

## **Appendix C: Calibration Certificate for probe and Dipole**



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CALIBRATION LABORATORY



中国认可  
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CALIBRATION  
CNAS L0570

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Client

TUV-CN

Certificate No: Z21-60202

## CALIBRATION CERTIFICATE

Object D2450V2 - SN: 1014

Calibration Procedure(s) FF-Z11-003-01  
Calibration Procedures for dipole validation kits

Calibration date: May 19, 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(Calibrated by, Certificate No.) | Scheduled Calibration |
|-------------------------|------------|------------------------------------------|-----------------------|
| Power Meter NRP2        | 106277     | 23-Sep-20 (CTTL, No.J20X08336)           | Sep-21                |
| Power sensor NRP8S      | 104291     | 23-Sep-20 (CTTL, No.J20X08336)           | Sep-21                |
| ReferenceProbe EX3DV4   | SN 3846    | 26-Apr-21(CTTL-SPEAG,No.Z21-60084)       | Apr-22                |
| DAE4                    | SN 777     | 08-Jan-21(CTTL-SPEAG,No.Z21-60003)       | Jan-22                |
| Secondary Standards     | ID #       | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
| Signal Generator E4438C | MY49071430 | 01-Feb-21 (CTTL, No.J21X00593)           | Jan-22                |
| NetworkAnalyzer E5071C  | MY46110673 | 14-Jan-21 (CTTL, No.J21X00232)           | Jan-22                |

|                | Name        | Function           | Signature                                                                             |
|----------------|-------------|--------------------|---------------------------------------------------------------------------------------|
| Calibrated by: | Zhao Jing   | SAR Test Engineer  |  |
| Reviewed by:   | Lin Hao     | SAR Test Engineer  |  |
| Approved by:   | Qi Dianyuan | SAR Project Leader |  |

Issued: May 24, 2021

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**Glossary:**

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

**Calibration is Performed According to the Following Standards:**

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices- Part 1: Device used next to the ear (Frequency range of 300MHz to 6GHz)", July 2016
- IEC 62209-2, "Procedure to measure the Specific Absorption Rate (SAR) For wireless communication devices used in close proximity to the human body (frequency range of 30MHz to 6GHz)", March 2010
- KDB865664, SAR Measurement Requirements for 100 MHz to 6 GHz

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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



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### Measurement Conditions

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

|                                     |                          |             |
|-------------------------------------|--------------------------|-------------|
| <b>DASY Version</b>                 | DASY52                   | V52.10.4    |
| <b>Extrapolation</b>                | Advanced Extrapolation   |             |
| <b>Phantom</b>                      | Triple Flat Phantom 5.1C |             |
| <b>Distance Dipole Center - TSL</b> | 10 mm                    | with Spacer |
| <b>Zoom Scan Resolution</b>         | dx, dy, dz = 5 mm        |             |
| <b>Frequency</b>                    | 2450 MHz ± 1 MHz         |             |

### Head TSL parameters

The following parameters and calculations were applied.

|                                                | Temperature     | Permittivity | Conductivity     |
|------------------------------------------------|-----------------|--------------|------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C         | 39.2         | 1.80 mho/m       |
| <b>Measured Head TSL parameters</b>            | (22.0 ± 0.2) °C | 39.4 ± 6 %   | 1.79 mho/m ± 6 % |
| <b>Head TSL temperature change during test</b> | <1.0 °C         | ----         | ----             |

### SAR result with Head TSL

| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>   | Condition          |                                 |
|---------------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                                  | 250 mW input power | 12.9 W/kg                       |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>51.8 W/kg ± 18.8 % (k=2)</b> |
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | Condition          |                                 |
| SAR measured                                                  | 250 mW input power | 5.89 W/kg                       |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>23.6 W/kg ± 18.7 % (k=2)</b> |



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#### Appendix (Additional assessments outside the scope of CNAS L0570)

##### Antenna Parameters with Head TSL

|                                      |               |
|--------------------------------------|---------------|
| Impedance, transformed to feed point | 53.8Ω- 1.16jΩ |
| Return Loss                          | - 28.3dB      |

##### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.053 ns |
|----------------------------------|----------|

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

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

##### Additional EUT Data

|                 |       |
|-----------------|-------|
| Manufactured by | SPEAG |
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**DASY5 Validation Report for Head TSL**

