

Client : **CTB**

Certificate No: **Z22-60280**

## CALIBRATION CERTIFICATE

Object **DAE4 - SN: 881**

Calibration Procedure(s) **FF-Z11-002-01**  
**Calibration Procedure for the Data Acquisition Electronics (DAEx)**

Calibration date: **July 27, 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(Calibrated by, Certificate No.) | Scheduled Calibration |
|------------------------|---------|------------------------------------------|-----------------------|
| Process Calibrator 753 | 1971018 | 14-Jun-22 (CTTL, No.J22X04180)           | Jun-23                |

|                | Name        | Function           |
|----------------|-------------|--------------------|
| Calibrated by: | Yu Zongying | SAR Test Engineer  |
| Reviewed by:   | Lin Hao     | SAR Test Engineer  |
| Approved by:   | Qi Dianyuan | SAR Project Leader |

Signature

*(Signatures)*

Issued: August 04, 2022

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### 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 report provide only calibration results for DAE, it does not contain other performance test results.



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## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 $\mu$ V, 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          | 404.698 $\pm$ 0.15% (k=2) | 404.711 $\pm$ 0.15% (k=2) | 404.964 $\pm$ 0.15% (k=2) |
| Low Range           | 4.00113 $\pm$ 0.7% (k=2)  | 4.00317 $\pm$ 0.7% (k=2)  | 3.97062 $\pm$ 0.7% (k=2)  |

## Connector Angle

|                                           |              |
|-------------------------------------------|--------------|
| Connector Angle to be used in DASY system | 5° $\pm$ 1 ° |
|-------------------------------------------|--------------|

Client **CTB**

Certificate No: **Z22-60281**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN : 3089**

Calibration Procedure(s) **FF-Z11-004-02**  
**Calibration Procedures for Dosimetric E-field Probes**

Calibration date: **August 01, 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( $22\pm 3$ )°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         | 101919      | 14-Jun-22(CTTL, No.J22X04181)            | Jun-23                |
| Power sensor NRP-Z91     | 101547      | 14-Jun-22(CTTL, No.J22X04181)            | Jun-23                |
| Power sensor NRP-Z91     | 101548      | 14-Jun-22(CTTL, No.J22X04181)            | Jun-23                |
| Reference 10dBAttenuator | 18N50W-10dB | 20-Jan-21(CTTL, No.J21X00486)            | Jan-23                |
| Reference 20dBAttenuator | 18N50W-20dB | 20-Jan-21(CTTL, No.J21X00485)            | Jan-23                |
| Reference Probe EX3DV4   | SN 3846     | 20-May-22(SPEAG, No.EX3-3846_May22)      | May-23                |
| DAE4                     | SN 771      | 20-Jan-22(SPEAG, No.DAE4-771_Jan22)      | Jan-23                |

| Secondary Standards     | ID #       | Cal Date(Calibrated by, Certificate No.) | Scheduled Calibration |
|-------------------------|------------|------------------------------------------|-----------------------|
| SignalGenerator MG3700A | 6201052605 | 14-Jun-22(CTTL, No.J22X04182)            | Jun-23                |
| Network Analyzer E5071C | MY46110673 | 14-Jan-22(CTTL, No.J22X00406)            | Jan-23                |

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

Issued: August 08, 2022

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## 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 $\Phi$   | $\Phi$ rotation around probe axis                                                                                                        |
| Polarization $\theta$ | $\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center)<br>$\theta=0$ 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:

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

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>:** Assessed for E-field polarization  $\theta=0$  ( $f \leq 900\text{MHz}$  in TEM-cell;  $f > 1800\text{MHz}$ : waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not effect the  $E^2$ -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 (no uncertainty required). 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>; VR<sub>x,y,z</sub>; A,B,C** 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  $f \leq 800\text{MHz}$ ) and inside waveguide using analytical field distributions based on power measurements for  $f > 800\text{MHz}$ . The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued 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  $\pm 50\text{MHz}$  to  $\pm 100\text{MHz}$ .
- 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).



