: | Sven Kühn | Deputy Manager | |

Issued: January 26, 2022

## Glossary

| | |
|---|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

| | | | | |
|---|---|---|---|---|
| High Range: | 1LSB = | 6.1μV , | full range = | -100...+300 mV |
| Low Range: | 1LSB = | 61nV , | full range = | -1.....+3mV |

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| **High Range** | 404.354 ± 0.02% (k=2) | 404.471 ± 0.02% (k=2) | 404.346 ± 0.02% (k=2) |
| **Low Range** | 3.94615 ± 1.50% (k=2) | 3.94156 ± 1.50% (k=2) | 3.93735 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 352.0 ° ± 1 ° |

## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 200037.31 | 3.07 | 0.00 |
| Channel X | + Input | 20009.91 | 4.11 | 0.02 |
| Channel X | - Input | -20006.43 | -0.58 | 0.00 |
| Channel Y | + Input | 200038.18 | -0.84 | -0.00 |
| Channel Y | + Input | 20009.41 | 3.71 | 0.02 |
| Channel Y | - Input | -20010.93 | -4.94 | 0.02 |
| Channel Z | + Input | 200036.49 | -2.45 | -0.00 |
| Channel Z | + Input | 20008.57 | 2.91 | 0.01 |
| Channel Z | - Input | -20011.15 | -5.09 | 0.03 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2000.95 | -0.21 | -0.01 |
| Channel X | + Input | 201.10 | -0.06 | -0.03 |
| Channel X | - Input | -199.24 | -0.42 | 0.21 |
| Channel Y | + Input | 2001.03 | 0.08 | 0.00 |
| Channel Y | + Input | 199.86 | -1.15 | -0.57 |
| Channel Y | - Input | -200.38 | -1.55 | 0.78 |
| Channel Z | + Input | 2000.94 | 0.03 | 0.00 |
| Channel Z | + Input | 200.21 | -0.77 | -0.38 |
| Channel Z | - Input | -200.14 | -1.20 | 0.60 |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|---|---|---|---|
| Channel X | 200 | 5.76 | 4.39 |
| | - 200 | -4.88 | -5.46 |
| Channel Y | 200 | -1.81 | -1.86 |
| | - 200 | -1.60 | -0.62 |
| Channel Z | 200 | -15.50 | -15.36 |
| | - 200 | 12.60 | 13.48 |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|---|---|---|---|---|
| Channel X | 200 | - | -1.34 | -1.75 |
| Channel Y | 200 | 5.21 | - | 0.26 |
| Channel Z | 200 | 7.15 | 2.59 | - |

## 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|---|---|---|
| **Channel X** | 16021 | 15259 |
| **Channel Y** | 16059 | 16229 |
| **Channel Z** | 16145 | 17266 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| **Channel X** | 0.28 | -0.78 | 1.30 | 0.38 |
| **Channel Y** | -0.63 | -1.59 | 0.33 | 0.37 |
| **Channel Z** | -0.56 | -1.52 | 0.29 | 0.38 |

## 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

## 7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|---|---|---|
| **Channel X** | 200 | 200 |
| **Channel Y** | 200 | 200 |
| **Channel Z** | 200 | 200 |

## 8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|---|---|
| **Supply (+ Vcc)** | +7.9 |
| **Supply (- Vcc)** | -7.6 |

## 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|---|---|---|---|
| **Supply (+ Vcc)** | +0.01 | +6 | +14 |
| **Supply (- Vcc)** | –0.01 | -8 | -9 |

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s p e a

DAE4
316
Spatial

# IMPORTANT NOTICE

## USAGE OF THE DAE4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

**Battery Exchange**: The battery cover of the DAE4 unit is fixed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE**: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

**E-Stop Failures**: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

**Repair**: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

**DASY Configuration Files:** Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

**Important Note:**
**Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.**

**Important Note:**
**Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.**

**Important Note:**
**To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.**

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**Accreditation No.: SCS 0108**

**Client** Sporton

**Certificate No: DAE4-656_Jan22**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE4 - SD 000 D04 BM - SN: 656 |
| Calibration procedure(s) | QA CAL-06.v30<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | January 19, 2022 |

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 |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 31-Aug-21 (No:31368) | Aug-22 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 07-Jan-21 (in house check) | In house check: Jan-22 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 07-Jan-21 (in house check) | In house check: Jan-22 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Dominique Steffen | Laboratory Technician | |
| Approved by: | Sven Kühn | Deputy Manager | i.V. |

Issued: January 19, 2022

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**Servizio svizzero di taratura**
**Swiss Calibration Service**

**Accreditation No.: SCS 0108**

## Glossary

| | |
|---|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

| | | | | |
|---|---|---|---|---|
| High Range: | 1LSB = | 6.1μV , | full range = | -100...+300 mV |
| Low Range: | 1LSB = | 61nV , | full range = | -1.....+3mV |