Date: 05.19.2021

Test Laboratory: CTTL, Beijing, China

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 1014**

Communication System: UID 0, CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.788$  S/m;  $\epsilon_r = 39.43$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Center Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3846; ConvF(7.45, 7.45, 7.45) @ 2450 MHz; Calibrated: 2021-04-26
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn777; Calibrated: 2021-01-08
- Phantom: MFP\_V5.1C (20deg probe tilt); Type: QD 000 P51 Cx; Serial: 1062
- Measurement SW: DASY52, Version 52.10 (4); SEMCAD X Version 14.6.14 (7483)

**Dipole Calibration/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 105.6 V/m; Power Drift = -0.04 dB

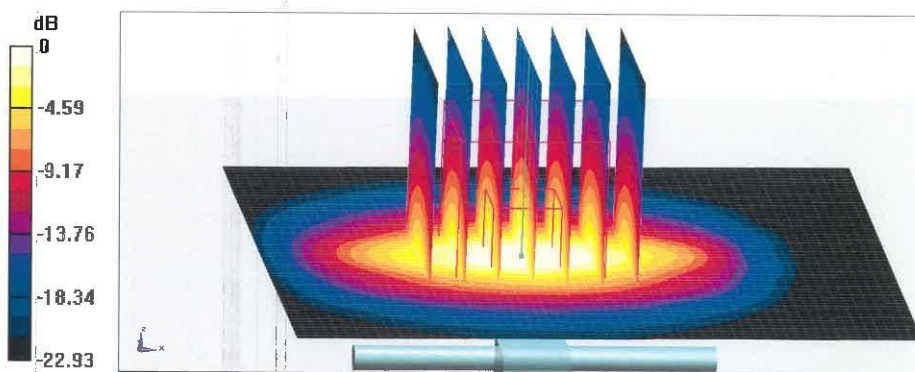
Peak SAR (extrapolated) = 27.5 W/kg

**SAR(1 g) = 12.9 W/kg; SAR(10 g) = 5.89 W/kg**

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