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## DASY/EASY – Parameters of Probe: ES3DV3 – SN:3089

### Basic Calibration Parameters

|                                                   | Sensor X | Sensor Y | Sensor Z | Unc ( $k=2$ ) |
|---------------------------------------------------|----------|----------|----------|---------------|
| Norm( $\mu\text{V}/(\text{V/m})^2$ ) <sup>A</sup> | 1.19     | 1.29     | 1.22     | $\pm 10.0\%$  |
| DCP(mV) <sup>B</sup>                              | 102.0    | 104.5    | 103.3    |               |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A<br>dB | B<br>dB $\sqrt{\mu\text{V}}$ | C   | D<br>dB | VR<br>mV | Unc <sup>E</sup><br>( $k=2$ ) |
|-----|---------------------------|---|---------|------------------------------|-----|---------|----------|-------------------------------|
| 0   | CW                        | X | 0.0     | 0.0                          | 1.0 | 0.00    | 240.2    | $\pm 2.9\%$                   |
|     |                           | Y | 0.0     | 0.0                          | 1.0 |         | 259.8    |                               |
|     |                           | Z | 0.0     | 0.0                          | 1.0 |         | 248.8    |                               |

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 4).

<sup>B</sup> Numerical linearization parameter: uncertainty not required.

<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.

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## DASY/EASY – Parameters of Probe: ES3DV3 – SN:3089

### Calibration Parameter Determined in Head Tissue Simulating Media

| f [MHz] <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 41.9                               | 0.89                            | 6.52    | 6.52    | 6.52    | 0.40               | 1.30                    | ± 12.1%     |
| 835                  | 41.5                               | 0.90                            | 6.28    | 6.28    | 6.28    | 0.40               | 1.40                    | ± 12.1%     |
| 900                  | 41.5                               | 0.97                            | 6.20    | 6.20    | 6.20    | 0.40               | 1.40                    | ± 12.1%     |
| 1450                 | 40.5                               | 1.20                            | 5.65    | 5.65    | 5.65    | 0.65               | 1.20                    | ± 12.1%     |
| 1640                 | 40.3                               | 1.29                            | 5.52    | 5.52    | 5.52    | 0.65               | 1.20                    | ± 12.1%     |
| 1750                 | 40.1                               | 1.37                            | 5.35    | 5.35    | 5.35    | 0.70               | 1.15                    | ± 12.1%     |
| 1810                 | 40.0                               | 1.40                            | 5.15    | 5.15    | 5.15    | 0.76               | 1.13                    | ± 12.1%     |
| 1900                 | 40.0                               | 1.40                            | 5.07    | 5.07    | 5.07    | 0.65               | 1.25                    | ± 12.1%     |
| 2000                 | 40.0                               | 1.40                            | 5.11    | 5.11    | 5.11    | 0.70               | 1.15                    | ± 12.1%     |
| 2100                 | 39.8                               | 1.49                            | 5.03    | 5.03    | 5.03    | 0.70               | 1.27                    | ± 12.1%     |
| 2300                 | 39.5                               | 1.67                            | 4.87    | 4.87    | 4.87    | 0.60               | 1.30                    | ± 12.1%     |
| 2450                 | 39.2                               | 1.80                            | 4.70    | 4.70    | 4.70    | 0.80               | 1.05                    | ± 12.1%     |
| 2600                 | 39.0                               | 1.96                            | 4.57    | 4.57    | 4.57    | 0.83               | 1.08                    | ± 12.1%     |
| 3300                 | 38.2                               | 2.71                            | 4.50    | 4.50    | 4.50    | 0.60               | 1.20                    | ± 13.3%     |
| 3500                 | 37.9                               | 2.91                            | 4.39    | 4.39    | 4.39    | 0.60               | 1.25                    | ± 13.3%     |