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| High Range | 404.146 ± 0.02% (k=2) | 404.648 ± 0.02% (k=2) | 404.915 ± 0.02% (k=2) |
| Low Range | 3.96369 ± 1.50% (k=2) | 3.97896 ± 1.50% (k=2) | 3.96657 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 314.0 ° ± 1 ° |

## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 200022.45 | -13.82 | -0.01 |
| Channel X | + Input | 20007.00 | 1.41 | 0.01 |
| Channel X | - Input | -20001.54 | 4.11 | -0.02 |
| Channel Y | + Input | 200026.91 | -4.48 | -0.00 |
| Channel Y | + Input | 20005.28 | -0.27 | -0.00 |
| Channel Y | - Input | -20003.83 | 1.96 | -0.01 |
| Channel Z | + Input | 200029.93 | -1.35 | -0.00 |
| Channel Z | + Input | 20003.01 | -2.42 | -0.01 |
| Channel Z | - Input | -20004.79 | 1.11 | -0.01 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2000.48 | -0.94 | -0.05 |
| Channel X | + Input | 200.75 | -0.51 | -0.26 |
| Channel X | - Input | -199.52 | -0.92 | 0.46 |
| Channel Y | + Input | 2000.84 | -0.41 | -0.02 |
| Channel Y | + Input | 200.34 | -0.82 | -0.41 |
| Channel Y | - Input | -199.90 | -1.20 | 0.60 |
| Channel Z | + Input | 2000.73 | -0.47 | -0.02 |
| Channel Z | + Input | 200.88 | -0.22 | -0.11 |
| Channel Z | - Input | -199.73 | -0.97 | 0.49 |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|---|---|---|---|
| Channel X | 200 | 0.76 | -0.98 |
| | - 200 | 1.20 | -0.19 |
| Channel Y | 200 | -1.51 | -1.27 |
| | - 200 | -1.02 | -0.82 |
| Channel Z | 200 | 5.72 | 5.16 |
| | - 200 | -6.32 | -6.81 |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|---|---|---|---|---|
| Channel X | 200 | - | -2.59 | -1.49 |
| Channel Y | 200 | 6.74 | - | -0.64 |
| Channel Z | 200 | 7.04 | 3.93 | - |

## 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|---|---|---|
| **Channel X** | 15632 | 16011 |
| **Channel Y** | 15859 | 16203 |
| **Channel Z** | 15660 | 15027 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| **Channel X** | 0.59 | -0.72 | 2.07 | 0.58 |
| **Channel Y** | -0.12 | -1.56 | 1.69 | 0.60 |
| **Channel Z** | -0.13 | -1.55 | 1.01 | 0.51 |

## 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

## 7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|---|---|---|
| **Channel X** | 200 | 200 |
| **Channel Y** | 200 | 200 |
| **Channel Z** | 200 | 200 |

## 8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|---|---|
| **Supply (+ Vcc)** | +7.9 |
| **Supply (- Vcc)** | -7.6 |

## 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|---|---|---|---|
| **Supply (+ Vcc)** | +0.01 | +6 | +14 |
| **Supply (- Vcc)** | -0.01 | -8 | -9 |

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s p e a g

# IMPORTANT NOTICE

## USAGE OF THE DAE4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

**Battery Exchange**: The battery cover of the DAE4 unit is fixed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE**: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

**E-Stop Failures**: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

**Repair**: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

**DASY Configuration Files:** Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

**Important Note:**
**Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.**

**Important Note:**
**Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.**

**Important Note:**
**To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.**

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

**Accreditation No.: SCS 0108**

**Client** **Sporton**

**Certificate No: DAE4-699_Feb22**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE4 - SD 000 D04 BO - SN: 699 |
| Calibration procedure(s) | QA CAL-06.v30<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | February 24, 2022 |

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 |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 31-Aug-21 (No:31368) | Aug-22 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 24-Jan-22 (in house check) | In house check: Jan-23 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 24-Jan-22 (in house check) | In house check: Jan-23 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Dominique Steffen | Laboratory Technician | |
| Approved by: | Sven Kühn | Deputy Manager | |

Issued: February 24, 2022

## Glossary

| | |
|---|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

| | | | | |
|---|---|---|---|---|
| High Range: | 1LSB = | 6.1μV , | full range = | -100...+300 mV |
| Low Range: | 1LSB = | 61nV , | full range = | -1.....+3mV |

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| High Range | 404.729 ± 0.02% (k=2) | 403.370 ± 0.02% (k=2) | 404.543 ± 0.02% (k=2) |
| Low Range | 3.93275 ± 1.50% (k=2) | 3.95092 ± 1.50% (k=2) | 3.97670 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 168.5 ° ± 1 ° |