Ratio of SAR at M2 to SAR at M1 = 46.5%

Maximum value of SAR (measured) = 22.1 W/kg



0 dB = 22.1 W/kg = 13.44 dBW/kg

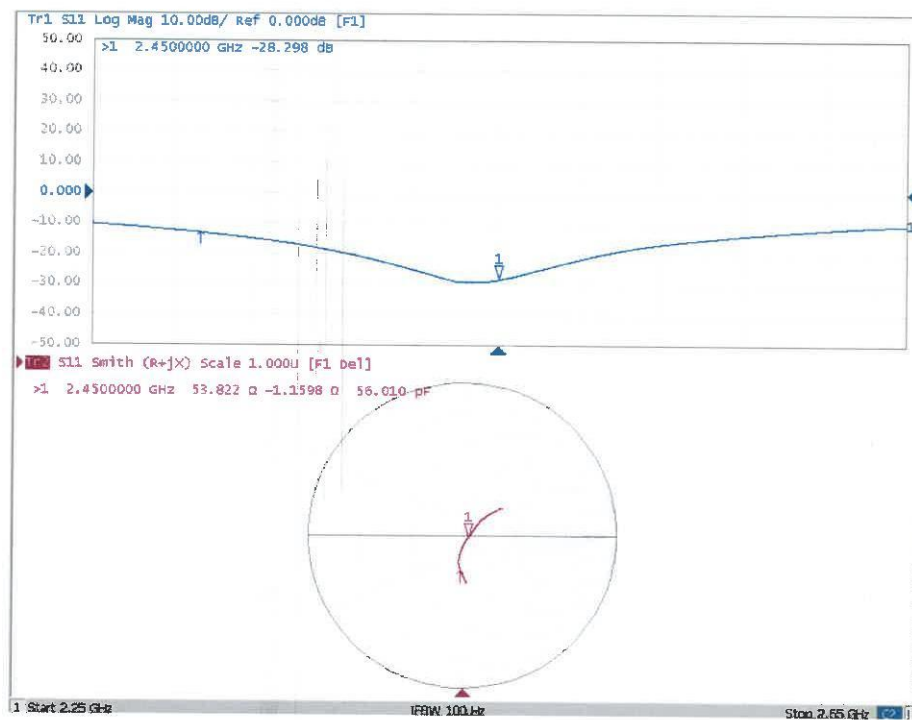


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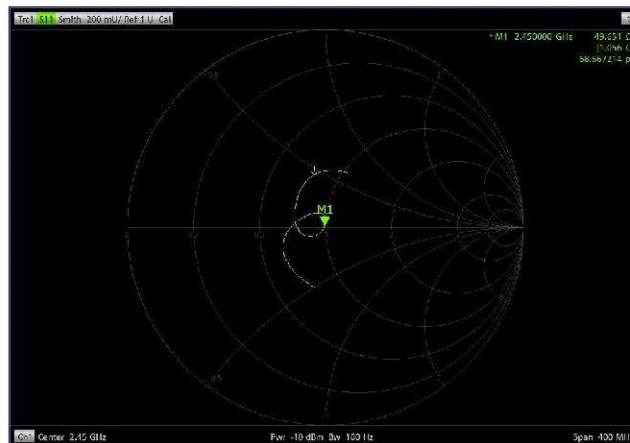
### Impedance Measurement Plot for Head TSL



Justification for Extended SAR Dipole Calibrations

| Dipole       | Date of Measurement | Return Loss (dB) | Delta (%) | Impedance (ohm) | Delta (ohm) |
|--------------|---------------------|------------------|-----------|-----------------|-------------|
| Head 2450MHz | May 19, 2021        | -28.3            | -2.71     | 53.8            | -4.17       |
|              | May 17, 2022        | -27.5            |           | 49.7            |             |

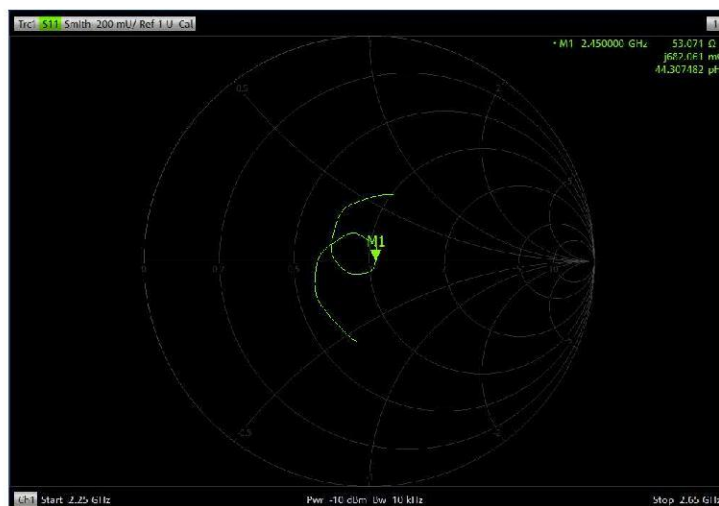
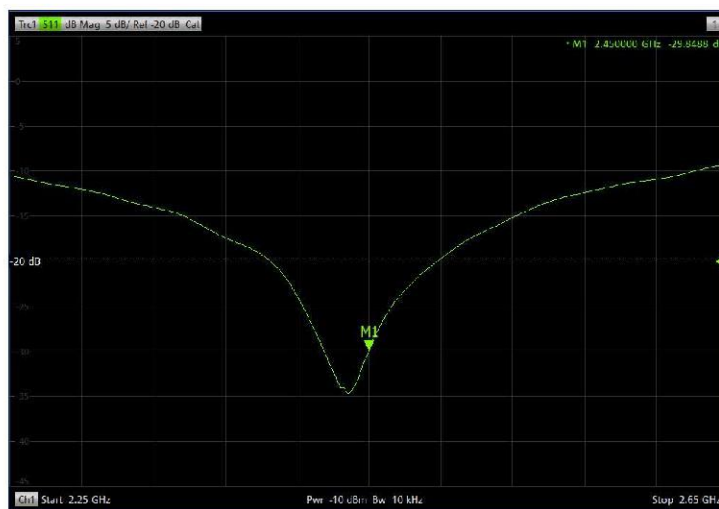
Note: The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification results meet the requirement of extended calibration.