<sup>C</sup> Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

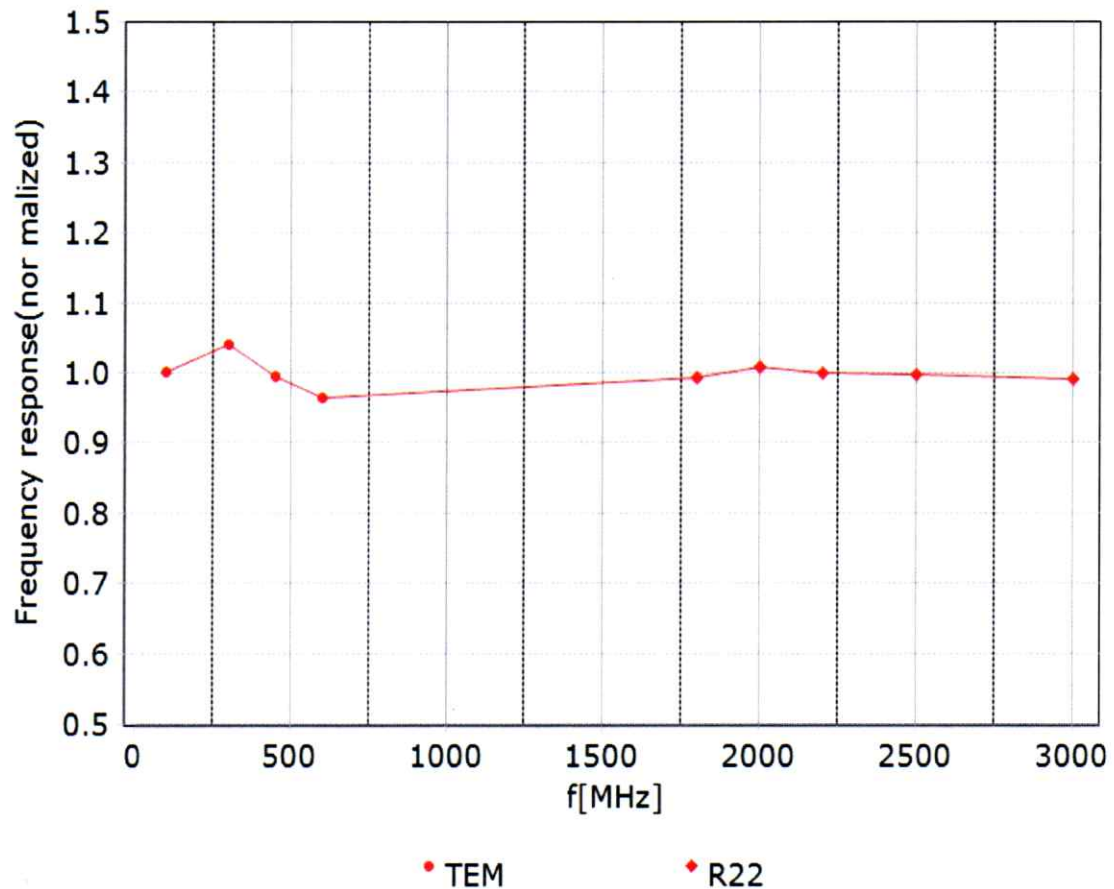
<sup>F</sup> At frequency below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

<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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.



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## Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)



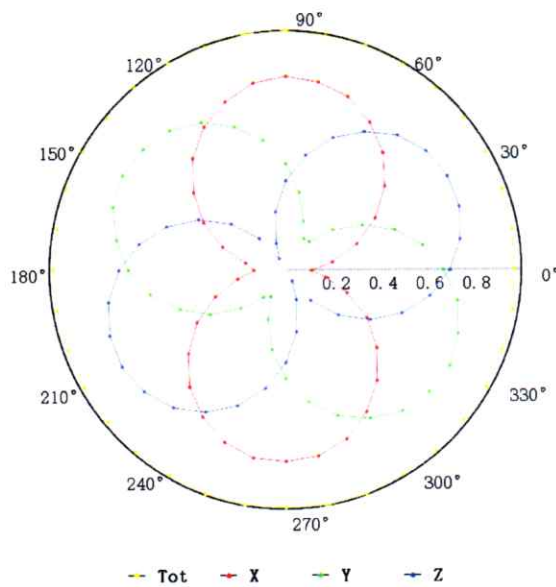
Uncertainty of Frequency Response of E-field:  $\pm 7.4\%$  ( $k=2$ )



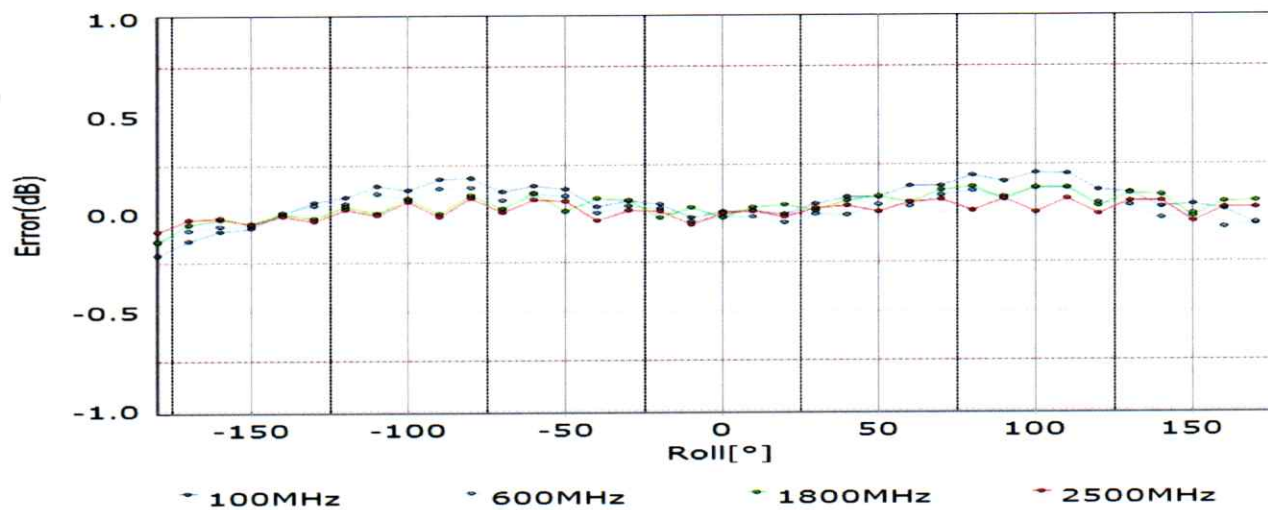
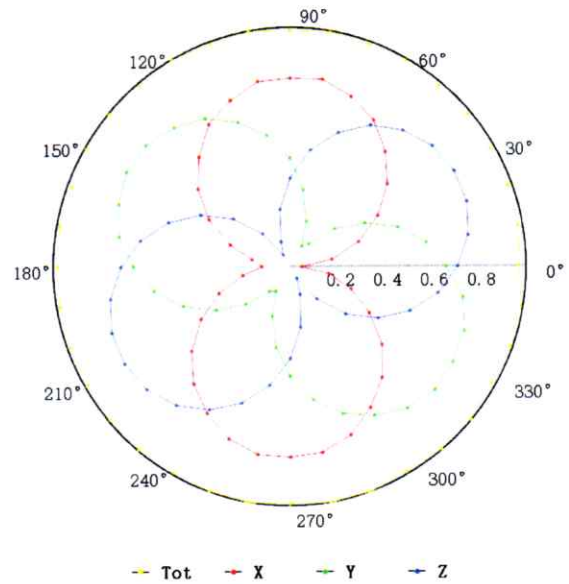
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## Receiving Pattern ( $\Phi$ ), $\theta=0^\circ$

**f=600 MHz, TEM**



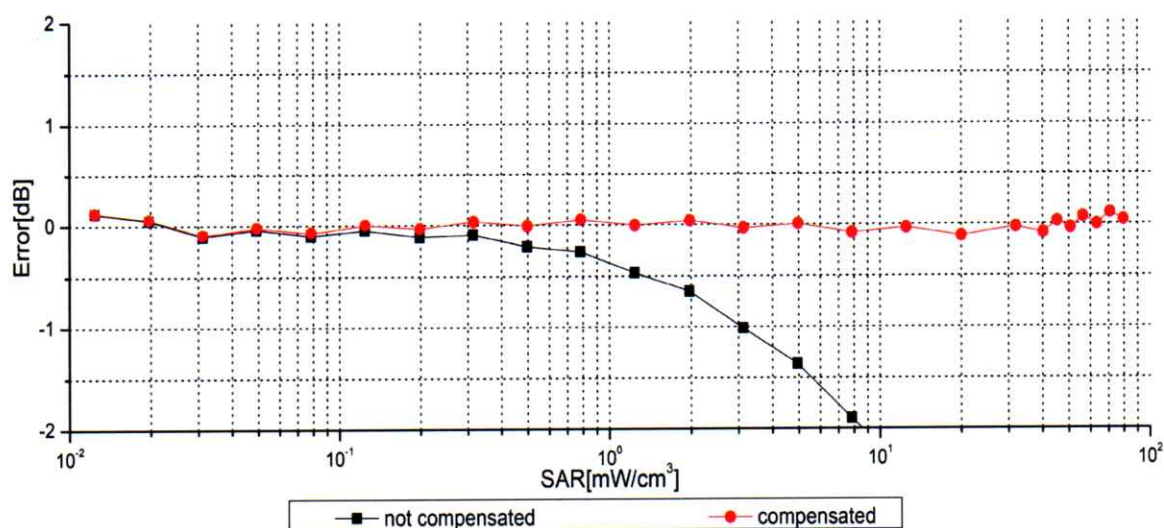
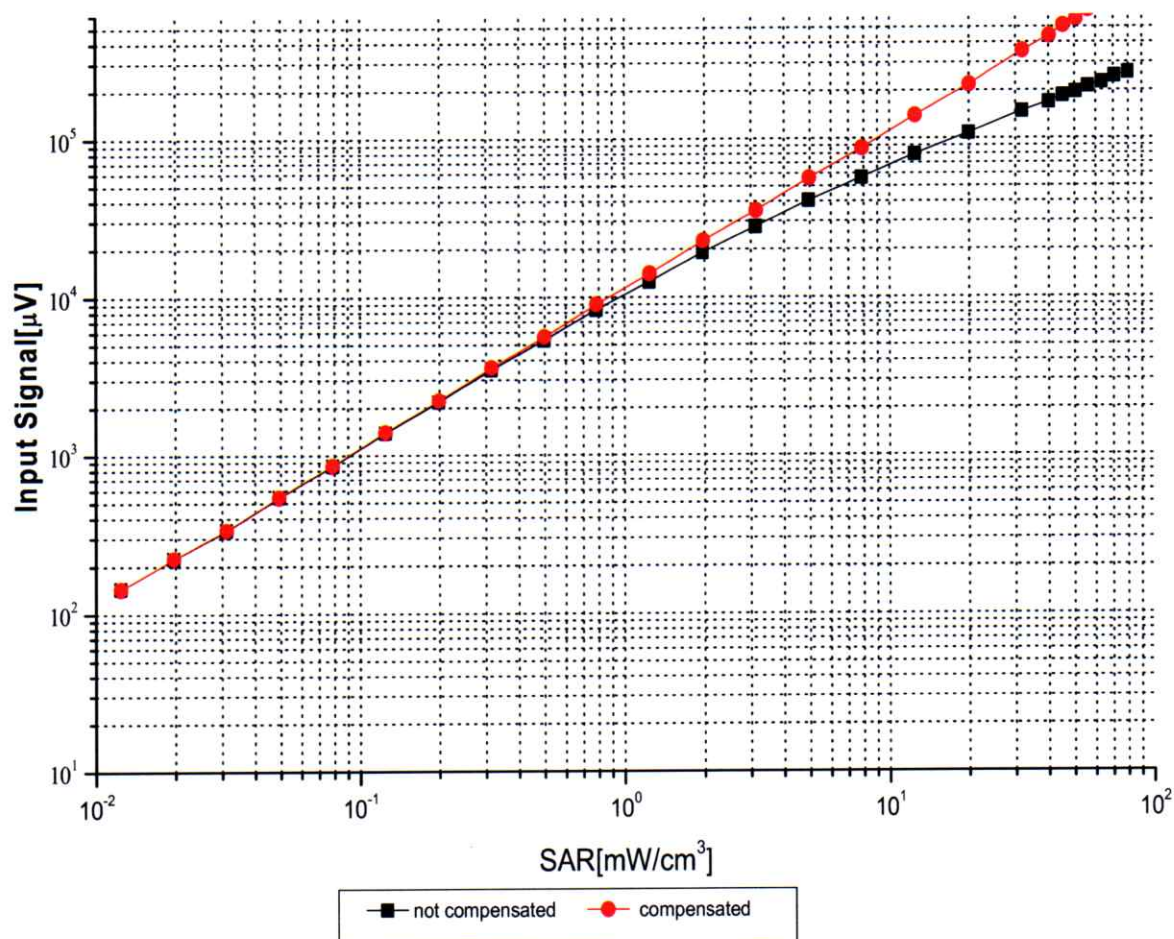
**f=1800 MHz, R22**



Uncertainty of Axial Isotropy Assessment:  $\pm 1.2\%$  ( $k=2$ )

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## Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f = 900 \text{ MHz}$ )



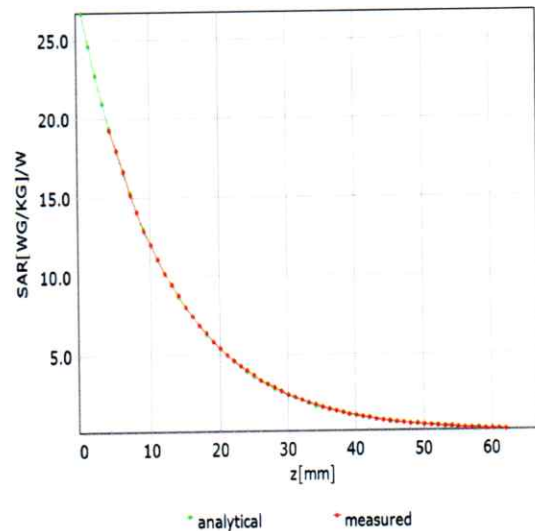
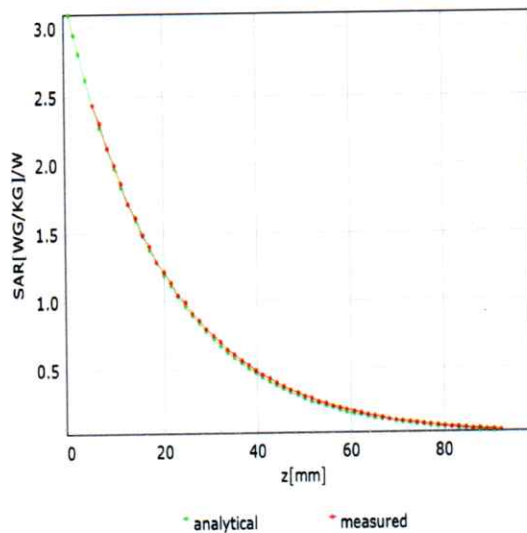
**Uncertainty of Linearity Assessment:  $\pm 0.9\%$  ( $k=2$ )**

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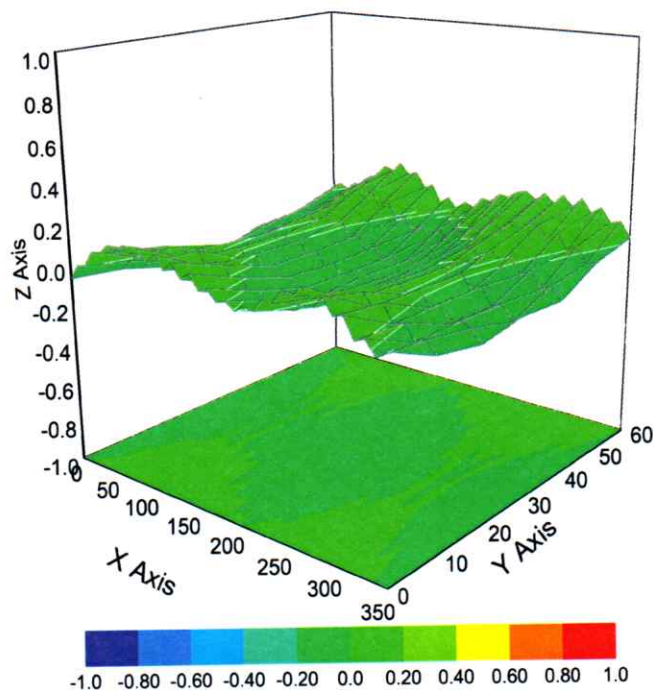
## Conversion Factor Assessment

**f=750 MHz,WGLS R9(H\_convF)**

**f=1750 MHz,WGLS R22(H\_convF)**



## Deviation from Isotropy in Liquid



**Uncertainty of Spherical Isotropy Assessment:  $\pm 3.2\%$  ( $k=2$ )**



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## DASY/EASY – Parameters of Probe: ES3DV3 – SN:3089

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 71.7       |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disable    |
| Probe Overall Length                          | 337mm      |
| Probe Body Diameter                           | 10mm       |
| Tip Length                                    | 10mm       |
| Tip Diameter                                  | 4mm        |
| Probe Tip to Sensor X Calibration Point       | 2mm        |
| Probe Tip to Sensor Y Calibration Point       | 2mm        |
| Probe Tip to Sensor Z Calibration Point       | 2mm        |
| Recommended Measurement Distance from Surface | 3mm        |



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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Multilateral Agreement for the recognition of calibration certificates

Client **CTB**

Certificate No: **D750V3-1088**

## CALIBRATION CERTIFICATE

Object **D750V3 - SN:1088**

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

Calibration date: **September 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 ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards           | ID #               | Cal Date (Certificate No.)      | Scheduled Calibration |
|-----------------------------|--------------------|---------------------------------|-----------------------|
| Power meter NRP             | SN: 104778         | 01-Apr-22 (No. 217-03100/03101) | Apr-23                |
| Power sensor NRP-Z91        | SN: 103244         | 01-Apr-22 (No. 217-03100)       | Apr-23                |
| Power sensor NRP-Z91        | SN: 103245         | 01-Apr-22(No. 217-03101)        | Apr-23                |
| Reference 20 dB Attenuator  | SN: BH9394 (20k)   | 31-Mar-22 (No. 217-03106)       | Apr-23                |
| Type-N mismatch combination | SN: 310982 / 06327 | 31-Mar-22 (No. 217-03104)       | Apr-23                |
| Reference Probe EX3DV4      | SN: 7349           | 31-Dec-21 (No. EX3-7349_Dec19)  | Dec-22                |
| DAE4                        | SN: 601            | 27-Dec-21(No. DAE4-601_Dec19)   | Dec-22                |

| Secondary Standards             | ID #           | Check Date (in house)             | Scheduled Check        |
|---------------------------------|----------------|-----------------------------------|------------------------|
| Power meter E4419B              | SN: GB39512475 | 30-Oct-16 (in house check Feb-21) | In house check: Oct-22 |
| Power sensor HP 8481A           | SN: US37292783 | 07-Oct-17 (in house check Oct-20) | In house check: Oct-22 |
| Power sensor HP 8481A           | SN: MY41092317 | 07-Oct-17 (in house check Oct-20) | In house check: Oct-22 |
| RF generator R&S SMT-06         | SN: 100972     | 15-Jun-17 (in house check Oct-20) | In house check: Oct-22 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-15 (in house check Oct-20) | In house check: Oct-22 |

Calibrated by: **Jeffrey Katzman** **Laboratory Technician**

Signature

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

Issued: September 27, 2022

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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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### Glossary:

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

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

- IEC/IEEE 62209-1528, "Measurement Procedure for The Assessment of Specific Absorption Rate of Human Exposure to Radio Frequency Fields from Hand-held and Body-mounted Wireless Communication Devices- Part 1528: Human Models, Instrumentation and Procedures (Frequency range of 4 MHz to 10 GHz)", October 2020*
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"*

### Additional Documentation:

- 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%.