## Appendix (Additional assessments outside the scope of SCS0108)

### 1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 199994.75 | 1.20 | 0.00 |
| Channel X | + Input | 19999.74 | -1.76 | -0.01 |
| Channel X | - Input | -19997.90 | 3.89 | -0.02 |
| Channel Y | + Input | 199993.31 | 0.03 | 0.00 |
| Channel Y | + Input | 19997.29 | -4.23 | -0.02 |
| Channel Y | - Input | -20002.03 | -0.16 | 0.00 |
| Channel Z | + Input | 199998.79 | 5.53 | 0.00 |
| Channel Z | + Input | 19998.77 | -2.67 | -0.01 |
| Channel Z | - Input | -20000.98 | 0.97 | -0.00 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2000.10 | -0.73 | -0.04 |
| Channel X | + Input | 201.39 | 0.22 | 0.11 |
| Channel X | - Input | -198.44 | 0.27 | -0.13 |
| Channel Y | + Input | 2000.39 | -0.37 | -0.02 |
| Channel Y | + Input | 201.37 | 0.21 | 0.10 |
| Channel Y | - Input | -199.76 | -0.90 | 0.45 |
| Channel Z | + Input | 2001.24 | 0.53 | 0.03 |
| Channel Z | + Input | 200.72 | -0.31 | -0.16 |
| Channel Z | - Input | -199.33 | -0.47 | 0.24 |

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|---|---|---|---|
| Channel X | 200 | -3.03 | -3.58 |
| | - 200 | 4.76 | 3.52 |
| Channel Y | 200 | 21.88 | 22.22 |
| | - 200 | -24.02 | -24.12 |
| Channel Z | 200 | 8.79 | 8.30 |
| | - 200 | -8.42 | -9.05 |

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|---|---|---|---|---|
| Channel X | 200 | - | -2.17 | -2.32 |
| Channel Y | 200 | 7.46 | - | -0.80 |
| Channel Z | 200 | 4.04 | 5.64 | - |

## 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|---|---|---|
| **Channel X** | 16101 | 15333 |
| **Channel Y** | 16429 | 16302 |
| **Channel Z** | 16296 | 16248 |

## 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

| | Average (μV) | min. Offset (μV) | max. Offset (μV) | Std. Deviation (μV) |
|---|---|---|---|---|
| **Channel X** | 0.96 | -0.27 | 2.15 | 0.40 |
| **Channel Y** | -0.83 | -2.49 | 0.64 | 0.59 |
| **Channel Z** | 0.23 | -1.54 | 2.09 | 0.51 |

## 6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

## 7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|---|---|---|
| **Channel X** | 200 | 200 |
| **Channel Y** | 200 | 200 |
| **Channel Z** | 200 | 200 |

## 8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|---|---|
| **Supply (+ Vcc)** | +7.9 |
| **Supply (- Vcc)** | -7.6 |

## 9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|---|---|---|---|
| **Supply (+ Vcc)** | +0.01 | +6 | +14 |
| **Supply (- Vcc)** | –0.01 | -8 | -9 |

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# IMPORTANT NOTICE

## USAGE OF THE DAE4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

**Battery Exchange**: The battery cover of the DAE4 unit is fixed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

**Shipping of the DAE**: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

**E-Stop Failures**: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

**Repair**: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

**DASY Configuration Files:** Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

**Important Note:**
**Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.**

**Important Note:**
**Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.**

**Important Note:**
**To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.**

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S 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** Sporton

**Certificate No: DAE4-1399_Feb22**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | DAE4 - SD 000 D04 BM - SN: 1399 |
| Calibration procedure(s) | QA CAL-06.v30<br>Calibration procedure for the data acquisition electronics (DAE) |
| Calibration date: | February 28, 2022 |

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 |
|---|---|---|---|
| Keithley Multimeter Type 2001 | SN: 0810278 | 31-Aug-21 (No:31368) | Aug-22 |
| **Secondary Standards** | **ID #** | **Check Date (in house)** | **Scheduled Check** |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 24-Jan-22 (in house check) | In house check: Jan-23 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 24-Jan-22 (in house check) | In house check: Jan-23 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Adrian Gehring | Laboratory Technician | |
| Approved by: | Sven Kühn | Deputy Manager | |

Issued: February 28, 2022

## Glossary

| | |
|---|---|
| DAE | data acquisition electronics |
| Connector angle | information used in DASY system to align probe sensor X to the robot coordinate system. |

## Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

| | | | | |
|---|---|---|---|---|
| High Range: | 1LSB = | 6.1μV , | full range = | -100...+300 mV |
| Low Range: | 1LSB = | 61nV , | full range = | -1.....+3mV |

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---|---|---|---|
| High Range | 403.609 ± 0.02% (k=2) | 403.869 ± 0.02% (k=2) | 403.724 ± 0.02% (k=2) |
| Low Range | 3.98239 ± 1.50% (k=2) | 3.99270 ± 1.50% (k=2) | 3.98082 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 302.5 ° ± 1 ° |