Justification for Extended SAR Dipole Calibrations

| Dipole       | Date of Measurement | Return Loss (dB) | Delta (%) | Impedance (ohm) | Delta (ohm) |
|--------------|---------------------|------------------|-----------|-----------------|-------------|
| Head 2450MHz | May 19, 2021        | -28.3            | 5.66      | 53.8            | -0.72       |
|              | May 20, 2023        | -29.9            |           | 53.1            |             |

Note: The return loss is <-20dB, within 20% of prior calibration; the impedance is within 5 ohm of prior calibration. Therefore the verification results meet the requirement of extended calibration.



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Accreditation No.: **SCS 0108**

Client **TUV**  
**Shenzhen**

Certificate No. **EX-7506\_Jun23**

### CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7506**

Calibration procedure(s) **QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6,  
QA CAL-25.v8  
Calibration procedure for dosimetric E-field probes**

Calibration date **June 29, 2023**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.  
All calibrations have been conducted in the closed laboratory facility: environment temperature  $(22 \pm 3)^\circ\text{C}$  and humidity  $< 70\%$ .  
Calibration Equipment used (M&TE critical for calibration)

| Primary Standards          | ID               | Cal Date (Certificate No.)        | Scheduled Calibration |
|----------------------------|------------------|-----------------------------------|-----------------------|
| Power meter NRP2           | SN: 104778       | 30-Mar-23 (No. 217-03804/03805)   | Mar-24                |
| Power sensor NRP-Z91       | SN: 103244       | 30-Mar-23 (No. 217-03804)         | Mar-24                |
| OCP DAK-3.5 (weighted)     | SN: 1249         | 20-Oct-22 (OCP-DAK3.5-1249_Oct22) | Oct-23                |
| OCP DAK-12                 | SN: 1016         | 20-Oct-22 (OCP-DAK12-1016_Oct22)  | Oct-23                |
| Reference 20 dB Attenuator | SN: CC2552 (20x) | 30-Mar-23 (No. 217-03809)         | Mar-24                |
| DAE4                       | SN: 660          | 16-Mar-23 (No. DAE4-660_Mar23)    | Mar-24                |
| Reference Probe ES3DV2     | SN: 3013         | 06-Jan-23 (No. ES3-3013_Jan23)    | Jan-24                |

| Secondary Standards     | ID               | Check Date (in house)             | Scheduled Check        |
|-------------------------|------------------|-----------------------------------|------------------------|
| Power meter E4419B      | SN: GB41293874   | 06-Apr-16 (in house check Jun-22) | In house check: Jun-24 |
| Power sensor E4412A     | SN: MY41498087   | 06-Apr-16 (in house check Jun-22) | In house check: Jun-24 |
| Power sensor E4412A     | SN: 000110210    | 06-Apr-16 (in house check Jun-22) | In house check: Jun-24 |
| RF generator HP 8648C   | SN: US3642U01700 | 04-Aug-99 (in house check Jun-22) | In house check: Jun-24 |
| Network Analyzer E8358A | SN: US41080477   | 31-Mar-14 (in house check Oct-22) | In house check: Oct-24 |

|               |                |                       |                                                                                       |
|---------------|----------------|-----------------------|---------------------------------------------------------------------------------------|
|               | Name           | Function              | Signature                                                                             |
| Calibrated by | Jeton Kasirati | Laboratory Technician |  |
| Approved by   | Sven Kühn      | Technical Manager     |  |

Issued: July 05, 2023

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Accreditation No.: SCS 0108

**Glossary**

|                        |                                                                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| TSL                    | tissue simulating liquid                                                                                                                       |
| NORM <sub>x,y,z</sub>  | sensitivity in free space                                                                                                                      |
| ConvF                  | sensitivity in TSL / NORM <sub>x,y,z</sub>                                                                                                     |
| DCP                    | diode compression point                                                                                                                        |
| CF                     | crest factor (1/duty_cycle) of the RF signal                                                                                                   |
| A, B, C, D             | modulation dependent linearization parameters                                                                                                  |
| Polarization $\varphi$ | $\varphi$ rotation around probe axis                                                                                                           |
| Polarization $\theta$  | $\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis |
| Connector Angle        | information used in DASY system to align probe sensor X to the robot coordinate system                                                         |

**Calibration is Performed According to the Following Standards:**

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

**Methods Applied and Interpretation of Parameters:**

- NORM<sub>x,y,z</sub>: Assessed for E-field polarization  $\theta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below ConvF).
- NORM( $f$ )<sub>x,y,z</sub> = NORM<sub>x,y,z</sub> \* frequency\_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP<sub>x,y,z</sub>: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal. DCP does not depend on frequency nor media.
- PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A<sub>x,y,z</sub>; B<sub>x,y,z</sub>; C<sub>x,y,z</sub>; D<sub>x,y,z</sub>; VR<sub>x,y,z</sub>: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters: Assessed in flat phantom using E-field (or Temperature Transfer Standard for  $f \leq 800$  MHz) and inside waveguide using analytical field distributions based on power measurements for  $f > 800$  MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM<sub>x,y,z</sub> \* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from  $\pm 50$  MHz to  $\pm 100$  MHz.
- Spherical isotropy (3D deviation from isotropy): in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle: The angle is assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).

EX3DV4 - SN:7506

June 29, 2023

### Parameters of Probe: EX3DV4 - SN:7506

#### Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc ( $k = 2$ ) |
|---------------------------------------|----------|----------|----------|-----------------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 0.55     | 0.41     | 0.50     | $\pm 10.1\%$    |
| DCP (mV) <sup>B</sup>                 | 99.2     | 99.5     | 97.8     | $\pm 4.7\%$     |

#### Calibration Results for Modulation Response

| UID | Communication System Name |   | A<br>dB | B<br>dB $\sqrt{\mu V}$ | C    | D<br>dB | VR<br>mV | Max<br>dev. | Max<br>Unc <sup>E</sup><br>$k = 2$ |
|-----|---------------------------|---|---------|------------------------|------|---------|----------|-------------|------------------------------------|
| 0   | CW                        | X | 0.00    | 0.00                   | 1.00 | 0.00    | 140.5    | $\pm 3.0\%$ | $\pm 4.7\%$                        |
|     |                           | Y | 0.00    | 0.00                   | 1.00 |         | 145.2    |             |                                    |
|     |                           | Z | 0.00    | 0.00                   | 1.00 |         | 138.7    |             |                                    |

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%.

<sup>A</sup> The uncertainties of Norm X,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Page 5).

<sup>B</sup> Linearization parameter uncertainty for maximum specified field strength.

<sup>E</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

EX3DV4 - SN:7506

June 29, 2023

**Parameters of Probe: EX3DV4 - SN:7506**

**Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle                               | -118.9°    |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 9 mm       |
| Tip Diameter                                  | 2.5 mm     |
| Probe Tip to Sensor X Calibration Point       | 1 mm       |
| Probe Tip to Sensor Y Calibration Point       | 1 mm       |
| Probe Tip to Sensor Z Calibration Point       | 1 mm       |
| Recommended Measurement Distance from Surface | 1.4 mm     |

**Note:** Measurement distance from surface can be increased to 3–4 mm for an *Area Scan* job.

EX3DV4 - SN:7506

June 29, 2023

### Parameters of Probe: EX3DV4 - SN:7506

#### Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity <sup>F</sup> (S/m) | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unc (k = 2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 450                  | 43.5                               | 0.87                            | 11.25   | 11.25   | 11.25   | 0.16               | 1.30                    | ±13.3%      |
| 750                  | 41.9                               | 0.89                            | 10.54   | 10.54   | 10.54   | 0.31               | 1.12                    | ±12.0%      |
| 835                  | 41.5                               | 0.90                            | 10.35   | 10.35   | 10.35   | 0.38               | 0.94                    | ±12.0%      |
| 900                  | 41.5                               | 0.97                            | 10.06   | 10.06   | 10.06   | 0.47               | 0.80                    | ±12.0%      |
| 1450                 | 40.5                               | 1.20                            | 9.04    | 9.04    | 9.04    | 0.30               | 0.80                    | ±12.0%      |
| 1750                 | 40.1                               | 1.37                            | 8.99    | 8.99    | 8.99    | 0.34               | 0.86                    | ±12.0%      |
| 1900                 | 40.0                               | 1.40                            | 8.56    | 8.56    | 8.56    | 0.35               | 0.86                    | ±12.0%      |
| 2000                 | 40.0                               | 1.40                            | 8.31    | 8.31    | 8.31    | 0.38               | 0.86                    | ±12.0%      |
| 2300                 | 39.5                               | 1.67                            | 8.18    | 8.18    | 8.18    | 0.32               | 0.90                    | ±12.0%      |
| 2450                 | 39.2                               | 1.80                            | 7.98    | 7.98    | 7.98    | 0.30               | 0.90                    | ±12.0%      |
| 2600                 | 39.0                               | 1.96                            | 7.64    | 7.64    | 7.64    | 0.42               | 0.90                    | ±12.0%      |
| 3500                 | 37.9                               | 2.91                            | 6.82    | 6.82    | 6.82    | 0.35               | 1.30                    | ±14.0%      |
| 3700                 | 37.7                               | 3.12                            | 6.81    | 6.81    | 6.81    | 0.30               | 1.35                    | ±14.0%      |
| 5250                 | 35.9                               | 4.71                            | 5.48    | 5.48    | 5.48    | 0.40               | 1.80                    | ±14.0%      |
| 5600                 | 35.5                               | 5.07                            | 4.99    | 4.99    | 4.99    | 0.40               | 1.80                    | ±14.0%      |
| 5800                 | 35.3                               | 5.27                            | 4.95    | 4.95    | 4.95    | 0.40               | 1.80                    | ±14.0%      |

<sup>C</sup> Frequency validity above 300 MHz of ±100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ±50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ±10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

<sup>F</sup> The probes are calibrated using tissue simulating liquids (TSL) that deviate for  $\epsilon$  and  $\sigma$  by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10%. If TSL with deviations from the target of less than ±5% are used, the calibration uncertainties are 11.1% for 0.7 – 3 GHz and 13.1% for 3 – 6 GHz.

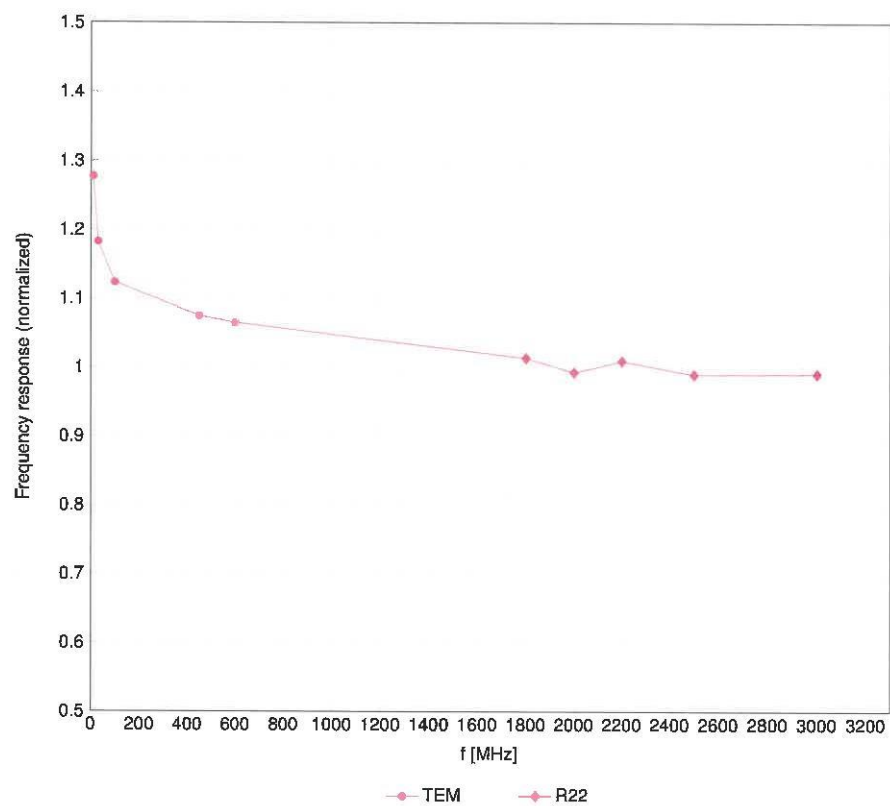
<sup>G</sup> Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the boundary.

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June 29, 2023

### Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide:R22)



Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )