

## APPENDIX C: PROBE CALIBRATION



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **ES3-3022\_Aug15**

## CALIBRATION CERTIFICATE

Object **ES3DV2 - SN:3022**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6**  
**Calibration procedure for dosimetric E-field probes**

Calibration date: **August 26, 2015**

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)

*BN ✓  
9/3/2015*

| Primary Standards          | ID              | Cal Date (Certificate No.)        | Scheduled Calibration  |
|----------------------------|-----------------|-----------------------------------|------------------------|
| Power meter E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

|                |                              |                                          |                              |
|----------------|------------------------------|------------------------------------------|------------------------------|
| Calibrated by: | Name<br><b>Michael Weber</b> | Function<br><b>Laboratory Technician</b> | Signature<br><i>M. Weber</i> |
| Approved by:   | <b>Katja Pokovic</b>         | <b>Technical Manager</b>                 | <i>[Signature]</i>           |

Issued: August 27, 2015

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



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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 $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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  $\vartheta = 0$  ( $f \leq 900$  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 (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>; 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).

# Probe ES3DV2

## SN:3022

Manufactured: April 15, 2003  
Calibrated: August 26, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

## Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 1.00     | 1.03     | 0.95     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 99.9     | 99.7     | 100.9    |               |

## 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    | 179.6    | $\pm 3.3 \%$              |
|           |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 183.9    |                           |
|           |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 179.0    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)          | X | 3.60    | 65.9                         | 14.2 | 10.00   | 43.5     | $\pm 2.2 \%$              |
|           |                                               | Y | 2.84    | 63.5                         | 13.0 |         | 43.3     |                           |
|           |                                               | Z | 2.76    | 63.7                         | 12.7 |         | 41.7     |                           |
| 10011-CAB | UMTS-FDD (WCDMA)                              | X | 3.32    | 67.0                         | 18.7 | 2.91    | 144.4    | $\pm 0.7 \%$              |
|           |                                               | Y | 3.24    | 66.3                         | 18.0 |         | 147.3    |                           |
|           |                                               | Z | 3.19    | 66.3                         | 18.0 |         | 143.5    |                           |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.15    | 69.9                         | 19.5 | 1.87    | 146.1    | $\pm 0.7 \%$              |
|           |                                               | Y | 2.88    | 67.7                         | 18.0 |         | 147.9    |                           |
|           |                                               | Z | 2.78    | 67.4                         | 17.8 |         | 145.6    |                           |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.40   | 71.3                         | 23.8 | 9.46    | 144.9    | $\pm 3.3 \%$              |
|           |                                               | Y | 11.15   | 70.5                         | 23.1 |         | 146.9    |                           |
|           |                                               | Z | 10.95   | 70.5                         | 23.3 |         | 140.3    |                           |
| 10021-DAB | GSM-FDD (TDMA, GMSK)                          | X | 20.66   | 99.8                         | 29.2 | 9.39    | 132.6    | $\pm 2.2 \%$              |
|           |                                               | Y | 14.36   | 93.3                         | 26.6 |         | 145.3    |                           |
|           |                                               | Z | 17.17   | 97.2                         | 27.8 |         | 145.4    |                           |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 17.22   | 96.5                         | 28.2 | 9.57    | 125.4    | $\pm 1.9 \%$              |
|           |                                               | Y | 11.06   | 88.6                         | 25.0 |         | 136.0    |                           |
|           |                                               | Z | 8.71    | 84.6                         | 23.4 |         | 130.7    |                           |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 31.05   | 99.5                         | 25.9 | 6.56    | 135.2    | $\pm 2.2 \%$              |
|           |                                               | Y | 25.28   | 97.4                         | 25.0 |         | 132.5    |                           |
|           |                                               | Z | 21.58   | 95.7                         | 24.5 |         | 144.4    |                           |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 42.88   | 99.9                         | 24.0 | 4.80    | 129.5    | $\pm 1.9 \%$              |
|           |                                               | Y | 40.80   | 99.6                         | 23.7 |         | 124.9    |                           |
|           |                                               | Z | 38.42   | 99.7                         | 23.7 |         | 137.8    |                           |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 44.48   | 100.0                        | 23.2 | 3.55    | 138.2    | $\pm 1.9 \%$              |
|           |                                               | Y | 44.03   | 99.7                         | 22.8 |         | 133.0    |                           |
|           |                                               | Z | 41.36   | 99.8                         | 22.8 |         | 147.5    |                           |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 16.08   | 99.5                         | 23.3 | 1.16    | 127.5    | $\pm 1.4 \%$              |
|           |                                               | Y | 79.69   | 99.6                         | 19.3 |         | 146.2    |                           |
|           |                                               | Z | 45.81   | 99.9                         | 20.4 |         | 138.2    |                           |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.43    | 67.4                         | 19.8 | 5.67    | 138.7    | $\pm 1.4 \%$              |
|           |                                               | Y | 6.27    | 66.8                         | 19.2 |         | 134.9    |                           |
|           |                                               | Z | 6.16    | 66.6                         | 19.2 |         | 127.6    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.13 | 75.0 | 25.9 | 9.29 | 129.4 | ±3.3 % |
|           |                                          | Y | 9.46  | 73.0 | 24.5 |      | 131.8 |        |
|           |                                          | Z | 9.52  | 74.0 | 25.4 |      | 137.0 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.27  | 66.9 | 19.7 | 5.80 | 137.0 | ±1.7 % |
|           |                                          | Y | 6.24  | 66.7 | 19.3 |      | 140.0 |        |
|           |                                          | Z | 6.06  | 66.3 | 19.2 |      | 127.1 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.16 | 68.7 | 21.3 | 8.07 | 127.7 | ±2.2 % |
|           |                                          | Y | 9.99  | 68.2 | 20.9 |      | 131.5 |        |
|           |                                          | Z | 10.22 | 69.1 | 21.4 |      | 141.6 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 9.34  | 73.4 | 25.2 | 9.28 | 125.0 | ±3.3 % |
|           |                                          | Y | 8.92  | 72.2 | 24.3 |      | 127.2 |        |
|           |                                          | Z | 8.95  | 73.1 | 25.1 |      | 131.9 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 5.95  | 66.4 | 19.4 | 5.75 | 134.4 | ±1.4 % |
|           |                                          | Y | 5.92  | 66.2 | 19.1 |      | 137.0 |        |
|           |                                          | Z | 5.98  | 66.7 | 19.5 |      | 146.8 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.39  | 66.9 | 19.6 | 5.82 | 139.9 | ±1.7 % |
|           |                                          | Y | 6.35  | 66.7 | 19.3 |      | 141.9 |        |
|           |                                          | Z | 6.15  | 66.2 | 19.2 |      | 128.4 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 4.96  | 66.6 | 19.8 | 5.73 | 137.3 | ±1.4 % |
|           |                                          | Y | 4.85  | 66.1 | 19.3 |      | 139.8 |        |
|           |                                          | Z | 4.85  | 66.6 | 19.7 |      | 146.7 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 8.75  | 78.7 | 28.3 | 9.21 | 138.9 | ±3.0 % |
|           |                                          | Y | 7.69  | 75.1 | 26.1 |      | 140.1 |        |
|           |                                          | Z | 7.80  | 76.6 | 27.2 |      | 144.0 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 4.88  | 66.2 | 19.6 | 5.72 | 132.0 | ±1.4 % |
|           |                                          | Y | 4.77  | 65.8 | 19.1 |      | 132.6 |        |
|           |                                          | Z | 4.83  | 66.5 | 19.6 |      | 146.0 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.91  | 66.3 | 19.7 | 5.72 | 131.7 | ±1.4 % |
|           |                                          | Y | 4.82  | 66.0 | 19.2 |      | 138.4 |        |
|           |                                          | Z | 4.86  | 66.7 | 19.7 |      | 145.7 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 10.04 | 69.1 | 21.7 | 8.10 | 140.9 | ±2.2 % |
|           |                                          | Y | 9.62  | 67.9 | 20.8 |      | 125.2 |        |
|           |                                          | Z | 9.74  | 68.6 | 21.3 |      | 133.3 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 7.01  | 67.1 | 19.6 | 5.97 | 143.7 | ±1.4 % |
|           |                                          | Y | 6.78  | 66.2 | 19.0 |      | 129.3 |        |
|           |                                          | Z | 6.80  | 66.7 | 19.3 |      | 136.5 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 8.55  | 78.0 | 27.9 | 9.21 | 134.6 | ±3.0 % |
|           |                                          | Y | 7.79  | 75.6 | 26.3 |      | 141.6 |        |
|           |                                          | Z | 7.89  | 76.9 | 27.4 |      | 145.2 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 9.30  | 74.8 | 26.1 | 9.24 | 134.8 | ±3.3 % |
|           |                                          | Y | 8.65  | 72.5 | 24.5 |      | 136.4 |        |
|           |                                          | Z | 8.33  | 72.3 | 24.8 |      | 126.6 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 10.20 | 76.2 | 26.8 | 9.30 | 144.8 | ±3.3 % |
|           |                                          | Y | 9.41  | 73.7 | 25.1 |      | 145.9 |        |
|           |                                          | Z | 9.18  | 73.9 | 25.6 |      | 138.6 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.45  | 66.7 | 18.9 | 3.96 | 147.0 | ±0.9 % |
|           |                                                               | Y | 4.21  | 65.5 | 17.9 |      | 126.5 |        |
|           |                                                               | Z | 4.36  | 66.5 | 18.5 |      | 148.0 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.57  | 66.3 | 18.5 | 3.46 | 134.3 | ±0.7 % |
|           |                                                               | Y | 3.48  | 65.6 | 17.8 |      | 136.8 |        |
|           |                                                               | Z | 3.51  | 66.2 | 18.3 |      | 136.4 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.53  | 66.4 | 18.6 | 3.39 | 135.8 | ±0.7 % |
|           |                                                               | Y | 3.45  | 65.8 | 17.9 |      | 140.4 |        |
|           |                                                               | Z | 3.50  | 66.5 | 18.5 |      | 137.0 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.18  | 66.5 | 19.5 | 5.81 | 129.4 | ±1.4 % |
|           |                                                               | Y | 6.15  | 66.3 | 19.1 |      | 133.6 |        |
|           |                                                               | Z | 6.13  | 66.5 | 19.3 |      | 131.2 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.77  | 67.2 | 19.9 | 6.06 | 134.8 | ±1.7 % |
|           |                                                               | Y | 6.81  | 67.3 | 19.7 |      | 144.8 |        |
|           |                                                               | Z | 6.68  | 67.1 | 19.7 |      | 136.7 |        |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 10.30 | 69.4 | 22.0 | 8.37 | 142.0 | ±2.5 % |
|           |                                                               | Y | 9.90  | 68.2 | 21.1 |      | 126.8 |        |
|           |                                                               | Z | 10.15 | 69.3 | 21.9 |      | 142.6 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.72  | 68.1 | 18.9 | 3.76 | 147.8 | ±0.7 % |
|           |                                                               | Y | 4.56  | 67.5 | 18.2 |      | 133.6 |        |
|           |                                                               | Z | 4.61  | 68.2 | 18.7 |      | 147.4 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.57  | 67.8 | 18.8 | 3.77 | 144.3 | ±0.7 % |
|           |                                                               | Y | 4.43  | 67.3 | 18.1 |      | 131.3 |        |
|           |                                                               | Z | 4.57  | 68.3 | 18.8 |      | 145.0 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.64  | 67.9 | 18.7 | 1.54 | 142.1 | ±0.5 % |
|           |                                                               | Y | 2.36  | 65.4 | 16.8 |      | 130.3 |        |
|           |                                                               | Z | 2.50  | 66.7 | 17.7 |      | 145.0 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.04 | 69.0 | 21.7 | 8.23 | 138.8 | ±2.2 % |
|           |                                                               | Y | 9.71  | 68.0 | 20.9 |      | 125.6 |        |
|           |                                                               | Z | 9.94  | 69.0 | 21.6 |      | 140.4 |        |

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 Pages 7 and 8).

<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.

## DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

### 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) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750                  | 41.9                               | 0.89                            | 6.33    | 6.33    | 6.33    | 0.46               | 1.43                    | ± 12.0 %  |
| 835                  | 41.5                               | 0.90                            | 6.11    | 6.11    | 6.11    | 0.24               | 2.08                    | ± 12.0 %  |
| 1750                 | 40.1                               | 1.37                            | 5.08    | 5.08    | 5.08    | 0.45               | 1.47                    | ± 12.0 %  |
| 1900                 | 40.0                               | 1.40                            | 4.93    | 4.93    | 4.93    | 0.59               | 1.25                    | ± 12.0 %  |
| 2300                 | 39.5                               | 1.67                            | 4.63    | 4.63    | 4.63    | 0.55               | 1.39                    | ± 12.0 %  |
| 2450                 | 39.2                               | 1.80                            | 4.30    | 4.30    | 4.30    | 0.51               | 1.47                    | ± 12.0 %  |
| 2600                 | 39.0                               | 1.96                            | 4.12    | 4.12    | 4.12    | 0.57               | 1.46                    | ± 12.0 %  |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

### Calibration Parameter Determined in Body 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) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750                  | 55.5                               | 0.96                            | 6.16    | 6.16    | 6.16    | 0.50               | 1.34                    | ± 12.0 %  |
| 835                  | 55.2                               | 0.97                            | 6.13    | 6.13    | 6.13    | 0.25               | 2.16                    | ± 12.0 %  |
| 1750                 | 53.4                               | 1.49                            | 4.79    | 4.79    | 4.79    | 0.61               | 1.33                    | ± 12.0 %  |
| 1900                 | 53.3                               | 1.52                            | 4.56    | 4.56    | 4.56    | 0.31               | 2.02                    | ± 12.0 %  |
| 2300                 | 52.9                               | 1.81                            | 4.32    | 4.32    | 4.32    | 0.79               | 1.19                    | ± 12.0 %  |
| 2450                 | 52.7                               | 1.95                            | 4.08    | 4.08    | 4.08    | 0.80               | 1.12                    | ± 12.0 %  |
| 2600                 | 52.5                               | 2.16                            | 3.96    | 3.96    | 3.96    | 0.80               | 1.10                    | ± 12.0 %  |

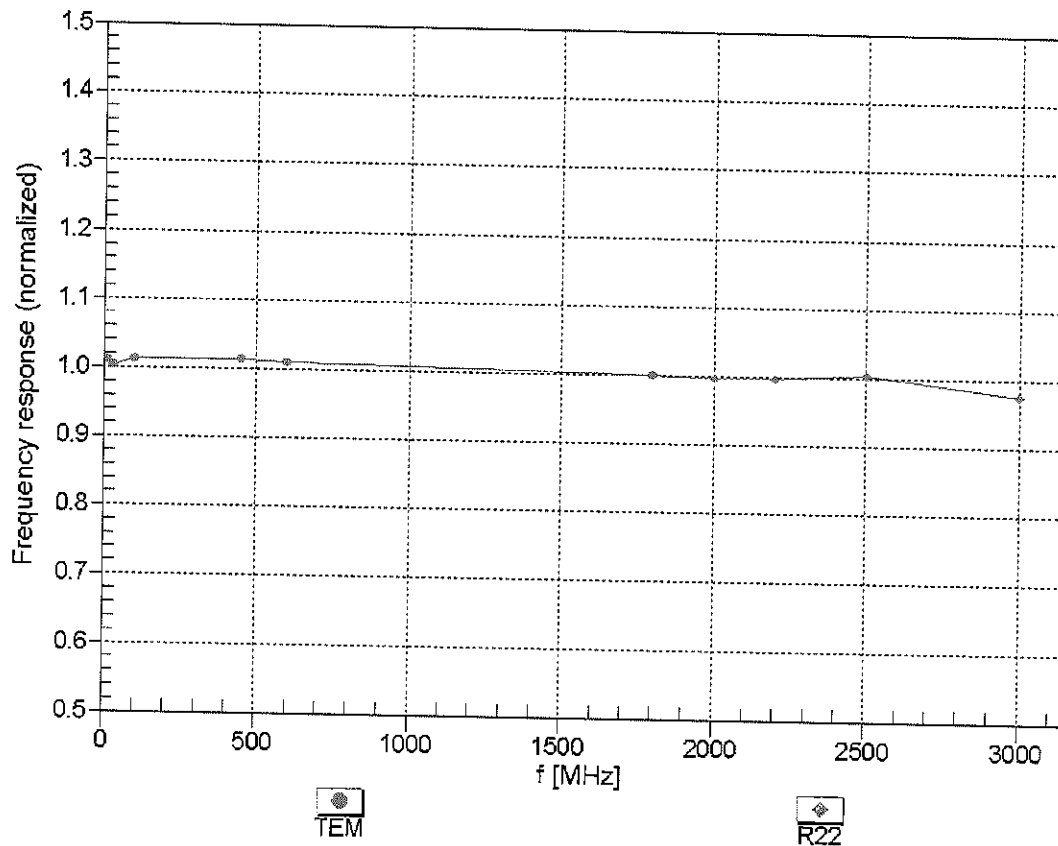
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

## Frequency Response of E-Field

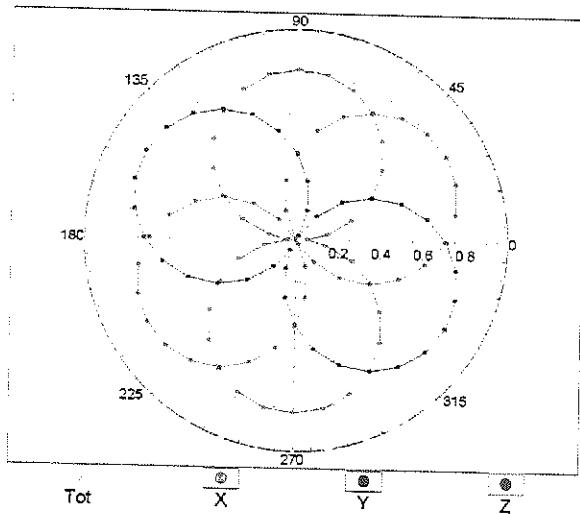
(TEM-Cell: ifi110 EXX, Waveguide: R22)



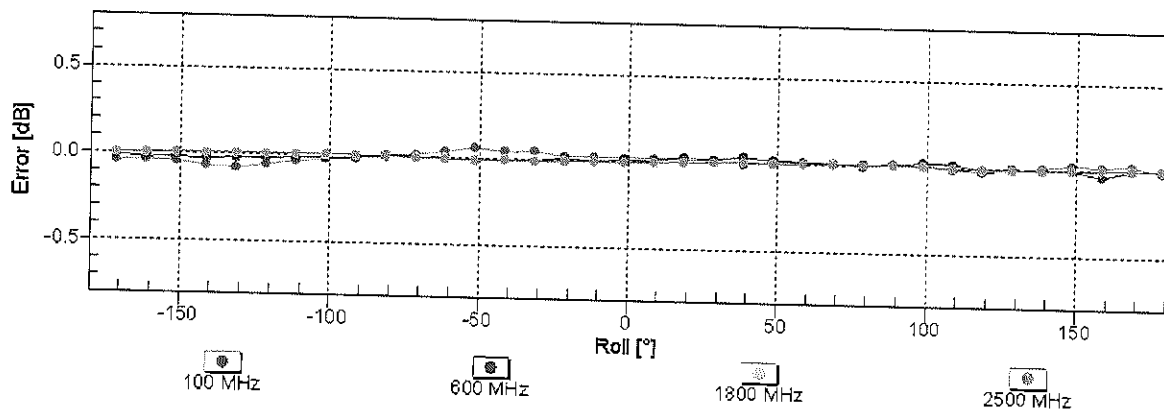
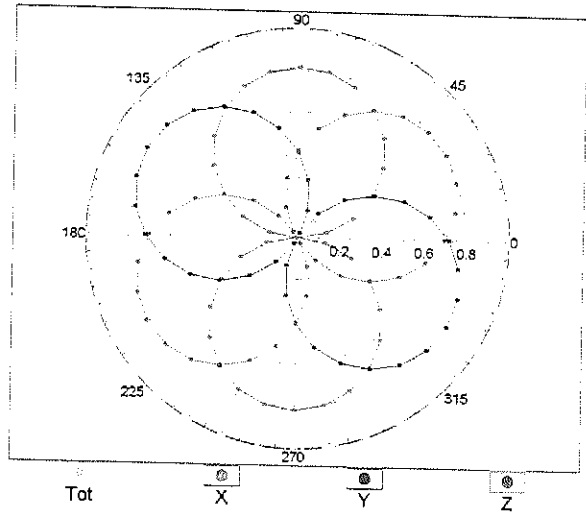
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz, TEM

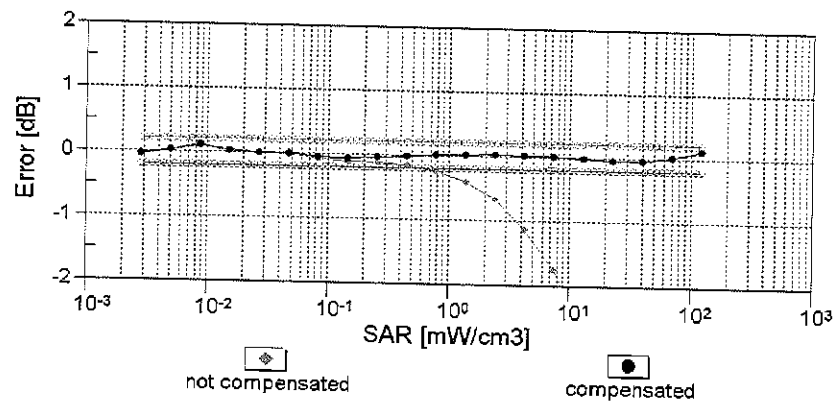
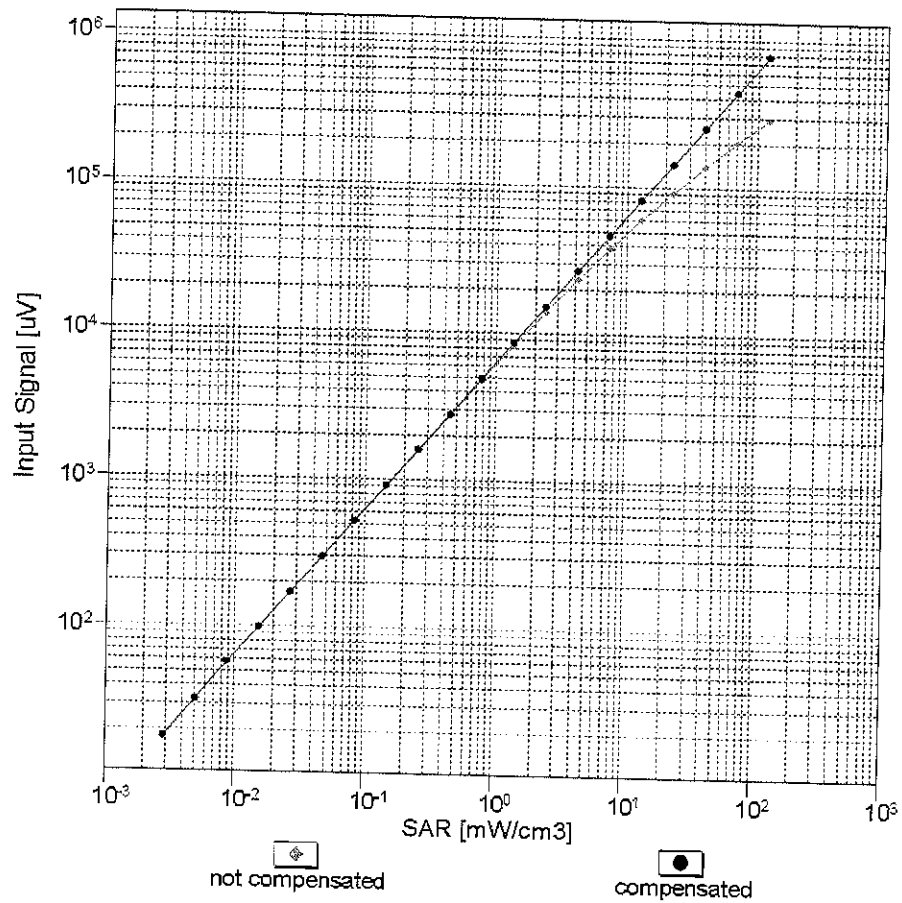


f=1800 MHz, R22



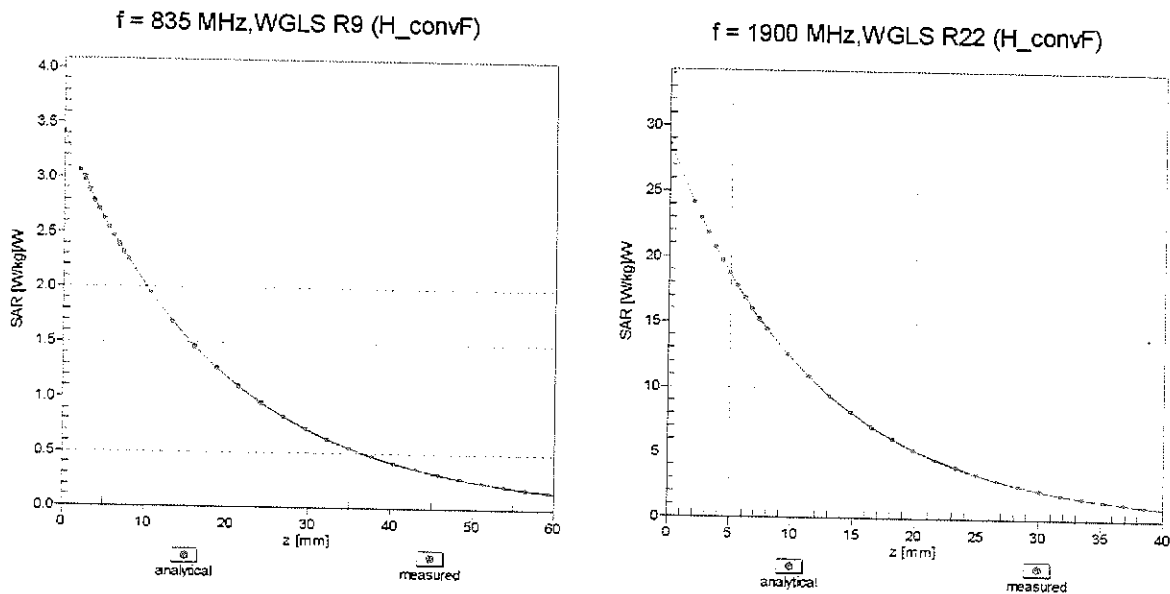
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

# Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )



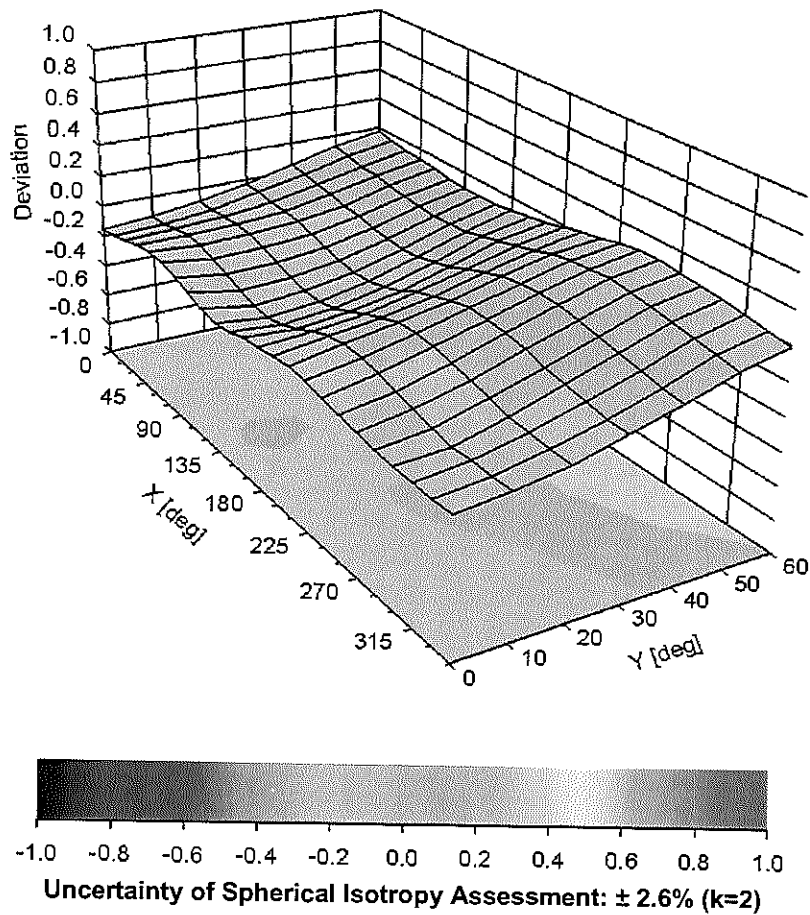
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

# Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ), f = 900 MHz



## DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 98.5       |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 10 mm      |
| Tip Diameter                                  | 4 mm       |
| Probe Tip to Sensor X Calibration Point       | 2 mm       |
| Probe Tip to Sensor Y Calibration Point       | 2 mm       |
| Probe Tip to Sensor Z Calibration Point       | 2 mm       |
| Recommended Measurement Distance from Surface | 3 mm       |



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 **PC Test**

Certificate No: **ES3-3319\_Mar15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3319**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6**  
**Calibration procedure for dosimetric E-field probes**

Calibration date: **March 19, 2015**

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 E4419B         | GB41293874      | 03-Apr-14 (No. 217-01911)         | Apr-15                 |
| Power sensor E4412A        | MY41498087      | 03-Apr-14 (No. 217-01911)         | Apr-15                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 03-Apr-14 (No. 217-01915)         | Apr-15                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 03-Apr-14 (No. 217-01919)         | Apr-15                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 03-Apr-14 (No. 217-01920)         | Apr-15                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

|                                                                                                                 |                              |                                          |                        |
|-----------------------------------------------------------------------------------------------------------------|------------------------------|------------------------------------------|------------------------|
| Calibrated by:                                                                                                  | Name<br><b>Israe Elnaouq</b> | Function<br><b>Laboratory Technician</b> | Signature<br>          |
| Approved by:                                                                                                    | <b>Katja Pokovic</b>         | <b>Technical Manager</b>                 |                        |
|                                                                                                                 |                              |                                          | Issued: March 19, 2015 |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                              |                                          |                        |



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

### 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 $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  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 (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>; 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).

# Probe ES3DV3

## SN:3319

Manufactured: January 10, 2012  
Calibrated: March 19, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319

## Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---------------------------------------|----------|----------|----------|-----------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 1.12     | 1.08     | 1.15     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                 | 104.4    | 106.0    | 104.4    |           |

## Modulation Calibration Parameters

| UID       | Communication System Name                     |   | A<br>dB | B<br>dB $\sqrt{\mu V}$ | 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    | 176.1    | ±3.3 %                    |
|           |                                               | Y | 0.0     | 0.0                    | 1.0  |         | 192.7    |                           |
|           |                                               | Z | 0.0     | 0.0                    | 1.0  |         | 174.6    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)          | X | 3.26    | 64.8                   | 13.4 | 10.00   | 41.7     | ±1.9 %                    |
|           |                                               | Y | 2.66    | 62.2                   | 11.7 |         | 39.5     |                           |
|           |                                               | Z | 3.51    | 64.8                   | 13.2 |         | 42.1     |                           |
| 10011-CAB | UMTS-FDD (WCDMA)                              | X | 3.47    | 68.1                   | 19.1 | 2.91    | 142.9    | ±0.5 %                    |
|           |                                               | Y | 3.37    | 67.9                   | 19.1 |         | 133.0    |                           |
|           |                                               | Z | 3.57    | 68.7                   | 19.4 |         | 138.6    |                           |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.48    | 71.8                   | 20.2 | 1.87    | 143.9    | ±0.7 %                    |
|           |                                               | Y | 3.23    | 70.9                   | 19.9 |         | 134.6    |                           |
|           |                                               | Z | 3.68    | 72.8                   | 20.6 |         | 140.5    |                           |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.18   | 70.5                   | 23.1 | 9.46    | 143.4    | ±3.3 %                    |
|           |                                               | Y | 10.98   | 70.5                   | 23.2 |         | 129.9    |                           |
|           |                                               | Z | 11.19   | 70.6                   | 23.1 |         | 138.8    |                           |
| 10021-DAB | GSM-FDD (TDMA, GMSK)                          | X | 15.55   | 92.7                   | 26.1 | 9.39    | 126.5    | ±1.7 %                    |
|           |                                               | Y | 21.21   | 98.0                   | 27.2 |         | 142.0    |                           |
|           |                                               | Z | 19.50   | 96.1                   | 27.0 |         | 125.4    |                           |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 23.54   | 100.0                  | 28.4 | 9.57    | 142.6    | ±2.2 %                    |
|           |                                               | Y | 23.24   | 99.9                   | 28.0 |         | 137.4    |                           |
|           |                                               | Z | 23.57   | 99.6                   | 28.2 |         | 139.7    |                           |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 17.00   | 90.2                   | 22.7 | 6.56    | 128.9    | ±2.2 %                    |
|           |                                               | Y | 35.20   | 99.7                   | 24.9 |         | 148.2    |                           |
|           |                                               | Z | 33.12   | 99.6                   | 25.4 |         | 123.8    |                           |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 44.20   | 99.6                   | 23.6 | 4.80    | 146.0    | ±1.9 %                    |
|           |                                               | Y | 49.99   | 99.9                   | 23.0 |         | 136.6    |                           |
|           |                                               | Z | 41.43   | 99.6                   | 23.9 |         | 141.4    |                           |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 46.56   | 99.7                   | 22.7 | 3.55    | 127.7    | ±2.2 %                    |
|           |                                               | Y | 58.11   | 99.8                   | 21.9 |         | 145.3    |                           |
|           |                                               | Z | 55.65   | 99.6                   | 22.2 |         | 124.3    |                           |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 34.25   | 99.4                   | 21.1 | 1.16    | 140.3    | ±1.7 %                    |
|           |                                               | Y | 40.72   | 100.0                  | 20.6 |         | 135.7    |                           |
|           |                                               | Z | 45.39   | 100.0                  | 20.8 |         | 136.4    |                           |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.30    | 67.1                   | 19.5 | 5.67    | 127.4    | ±1.4 %                    |
|           |                                               | Y | 6.58    | 68.4                   | 20.3 |         | 149.0    |                           |
|           |                                               | Z | 6.55    | 68.0                   | 19.9 |         | 146.3    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.47 | 75.6 | 25.8 | 9.29 | 146.6 | ±3.0 % |
|           |                                          | Y | 10.18 | 75.8 | 26.3 |      | 136.2 |        |
|           |                                          | Z | 10.38 | 75.3 | 25.6 |      | 140.8 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.18  | 66.6 | 19.4 | 5.80 | 126.9 | ±1.4 % |
|           |                                          | Y | 6.40  | 67.8 | 20.1 |      | 147.0 |        |
|           |                                          | Z | 6.44  | 67.6 | 19.9 |      | 145.7 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.24 | 69.0 | 21.3 | 8.07 | 142.7 | ±2.5 % |
|           |                                          | Y | 10.25 | 69.2 | 21.5 |      | 136.7 |        |
|           |                                          | Z | 10.16 | 68.8 | 21.2 |      | 136.6 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 9.85  | 74.8 | 25.6 | 9.28 | 140.8 | ±3.0 % |
|           |                                          | Y | 9.49  | 74.7 | 25.9 |      | 130.5 |        |
|           |                                          | Z | 9.90  | 74.8 | 25.6 |      | 136.8 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 6.13  | 67.1 | 19.7 | 5.75 | 146.6 | ±1.4 % |
|           |                                          | Y | 6.11  | 67.4 | 19.9 |      | 147.7 |        |
|           |                                          | Z | 6.12  | 67.1 | 19.7 |      | 142.3 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.33  | 66.7 | 19.4 | 5.82 | 128.9 | ±1.4 % |
|           |                                          | Y | 6.33  | 67.1 | 19.7 |      | 128.7 |        |
|           |                                          | Z | 6.57  | 67.6 | 19.9 |      | 147.4 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 4.89  | 66.4 | 19.5 | 5.73 | 127.5 | ±1.2 % |
|           |                                          | Y | 4.99  | 67.5 | 20.2 |      | 149.3 |        |
|           |                                          | Z | 5.09  | 67.3 | 20.0 |      | 145.1 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 7.99  | 75.8 | 26.3 | 9.21 | 127.6 | ±2.7 % |
|           |                                          | Y | 9.29  | 81.7 | 29.6 |      | 149.8 |        |
|           |                                          | Z | 8.04  | 75.8 | 26.3 |      | 123.6 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 5.08  | 67.3 | 20.0 | 5.72 | 149.3 | ±1.4 % |
|           |                                          | Y | 5.00  | 67.6 | 20.3 |      | 145.0 |        |
|           |                                          | Z | 5.09  | 67.3 | 20.0 |      | 145.0 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 5.08  | 67.3 | 20.0 | 5.72 | 148.5 | ±1.4 % |
|           |                                          | Y | 5.06  | 67.9 | 20.4 |      | 147.1 |        |
|           |                                          | Z | 5.11  | 67.4 | 20.0 |      | 144.8 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.89  | 68.7 | 21.2 | 8.10 | 134.6 | ±2.2 % |
|           |                                          | Y | 9.84  | 68.9 | 21.4 |      | 130.4 |        |
|           |                                          | Z | 9.82  | 68.5 | 21.1 |      | 130.4 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 7.02  | 67.1 | 19.5 | 5.97 | 138.0 | ±1.4 % |
|           |                                          | Y | 6.88  | 67.0 | 19.5 |      | 133.2 |        |
|           |                                          | Z | 7.01  | 67.1 | 19.5 |      | 134.6 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 8.01  | 75.9 | 26.4 | 9.21 | 128.0 | ±2.7 % |
|           |                                          | Y | 9.39  | 82.1 | 29.9 |      | 149.7 |        |
|           |                                          | Z | 8.34  | 76.9 | 26.9 |      | 129.1 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 9.05  | 73.6 | 25.1 | 9.24 | 130.6 | ±3.0 % |
|           |                                          | Y | 8.76  | 73.7 | 25.5 |      | 123.6 |        |
|           |                                          | Z | 9.10  | 73.6 | 25.1 |      | 127.8 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.81  | 74.7 | 25.6 | 9.30 | 139.3 | ±3.0 % |
|           |                                          | Y | 9.50  | 74.8 | 25.9 |      | 130.7 |        |
|           |                                          | Z | 9.81  | 74.6 | 25.5 |      | 135.0 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.49  | 67.1 | 18.9 | 3.96 | 140.1 | ±0.7 % |
|           |                                                               | Y | 4.46  | 67.2 | 19.0 |      | 137.6 |        |
|           |                                                               | Z | 4.52  | 67.1 | 18.9 |      | 137.1 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.68  | 67.0 | 18.8 | 3.46 | 129.3 | ±0.7 % |
|           |                                                               | Y | 3.64  | 67.3 | 19.0 |      | 130.3 |        |
|           |                                                               | Z | 3.84  | 67.9 | 19.2 |      | 148.6 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.64  | 67.2 | 18.8 | 3.39 | 131.8 | ±0.5 % |
|           |                                                               | Y | 3.60  | 67.4 | 19.1 |      | 128.2 |        |
|           |                                                               | Z | 3.71  | 67.5 | 19.0 |      | 128.0 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.43  | 67.5 | 19.9 | 5.81 | 147.2 | ±1.7 % |
|           |                                                               | Y | 6.39  | 67.7 | 20.0 |      | 145.4 |        |
|           |                                                               | Z | 6.42  | 67.5 | 19.8 |      | 143.2 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.73  | 67.1 | 19.7 | 6.06 | 129.7 | ±1.4 % |
|           |                                                               | Y | 6.75  | 67.5 | 19.9 |      | 130.8 |        |
|           |                                                               | Z | 6.75  | 67.3 | 19.7 |      | 126.2 |        |
| 10400-AAB | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 10.14 | 68.9 | 21.5 | 8.37 | 136.7 | ±2.5 % |
|           |                                                               | Y | 10.23 | 69.5 | 22.0 |      | 136.5 |        |
|           |                                                               | Z | 10.13 | 68.9 | 21.5 |      | 132.8 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.97  | 69.2 | 19.3 | 3.76 | 143.5 | ±0.5 % |
|           |                                                               | Y | 4.87  | 69.3 | 19.4 |      | 141.0 |        |
|           |                                                               | Z | 5.02  | 69.2 | 19.3 |      | 139.6 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.91  | 69.3 | 19.4 | 3.77 | 139.8 | ±0.7 % |
|           |                                                               | Y | 4.67  | 68.9 | 19.1 |      | 138.9 |        |
|           |                                                               | Z | 4.89  | 69.1 | 19.3 |      | 137.1 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.93  | 70.1 | 19.6 | 1.54 | 137.8 | ±0.7 % |
|           |                                                               | Y | 2.84  | 69.8 | 19.6 |      | 138.2 |        |
|           |                                                               | Z | 3.04  | 70.8 | 19.9 |      | 134.2 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.94  | 68.7 | 21.3 | 8.23 | 134.6 | ±2.2 % |
|           |                                                               | Y | 10.00 | 69.1 | 21.7 |      | 134.1 |        |
|           |                                                               | Z | 9.89  | 68.5 | 21.2 |      | 130.1 |        |

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 NormX,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 7 and 8).

<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.

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319

### 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                            | 6.69    | 6.69    | 6.69    | 0.40               | 1.70                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.41    | 6.41    | 6.41    | 0.43               | 1.62                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.29    | 5.29    | 5.29    | 0.80               | 1.16                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.10    | 5.10    | 5.10    | 0.80               | 1.24                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 4.77    | 4.77    | 4.77    | 0.64               | 1.38                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.55    | 4.55    | 4.55    | 0.80               | 1.29                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.39    | 4.39    | 4.39    | 0.80               | 1.31                    | ± 12.0 %    |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319

### Calibration Parameter Determined in Body 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 (mm) <sup>G</sup> | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 55.5                               | 0.96                            | 6.10    | 6.10    | 6.10    | 0.34               | 1.80                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.07    | 6.07    | 6.07    | 0.47               | 1.56                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.83    | 4.83    | 4.83    | 0.70               | 1.36                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.53    | 4.53    | 4.53    | 0.71               | 1.39                    | ± 12.0 %    |
| 2300                 | 52.9                               | 1.81                            | 4.24    | 4.24    | 4.24    | 0.80               | 1.26                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.11    | 4.11    | 4.11    | 0.80               | 1.10                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 3.90    | 3.90    | 3.90    | 0.80               | 1.11                    | ± 12.0 %    |

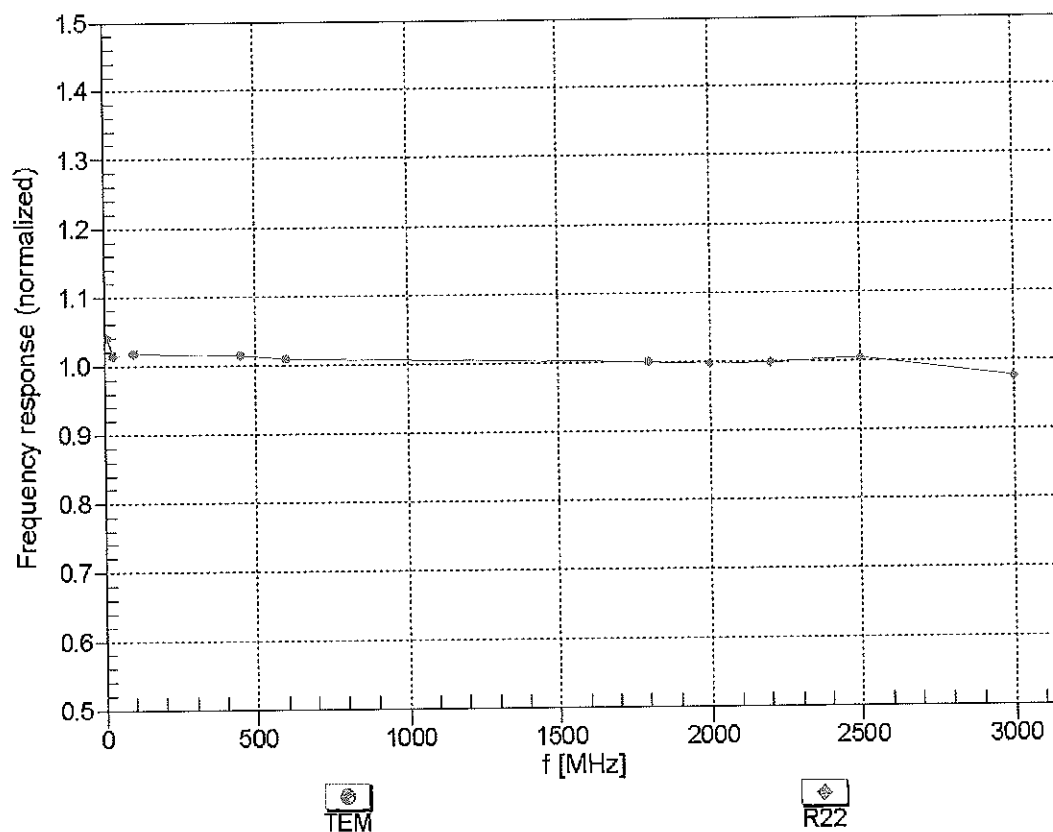
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

## Frequency Response of E-Field

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

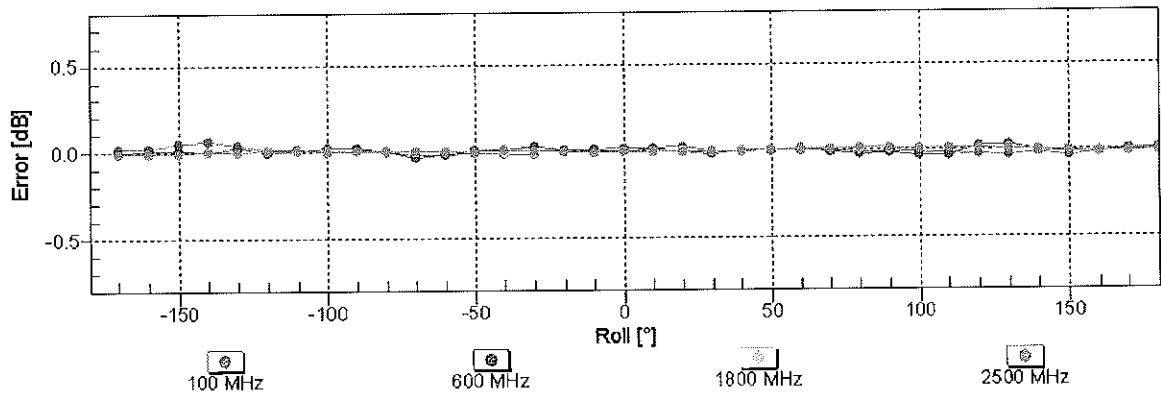
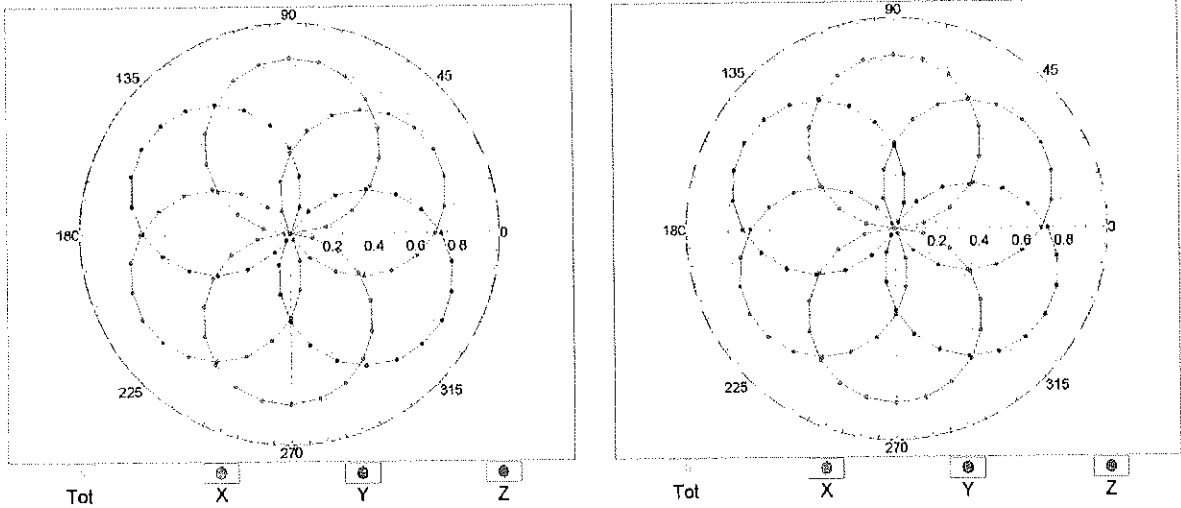


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

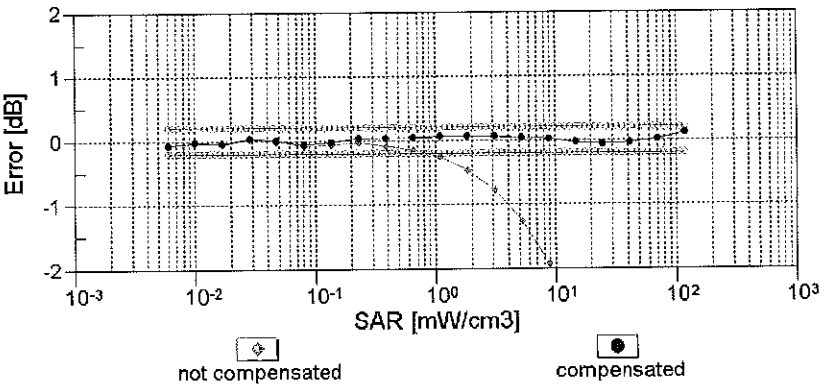
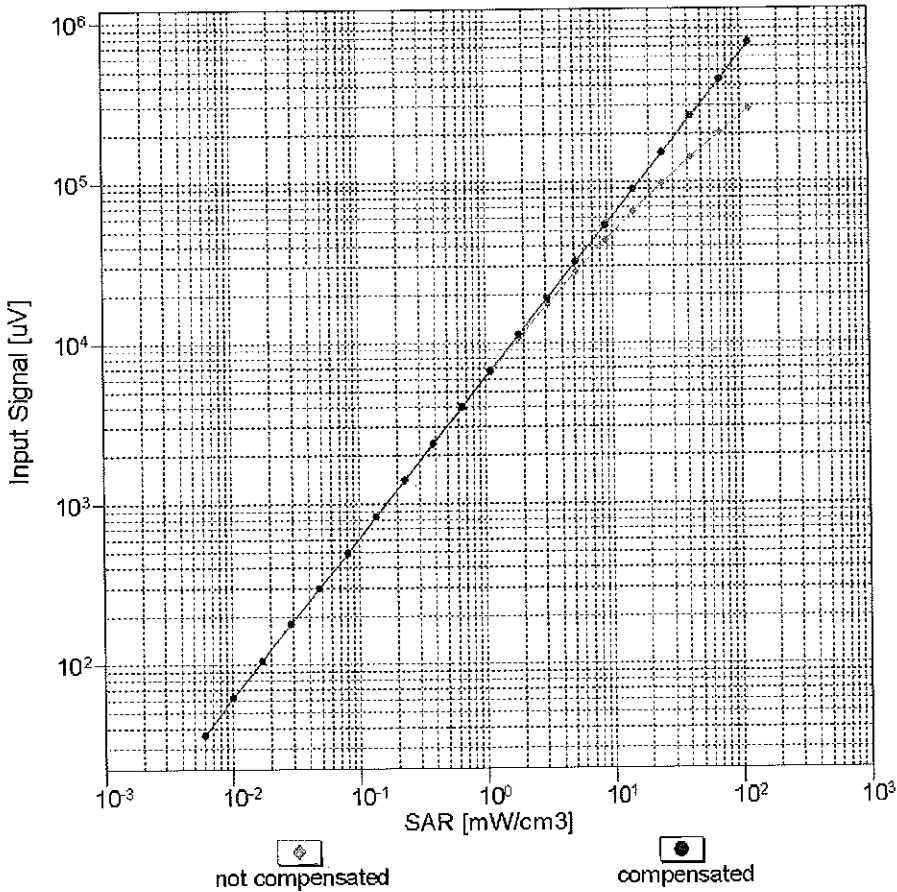
f=600 MHz,TEM

f=1800 MHz,R22



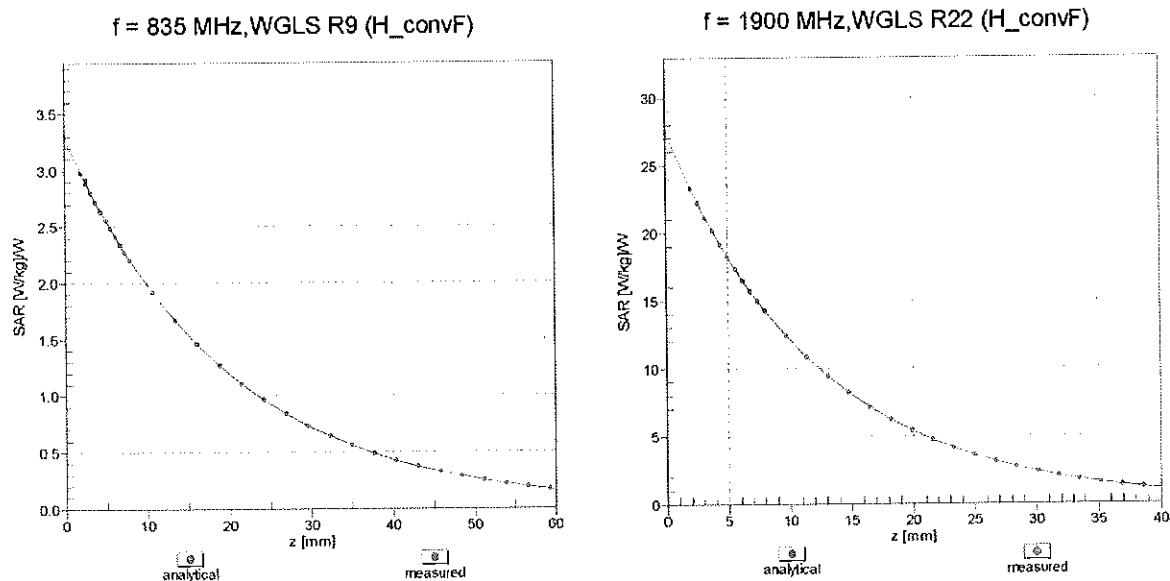
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

**Dynamic Range f(SAR<sub>head</sub>)**  
(TEM cell , f<sub>eval</sub>= 1900 MHz)



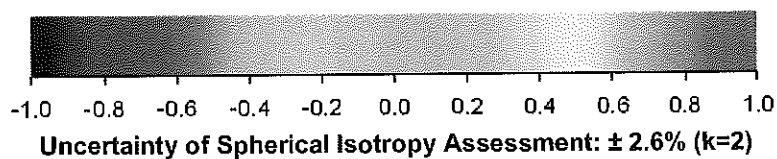
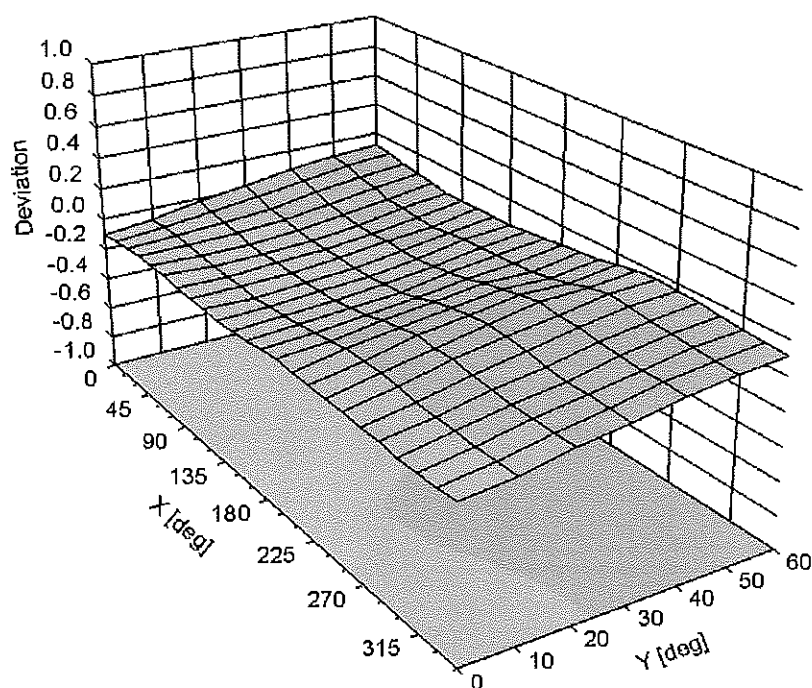
**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ),  $f = 900 \text{ MHz}$



**DASY/EASY - Parameters of Probe: ES3DV3 - SN:3319****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -120.2     |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 10 mm      |
| Tip Diameter                                  | 4 mm       |
| Probe Tip to Sensor X Calibration Point       | 2 mm       |
| Probe Tip to Sensor Y Calibration Point       | 2 mm       |
| Probe Tip to Sensor Z Calibration Point       | 2 mm       |
| Recommended Measurement Distance from Surface | 3 mm       |



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 **PC Test**

Certificate No: **ES3-3351\_Jun15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3351**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6**  
**Calibration procedure for dosimetric E-field probes**

Calibration date: **June 22, 2015**

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 E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

|                                                                                                                 |                              |                                          |                       |
|-----------------------------------------------------------------------------------------------------------------|------------------------------|------------------------------------------|-----------------------|
| Calibrated by:                                                                                                  | Name<br><b>Leif Klysner</b>  | Function<br><b>Laboratory Technician</b> | Signature<br>         |
| Approved by:                                                                                                    | Name<br><b>Katja Pokovic</b> | Function<br><b>Technical Manager</b>     | Signature<br>         |
|                                                                                                                 |                              |                                          | Issued: June 22, 2015 |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                              |                                          |                       |



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Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

## 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 $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  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 (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>; 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).

# Probe ES3DV3

## SN:3351

Manufactured: May 22, 2012  
Calibrated: June 22, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3351

## Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---------------------------------------|----------|----------|----------|-----------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 0.99     | 1.17     | 1.19     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                 | 113.6    | 105.2    | 104.5    |           |

## Modulation Calibration Parameters

| UID       | Communication System Name                     |   | A<br>dB | B<br>dB $\sqrt{\mu V}$ | 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    | 188.8    | ±3.8 %                    |
|           |                                               | Y | 0.0     | 0.0                    | 1.0  |         | 196.2    |                           |
|           |                                               | Z | 0.0     | 0.0                    | 1.0  |         | 151.3    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)          | X | 2.73    | 65.7                   | 12.7 | 10.00   | 35.9     | ±1.2 %                    |
|           |                                               | Y | 1.18    | 58.1                   | 9.8  |         | 37.4     |                           |
|           |                                               | Z | 2.44    | 61.9                   | 12.5 |         | 42.0     |                           |
| 10011-CAB | UMTS-FDD (WCDMA)                              | X | 3.43    | 68.2                   | 18.9 | 2.91    | 148.5    | ±0.5 %                    |
|           |                                               | Y | 3.14    | 66.5                   | 18.1 |         | 114.3    |                           |
|           |                                               | Z | 3.26    | 66.5                   | 18.1 |         | 119.3    |                           |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.13    | 70.5                   | 19.4 | 1.87    | 149.0    | ±0.5 %                    |
|           |                                               | Y | 2.46    | 65.9                   | 17.0 |         | 115.2    |                           |
|           |                                               | Z | 3.02    | 68.7                   | 18.5 |         | 120.9    |                           |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.59   | 69.9                   | 22.6 | 9.46    | 139.1    | ±2.5 %                    |
|           |                                               | Y | 10.11   | 68.9                   | 22.4 |         | 103.4    |                           |
|           |                                               | Z | 10.74   | 69.4                   | 22.4 |         | 114.3    |                           |
| 10021-DAB | GSM-FDD (TDMA, GMSK)                          | X | 4.33    | 75.1                   | 18.5 | 9.39    | 125.5    | ±1.4 %                    |
|           |                                               | Y | 5.13    | 77.6                   | 20.0 |         | 144.5    |                           |
|           |                                               | Z | 17.70   | 96.1                   | 27.5 |         | 123.5    |                           |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 4.56    | 75.8                   | 18.9 | 9.57    | 147.7    | ±2.2 %                    |
|           |                                               | Y | 5.75    | 78.8                   | 20.2 |         | 140.4    |                           |
|           |                                               | Z | 18.60   | 97.9                   | 28.5 |         | 117.3    |                           |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 3.42    | 71.8                   | 15.3 | 6.56    | 119.6    | ±1.4 %                    |
|           |                                               | Y | 14.95   | 90.8                   | 22.0 |         | 132.7    |                           |
|           |                                               | Z | 29.34   | 98.9                   | 25.6 |         | 106.6    |                           |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 28.96   | 99.9                   | 23.5 | 4.80    | 135.7    | ±1.9 %                    |
|           |                                               | Y | 55.26   | 99.9                   | 21.9 |         | 107.5    |                           |
|           |                                               | Z | 35.15   | 99.9                   | 24.6 |         | 120.0    |                           |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 36.32   | 96.2                   | 20.3 | 3.55    | 147.5    | ±1.9 %                    |
|           |                                               | Y | 73.22   | 99.9                   | 20.7 |         | 117.0    |                           |
|           |                                               | Z | 52.78   | 99.6                   | 22.4 |         | 128.3    |                           |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 31.23   | 99.5                   | 20.1 | 1.16    | 122.8    | ±1.4 %                    |
|           |                                               | Y | 0.74    | 62.4                   | 7.0  |         | 135.2    |                           |
|           |                                               | Z | 56.68   | 99.6                   | 20.2 |         | 141.5    |                           |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.01    | 66.4                   | 18.9 | 5.67    | 112.7    | ±1.2 %                    |
|           |                                               | Y | 6.14    | 66.9                   | 19.3 |         | 124.6    |                           |
|           |                                               | Z | 6.37    | 67.2                   | 19.4 |         | 129.3    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 8.50  | 71.4 | 23.6 | 9.29 | 137.9 | ±2.7 % |
|           |                                          | Y | 8.12  | 70.6 | 23.6 |      | 105.2 |        |
|           |                                          | Z | 9.68  | 73.4 | 24.7 |      | 118.6 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 5.88  | 66.0 | 18.8 | 5.80 | 111.2 | ±1.2 % |
|           |                                          | Y | 5.99  | 66.5 | 19.2 |      | 122.8 |        |
|           |                                          | Z | 6.28  | 66.9 | 19.4 |      | 128.7 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.19 | 69.3 | 21.2 | 8.07 | 149.1 | ±2.2 % |
|           |                                          | Y | 9.73  | 68.2 | 20.9 |      | 111.5 |        |
|           |                                          | Z | 9.97  | 68.3 | 20.8 |      | 117.7 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 8.07  | 71.0 | 23.5 | 9.28 | 132.7 | ±2.5 % |
|           |                                          | Y | 8.82  | 74.2 | 25.9 |      | 147.0 |        |
|           |                                          | Z | 9.11  | 72.5 | 24.4 |      | 115.3 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 5.55  | 65.4 | 18.6 | 5.75 | 107.9 | ±0.9 % |
|           |                                          | Y | 5.67  | 66.0 | 19.0 |      | 120.3 |        |
|           |                                          | Z | 5.96  | 66.3 | 19.1 |      | 126.2 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 5.96  | 65.9 | 18.7 | 5.82 | 111.9 | ±1.2 % |
|           |                                          | Y | 6.12  | 66.6 | 19.3 |      | 125.0 |        |
|           |                                          | Z | 6.38  | 66.8 | 19.3 |      | 131.2 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 4.68  | 66.6 | 19.4 | 5.73 | 130.7 | ±0.9 % |
|           |                                          | Y | 4.81  | 67.2 | 20.0 |      | 144.7 |        |
|           |                                          | Z | 4.74  | 65.5 | 18.9 |      | 109.9 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 6.59  | 73.2 | 25.1 | 9.21 | 143.9 | ±2.5 % |
|           |                                          | Y | 6.42  | 72.7 | 25.3 |      | 113.3 |        |
|           |                                          | Z | 7.92  | 75.5 | 26.2 |      | 127.2 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 4.68  | 66.5 | 19.4 | 5.72 | 128.6 | ±0.9 % |
|           |                                          | Y | 4.80  | 67.2 | 20.0 |      | 144.2 |        |
|           |                                          | Z | 4.73  | 65.5 | 18.9 |      | 109.1 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.71  | 66.7 | 19.5 | 5.72 | 128.9 | ±1.2 % |
|           |                                          | Y | 4.78  | 67.1 | 19.9 |      | 143.9 |        |
|           |                                          | Z | 5.12  | 67.3 | 19.9 |      | 149.9 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.72  | 68.8 | 21.1 | 8.10 | 138.3 | ±1.9 % |
|           |                                          | Y | 9.32  | 67.9 | 20.9 |      | 105.9 |        |
|           |                                          | Z | 9.58  | 67.8 | 20.6 |      | 111.2 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 6.60  | 66.5 | 18.9 | 5.97 | 117.6 | ±1.2 % |
|           |                                          | Y | 6.69  | 66.9 | 19.3 |      | 132.0 |        |
|           |                                          | Z | 7.08  | 67.2 | 19.5 |      | 139.9 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 6.57  | 73.1 | 25.0 | 9.21 | 144.5 | ±2.2 % |
|           |                                          | Y | 6.59  | 73.6 | 25.8 |      | 114.3 |        |
|           |                                          | Z | 8.03  | 76.0 | 26.4 |      | 127.7 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 7.44  | 70.0 | 23.2 | 9.24 | 122.9 | ±2.5 % |
|           |                                          | Y | 8.16  | 73.3 | 25.5 |      | 138.8 |        |
|           |                                          | Z | 8.43  | 71.6 | 24.1 |      | 108.3 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 8.01  | 70.7 | 23.4 | 9.30 | 130.5 | ±2.7 % |
|           |                                          | Y | 8.86  | 74.4 | 26.1 |      | 146.7 |        |
|           |                                          | Z | 9.12  | 72.6 | 24.5 |      | 114.0 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.49  | 67.5 | 18.8 | 3.96 | 146.9 | ±0.7 % |
|           |                                                               | Y | 4.13  | 65.9 | 18.1 |      | 117.5 |        |
|           |                                                               | Z | 4.36  | 66.2 | 18.2 |      | 121.1 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.66  | 67.7 | 18.9 | 3.46 | 133.9 | ±0.5 % |
|           |                                                               | Y | 3.37  | 66.1 | 18.1 |      | 109.3 |        |
|           |                                                               | Z | 3.54  | 66.0 | 18.0 |      | 112.1 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.55  | 67.5 | 18.7 | 3.39 | 136.7 | ±0.7 % |
|           |                                                               | Y | 3.35  | 66.4 | 18.2 |      | 110.1 |        |
|           |                                                               | Z | 3.44  | 65.7 | 17.9 |      | 112.9 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 5.86  | 65.9 | 18.8 | 5.81 | 109.3 | ±1.2 % |
|           |                                                               | Y | 6.00  | 66.5 | 19.3 |      | 122.6 |        |
|           |                                                               | Z | 6.23  | 66.7 | 19.3 |      | 126.8 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.42  | 66.5 | 19.1 | 6.06 | 114.1 | ±1.2 % |
|           |                                                               | Y | 6.60  | 67.2 | 19.7 |      | 127.9 |        |
|           |                                                               | Z | 6.85  | 67.4 | 19.7 |      | 132.6 |        |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 10.03 | 69.2 | 21.5 | 8.37 | 141.2 | ±1.9 % |
|           |                                                               | Y | 9.51  | 68.0 | 21.1 |      | 106.9 |        |
|           |                                                               | Z | 9.90  | 68.2 | 21.1 |      | 114.0 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 5.00  | 70.6 | 19.6 | 3.76 | 146.5 | ±0.5 % |
|           |                                                               | Y | 4.32  | 67.9 | 18.3 |      | 115.0 |        |
|           |                                                               | Z | 4.63  | 67.5 | 18.3 |      | 121.9 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.99  | 71.0 | 19.8 | 3.77 | 143.8 | ±0.5 % |
|           |                                                               | Y | 4.37  | 68.5 | 18.7 |      | 113.5 |        |
|           |                                                               | Z | 4.56  | 67.5 | 18.2 |      | 120.2 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 3.07  | 71.2 | 19.9 | 1.54 | 145.7 | ±0.5 % |
|           |                                                               | Y | 2.43  | 66.6 | 17.4 |      | 116.6 |        |
|           |                                                               | Z | 2.59  | 67.1 | 17.8 |      | 124.3 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.84  | 69.0 | 21.3 | 8.23 | 139.6 | ±1.9 % |
|           |                                                               | Y | 9.37  | 67.9 | 21.0 |      | 106.5 |        |
|           |                                                               | Z | 9.84  | 68.4 | 21.1 |      | 117.4 |        |

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 NormX,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 7 and 8).

<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.

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3351

### 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                            | 6.43    | 6.43    | 6.43    | 0.31               | 1.96                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.17    | 6.17    | 6.17    | 0.21               | 2.59                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.24    | 5.24    | 5.24    | 0.55               | 1.35                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.07    | 5.07    | 5.07    | 0.54               | 1.42                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 4.74    | 4.74    | 4.74    | 0.69               | 1.31                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.46    | 4.46    | 4.46    | 0.80               | 1.26                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.35    | 4.35    | 4.35    | 0.80               | 1.26                    | ± 12.0 %    |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3351

### Calibration Parameter Determined in Body 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) | Uct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|------------|
| 750                  | 55.5                               | 0.96                            | 6.21    | 6.21    | 6.21    | 0.29               | 1.98                    | ± 12.0 %   |
| 835                  | 55.2                               | 0.97                            | 6.11    | 6.11    | 6.11    | 0.77               | 1.20                    | ± 12.0 %   |
| 1750                 | 53.4                               | 1.49                            | 4.88    | 4.88    | 4.88    | 0.68               | 1.30                    | ± 12.0 %   |
| 1900                 | 53.3                               | 1.52                            | 4.68    | 4.68    | 4.68    | 0.61               | 1.46                    | ± 12.0 %   |
| 2300                 | 52.9                               | 1.81                            | 4.47    | 4.47    | 4.47    | 0.80               | 1.16                    | ± 12.0 %   |
| 2450                 | 52.7                               | 1.95                            | 4.30    | 4.30    | 4.30    | 0.80               | 1.16                    | ± 12.0 %   |
| 2600                 | 52.5                               | 2.16                            | 4.16    | 4.16    | 4.16    | 0.80               | 1.20                    | ± 12.0 %   |

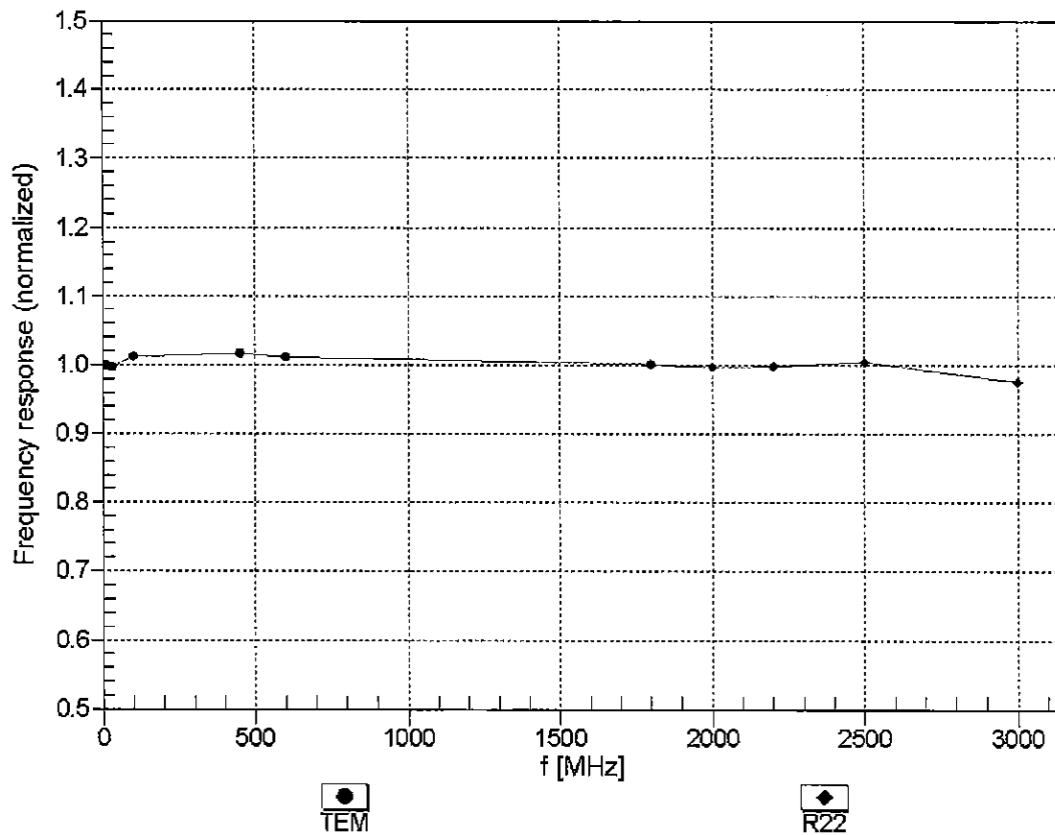
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

## Frequency Response of E-Field

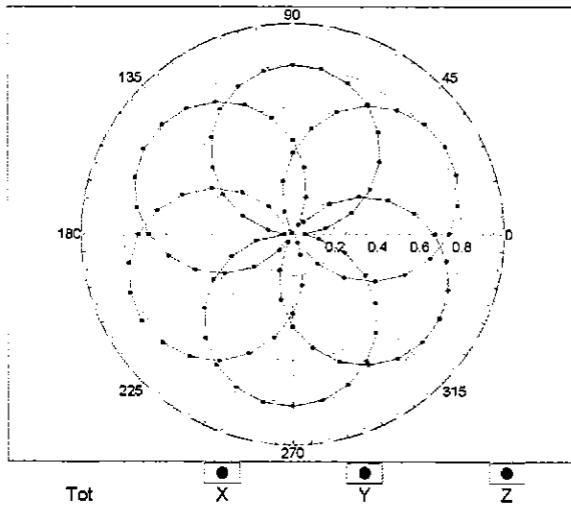
(TEM-Cell:ifi110 EXX, Waveguide: R22)



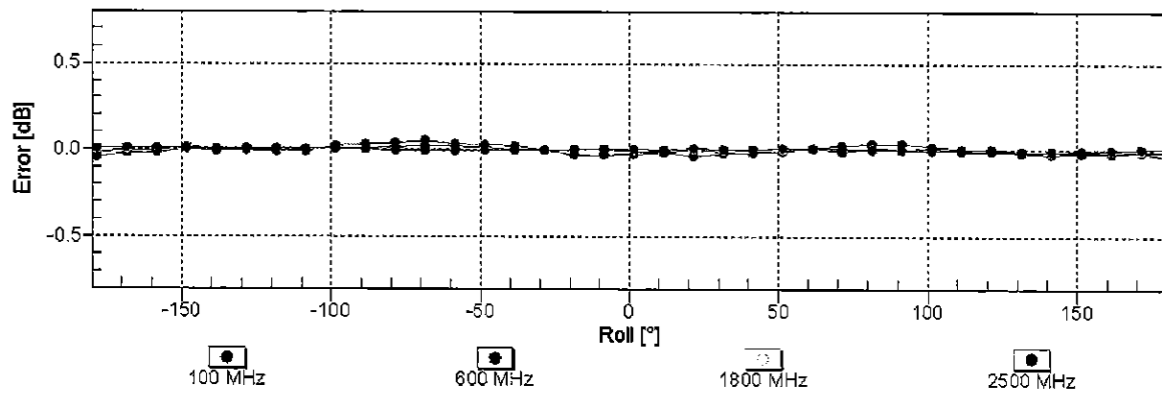
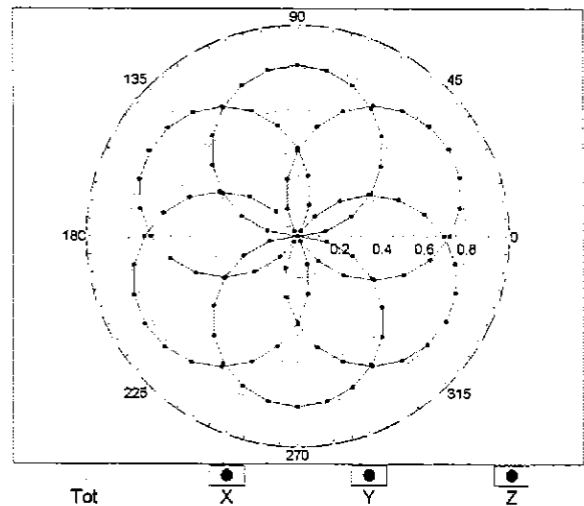
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM

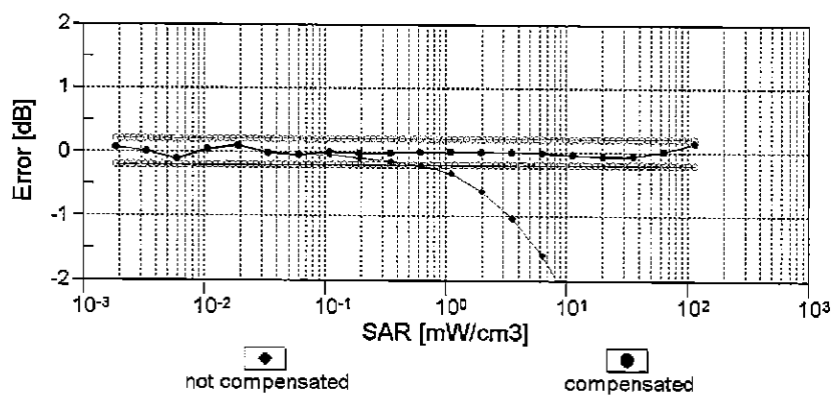
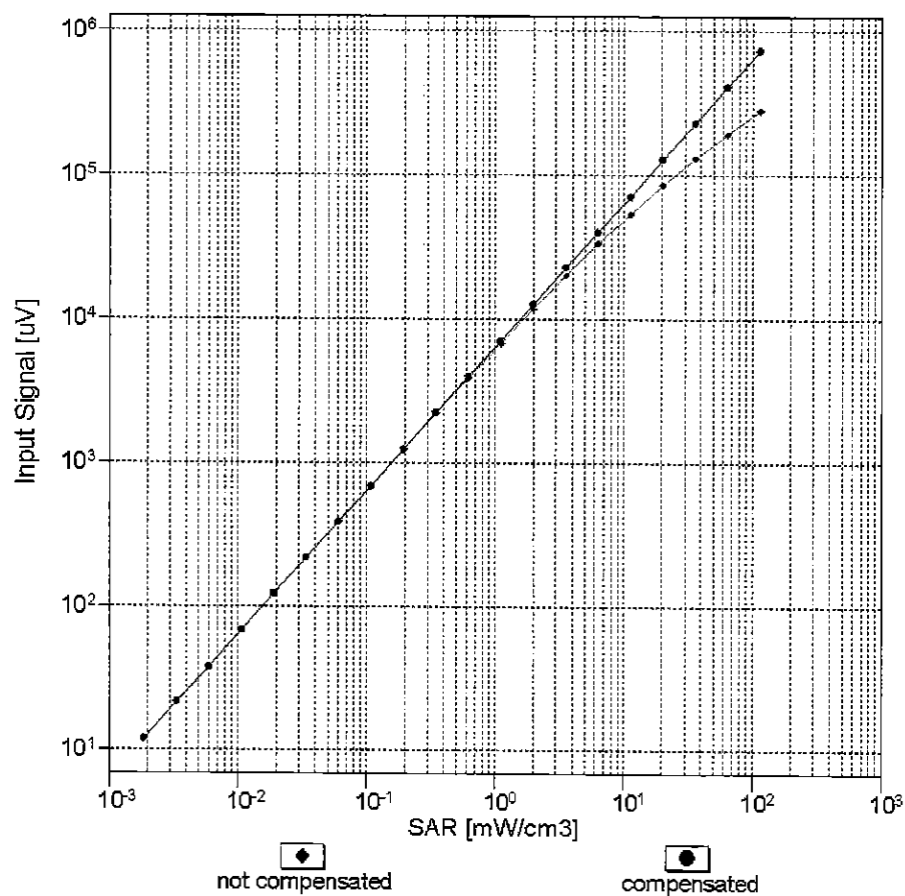


f=1800 MHz,R22



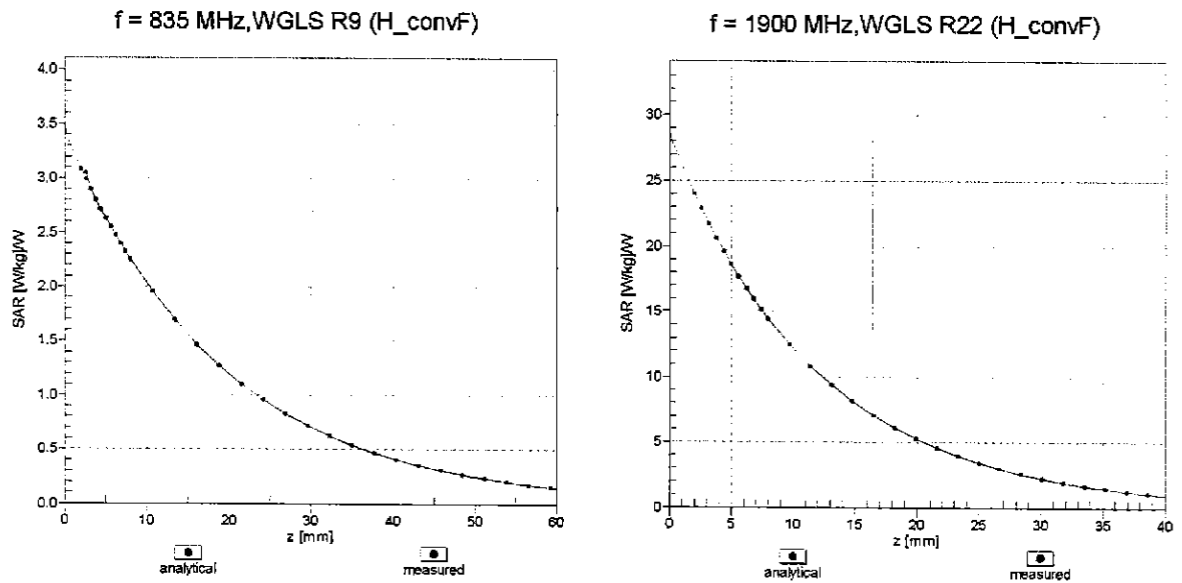
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

# Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )



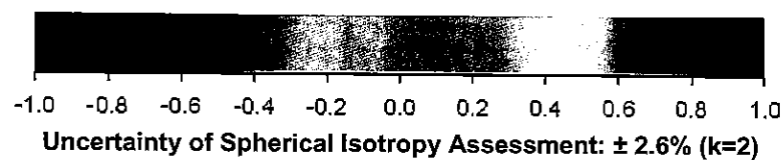
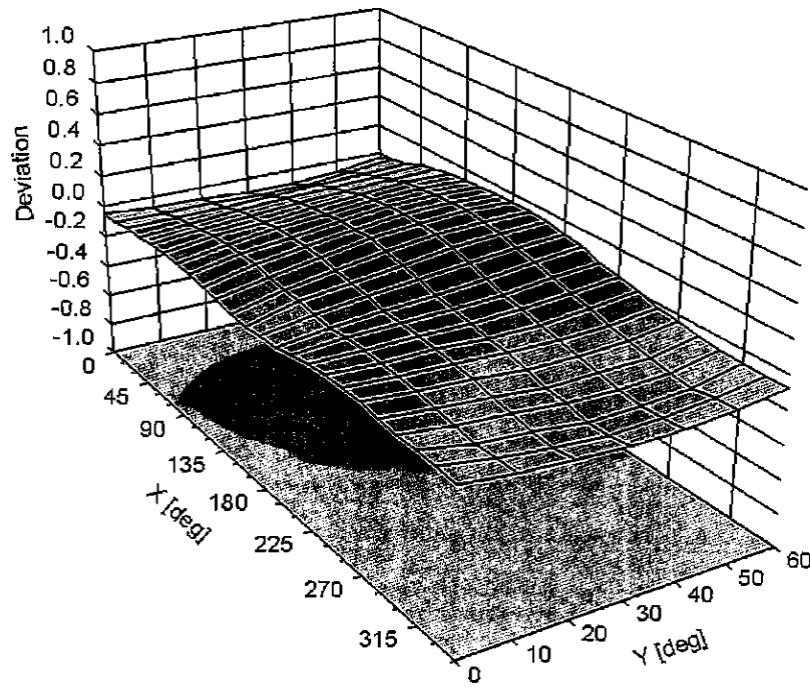
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ),  $f = 900 \text{ MHz}$



## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3351

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 21.5       |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 10 mm      |
| Tip Diameter                                  | 4 mm       |
| Probe Tip to Sensor X Calibration Point       | 2 mm       |
| Probe Tip to Sensor Y Calibration Point       | 2 mm       |
| Probe Tip to Sensor Z Calibration Point       | 2 mm       |
| Recommended Measurement Distance from Surface | 3 mm       |



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Client **PC Test**

Certificate No: **ES3-3333\_Oct15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3333**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6**  
**Calibration procedure for dosimetric E-field probes**

*DN ✓  
14/03/15*

Calibration date: **October 29, 2015**

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 E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (In house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

|                                                                                                                 |                              |                                          |               |
|-----------------------------------------------------------------------------------------------------------------|------------------------------|------------------------------------------|---------------|
| Calibrated by:                                                                                                  | Name<br><b>Lutz Klysner</b>  | Function<br><b>Laboratory Technician</b> | Signature<br> |
| Approved by:                                                                                                    | Name<br><b>Katja Pokovic</b> | Technical Manager                        |               |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                              |                                          |               |

Issued: October 29, 2015



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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>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:

- 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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 865604, "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.
- DCPx,y,z**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (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>; 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).

# Probe ES3DV3

## SN:3333

Manufactured: January 24, 2012  
Calibrated: October 29, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333

## Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 1.07     | 0.90     | 0.88     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 106.8    | 108.5    | 106.8    |               |

## 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    | 201.0    | $\pm 3.5 \%$              |
|               |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 187.1    |                           |
|               |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 184.8    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 2.43    | 80.7                         | 11.4 | 10.00   | 41.6     | $\pm 2.2 \%$              |
|               |                                               | Y | 4.35    | 67.4                         | 13.2 |         | 35.6     |                           |
|               |                                               | Z | 1.46    | 57.0                         | 8.7  |         | 36.2     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.35    | 67.9                         | 19.1 | 2.91    | 138.2    | $\pm 0.5 \%$              |
|               |                                               | Y | 3.48    | 68.8                         | 19.2 |         | 127.5    |                           |
|               |                                               | Z | 3.37    | 67.6                         | 18.6 |         | 149.0    |                           |
| 10012-<br>CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.80    | 72.8                         | 20.8 | 1.87    | 141.0    | $\pm 0.7 \%$              |
|               |                                               | Y | 3.68    | 73.3                         | 20.8 |         | 128.0    |                           |
|               |                                               | Z | 3.01    | 69.3                         | 18.8 |         | 128.2    |                           |
| 10013-<br>CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.52   | 71.7                         | 23.9 | 9.46    | 139.3    | $\pm 3.0 \%$              |
|               |                                               | Y | 10.94   | 70.4                         | 22.9 |         | 147.1    |                           |
|               |                                               | Z | 10.95   | 70.8                         | 23.4 |         | 144.5    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 21.45   | 95.2                         | 26.5 | 9.39    | 139.9    | $\pm 2.5 \%$              |
|               |                                               | Y | 9.12    | 82.9                         | 21.9 |         | 142.0    |                           |
|               |                                               | Z | 11.47   | 88.1                         | 23.9 |         | 127.6    |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 20.81   | 95.6                         | 27.0 | 9.57    | 135.8    | $\pm 2.2 \%$              |
|               |                                               | Y | 9.78    | 84.4                         | 22.7 |         | 135.3    |                           |
|               |                                               | Z | 9.12    | 83.5                         | 22.1 |         | 144.6    |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 39.84   | 99.8                         | 25.2 | 6.56    | 140.9    | $\pm 1.9 \%$              |
|               |                                               | Y | 35.07   | 100.0                        | 25.0 |         | 128.4    |                           |
|               |                                               | Z | 35.20   | 99.8                         | 24.7 |         | 131.9    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 47.16   | 99.8                         | 23.9 | 4.80    | 124.9    | $\pm 2.5 \%$              |
|               |                                               | Y | 49.75   | 99.6                         | 22.8 |         | 145.4    |                           |
|               |                                               | Z | 45.37   | 99.9                         | 23.1 |         | 148.5    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 56.24   | 99.6                         | 22.6 | 3.55    | 140.4    | $\pm 2.7 \%$              |
|               |                                               | Y | 56.95   | 99.7                         | 21.9 |         | 129.1    |                           |
|               |                                               | Z | 48.45   | 99.6                         | 22.1 |         | 133.2    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 18.03   | 98.1                         | 22.8 | 1.16    | 127.5    | $\pm 1.9 \%$              |
|               |                                               | Y | 35.17   | 99.6                         | 20.7 |         | 141.1    |                           |
|               |                                               | Z | 21.08   | 99.9                         | 21.9 |         | 127.5    |                           |
| 10100-<br>CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.36    | 87.6                         | 19.8 | 5.67    | 137.5    | $\pm 1.2 \%$              |
|               |                                               | Y | 6.29    | 87.4                         | 19.6 |         | 128.9    |                           |
|               |                                               | Z | 6.35    | 87.5                         | 19.7 |         | 139.5    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.85 | 76.6 | 28.4 | 9.29 | 130.8 | ±2.7 % |
|           |                                          | Y | 9.58  | 73.7 | 24.8 |      | 143.0 |        |
|           |                                          | Z | 9.94  | 75.6 | 26.2 |      | 149.3 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 8.21  | 67.0 | 19.7 | 5.80 | 128.9 | ±1.2 % |
|           |                                          | Y | 6.16  | 66.9 | 19.5 |      | 129.2 |        |
|           |                                          | Z | 6.22  | 67.2 | 19.7 |      | 138.0 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.05 | 68.7 | 21.2 | 8.07 | 126.1 | ±2.5 % |
|           |                                          | Y | 10.13 | 69.0 | 21.3 |      | 146.1 |        |
|           |                                          | Z | 9.97  | 68.7 | 21.1 |      | 126.2 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 10.11 | 75.5 | 26.0 | 9.28 | 125.8 | ±3.3 % |
|           |                                          | Y | 9.08  | 73.2 | 24.7 |      | 138.2 |        |
|           |                                          | Z | 9.32  | 74.8 | 26.0 |      | 143.1 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 5.97  | 66.8 | 19.6 | 5.75 | 133.4 | ±1.2 % |
|           |                                          | Y | 5.92  | 66.7 | 19.5 |      | 127.0 |        |
|           |                                          | Z | 5.91  | 68.7 | 19.5 |      | 134.2 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.40  | 67.3 | 19.9 | 5.82 | 137.8 | ±1.2 % |
|           |                                          | Y | 6.31  | 67.1 | 19.6 |      | 130.7 |        |
|           |                                          | Z | 6.32  | 67.1 | 19.8 |      | 139.8 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 5.05  | 67.3 | 20.1 | 5.73 | 136.8 | ±1.2 % |
|           |                                          | Y | 4.89  | 67.0 | 19.9 |      | 131.1 |        |
|           |                                          | Z | 4.93  | 67.2 | 20.0 |      | 137.4 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 10.74 | 83.9 | 30.3 | 9.21 | 136.8 | ±2.7 % |
|           |                                          | Y | 7.34  | 74.3 | 25.5 |      | 125.9 |        |
|           |                                          | Z | 7.74  | 76.6 | 27.1 |      | 131.2 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 4.97  | 66.9 | 19.9 | 5.72 | 130.8 | ±1.2 % |
|           |                                          | Y | 4.86  | 66.9 | 19.8 |      | 128.5 |        |
|           |                                          | Z | 4.97  | 67.3 | 20.1 |      | 137.0 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.99  | 67.0 | 19.9 | 5.72 | 130.1 | ±1.2 % |
|           |                                          | Y | 4.88  | 67.0 | 19.9 |      | 127.6 |        |
|           |                                          | Z | 4.95  | 67.2 | 20.0 |      | 136.2 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 10.00 | 69.2 | 21.7 | 8.10 | 137.9 | ±2.2 % |
|           |                                          | Y | 9.75  | 68.7 | 21.2 |      | 137.5 |        |
|           |                                          | Z | 9.94  | 69.4 | 21.7 |      | 145.3 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 7.08  | 67.5 | 19.8 | 5.97 | 147.1 | ±1.4 % |
|           |                                          | Y | 7.06  | 67.7 | 19.8 |      | 142.3 |        |
|           |                                          | Z | 7.04  | 67.7 | 19.9 |      | 148.8 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 10.66 | 83.5 | 30.1 | 9.21 | 144.0 | ±3.0 % |
|           |                                          | Y | 7.43  | 74.7 | 25.7 |      | 127.6 |        |
|           |                                          | Z | 7.86  | 77.1 | 27.4 |      | 132.3 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 10.81 | 78.7 | 27.9 | 9.24 | 139.7 | ±3.0 % |
|           |                                          | Y | 8.48  | 72.4 | 24.4 |      | 130.1 |        |
|           |                                          | Z | 8.71  | 74.1 | 25.8 |      | 135.2 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 11.73 | 79.9 | 28.3 | 9.30 | 148.6 | ±3.3 % |
|           |                                          | Y | 9.11  | 73.2 | 24.8 |      | 139.0 |        |
|           |                                          | Z | 9.38  | 74.9 | 26.1 |      | 142.7 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Ref8.4)                      | X | 4.52  | 67.6 | 19.3 | 3.96 | 144.5 | ±0.7 % |
|           |                                                               | Y | 4.67  | 68.3 | 19.6 |      | 146.0 |        |
|           |                                                               | Z | 4.41  | 67.0 | 18.9 |      | 130.0 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.66  | 67.2 | 19.0 | 3.46 | 134.5 | ±0.5 % |
|           |                                                               | Y | 3.91  | 68.9 | 19.9 |      | 133.2 |        |
|           |                                                               | Z | 3.86  | 68.5 | 19.6 |      | 146.9 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.63  | 67.5 | 19.1 | 3.39 | 134.9 | ±0.5 % |
|           |                                                               | Y | 3.93  | 69.3 | 20.0 |      | 136.0 |        |
|           |                                                               | Z | 3.81  | 68.5 | 19.6 |      | 148.6 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.20  | 67.1 | 19.7 | 5.81 | 129.0 | ±1.2 % |
|           |                                                               | Y | 6.20  | 67.0 | 19.6 |      | 128.0 |        |
|           |                                                               | Z | 6.32  | 67.5 | 19.9 |      | 142.7 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.76  | 67.6 | 20.0 | 6.06 | 134.7 | ±1.4 % |
|           |                                                               | Y | 6.75  | 67.5 | 19.9 |      | 133.5 |        |
|           |                                                               | Z | 6.90  | 68.1 | 20.3 |      | 149.2 |        |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 10.30 | 69.7 | 22.1 | 8.37 | 140.1 | ±2.5 % |
|           |                                                               | Y | 10.05 | 69.0 | 21.5 |      | 141.2 |        |
|           |                                                               | Z | 9.94  | 69.0 | 21.7 |      | 126.3 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.80  | 68.5 | 19.0 | 3.76 | 129.3 | ±0.5 % |
|           |                                                               | Y | 5.30  | 71.1 | 20.2 |      | 148.4 |        |
|           |                                                               | Z | 5.10  | 70.4 | 19.9 |      | 135.2 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.77  | 68.8 | 19.2 | 3.77 | 127.3 | ±0.7 % |
|           |                                                               | Y | 5.35  | 71.7 | 20.5 |      | 145.4 |        |
|           |                                                               | Z | 5.03  | 70.6 | 20.1 |      | 133.3 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.77  | 69.7 | 19.7 | 1.54 | 147.0 | ±0.7 % |
|           |                                                               | Y | 3.73  | 75.4 | 22.2 |      | 143.7 |        |
|           |                                                               | Z | 3.25  | 72.2 | 20.7 |      | 133.9 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 8 Mbps, 99pc duty cycle) | X | 10.11 | 69.4 | 21.8 | 8.23 | 144.7 | ±2.5 % |
|           |                                                               | Y | 9.86  | 68.8 | 21.4 |      | 139.3 |        |
|           |                                                               | Z | 9.72  | 68.6 | 21.3 |      | 126.0 |        |

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 Pages 7 and 8).

<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.

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333

### 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) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750                  | 41.9                               | 0.89                            | 6.46    | 6.46    | 6.46    | 0.75               | 1.22                    | ± 12.0 %  |
| 835                  | 41.5                               | 0.90                            | 6.16    | 6.16    | 6.16    | 0.36               | 1.67                    | ± 12.0 %  |
| 1750                 | 40.1                               | 1.37                            | 5.21    | 5.21    | 5.21    | 0.80               | 1.19                    | ± 12.0 %  |
| 1900                 | 40.0                               | 1.40                            | 5.03    | 5.03    | 5.03    | 0.73               | 1.25                    | ± 12.0 %  |
| 2300                 | 39.5                               | 1.67                            | 4.73    | 4.73    | 4.73    | 0.60               | 1.43                    | ± 12.0 %  |
| 2450                 | 39.2                               | 1.80                            | 4.53    | 4.53    | 4.53    | 0.80               | 1.28                    | ± 12.0 %  |
| 2600                 | 39.0                               | 1.96                            | 4.39    | 4.39    | 4.39    | 0.80               | 1.29                    | ± 12.0 %  |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333

### Calibration Parameter Determined in Body Tissue Simulating Media

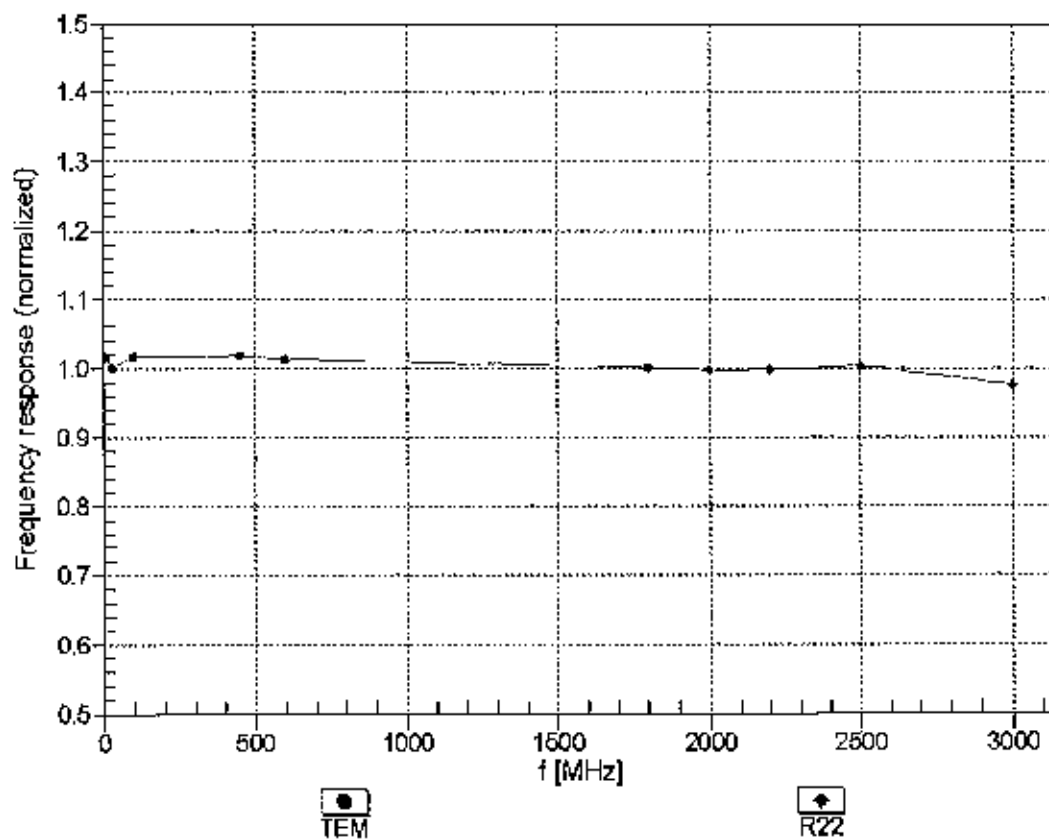
| f (MHz) <sup>c</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>g</sup> | Depth (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|------------|-----------|
| 750                  | 55.5                               | 0.98                            | 6.31    | 6.31    | 6.31    | 0.70               | 1.26       | ± 12.0 %  |
| 835                  | 55.2                               | 0.97                            | 6.25    | 6.25    | 6.25    | 0.47               | 1.54       | ± 12.0 %  |
| 1750                 | 53.4                               | 1.49                            | 4.90    | 4.90    | 4.90    | 0.49               | 1.63       | ± 12.0 %  |
| 1900                 | 53.3                               | 1.52                            | 4.70    | 4.70    | 4.70    | 0.54               | 1.49       | ± 12.0 %  |
| 2300                 | 52.9                               | 1.81                            | 4.51    | 4.51    | 4.51    | 0.80               | 1.15       | ± 12.0 %  |
| 2450                 | 52.7                               | 1.95                            | 4.34    | 4.34    | 4.34    | 0.80               | 1.15       | ± 12.0 %  |
| 2600                 | 52.5                               | 2.16                            | 4.23    | 4.23    | 4.23    | 0.80               | 1.03       | ± 12.0 %  |

<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, 160 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

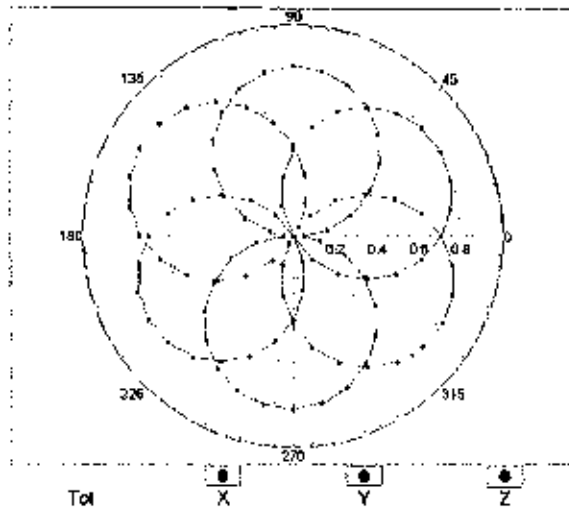
## Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



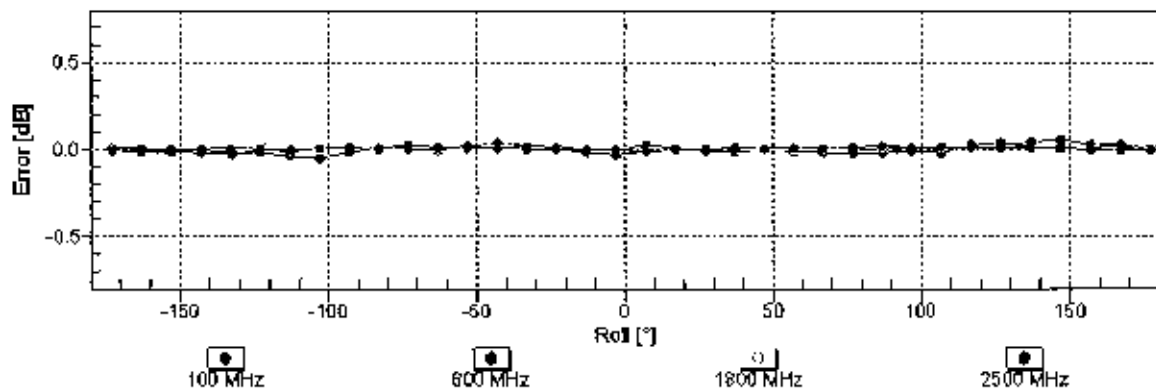
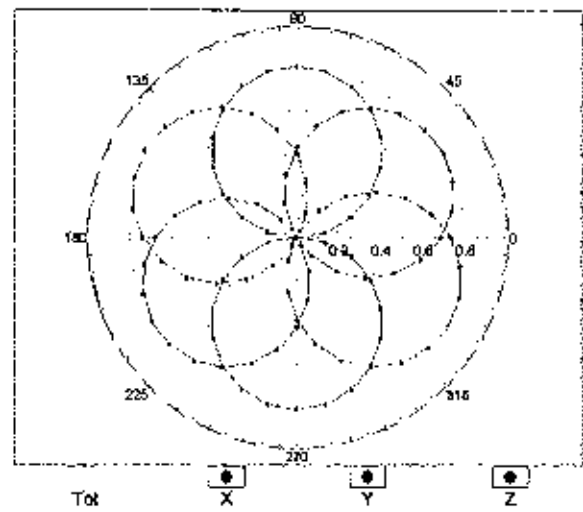
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM

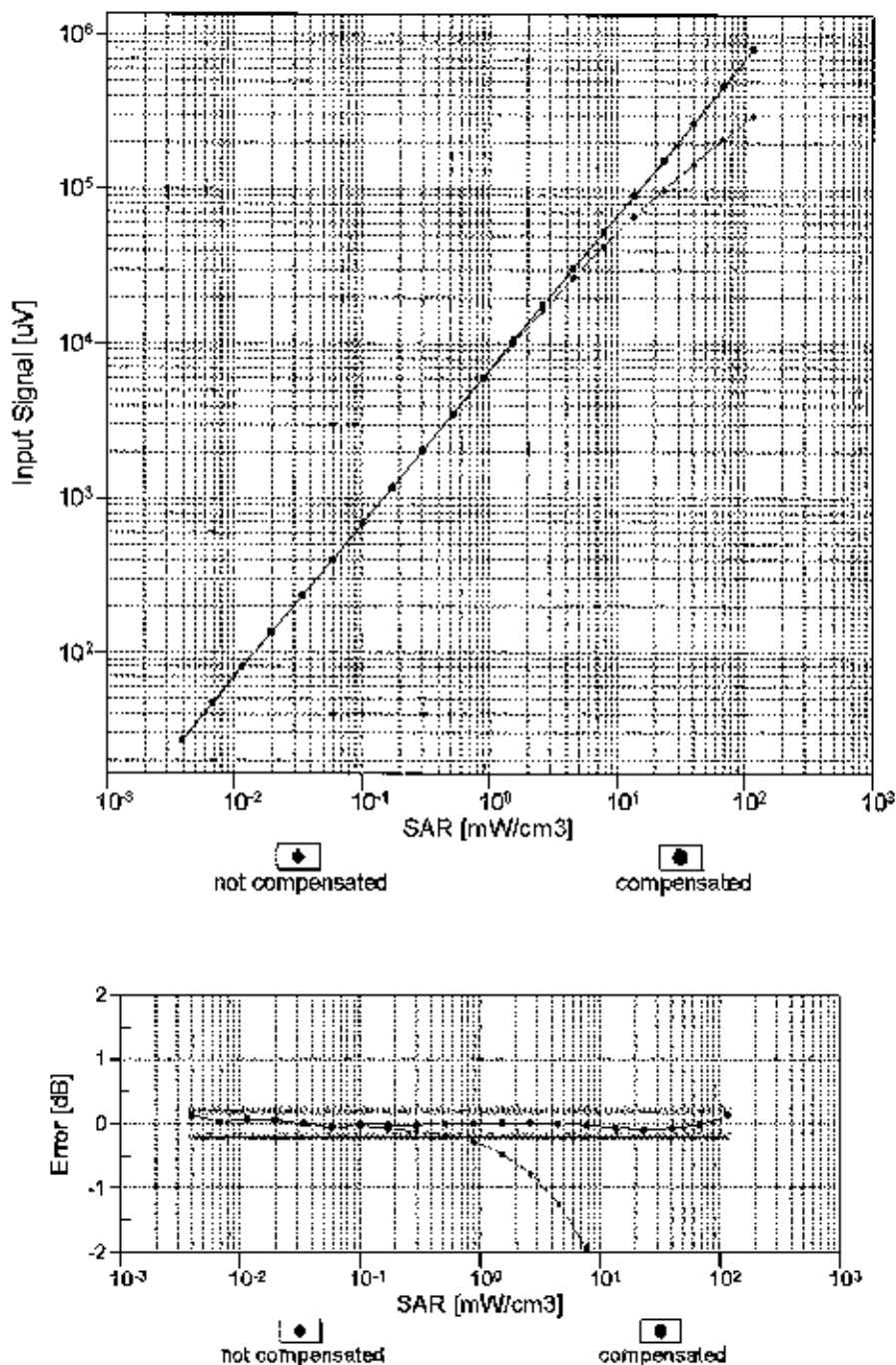


f=1800 MHz,R22



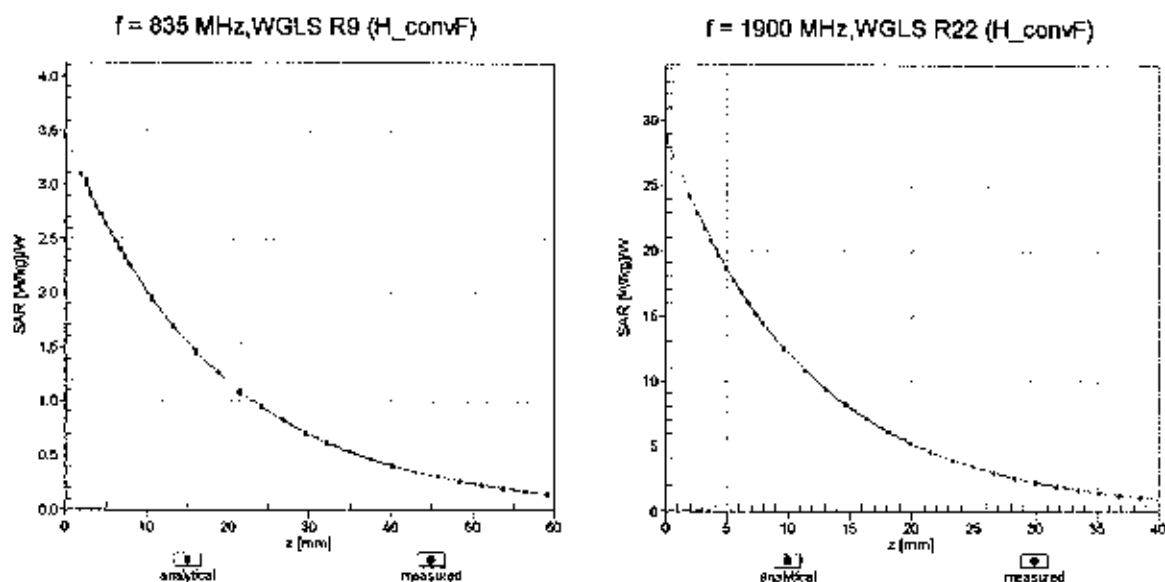
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

# **Dynamic Range $f(\text{SAR}_{\text{head}})$** **(TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )**



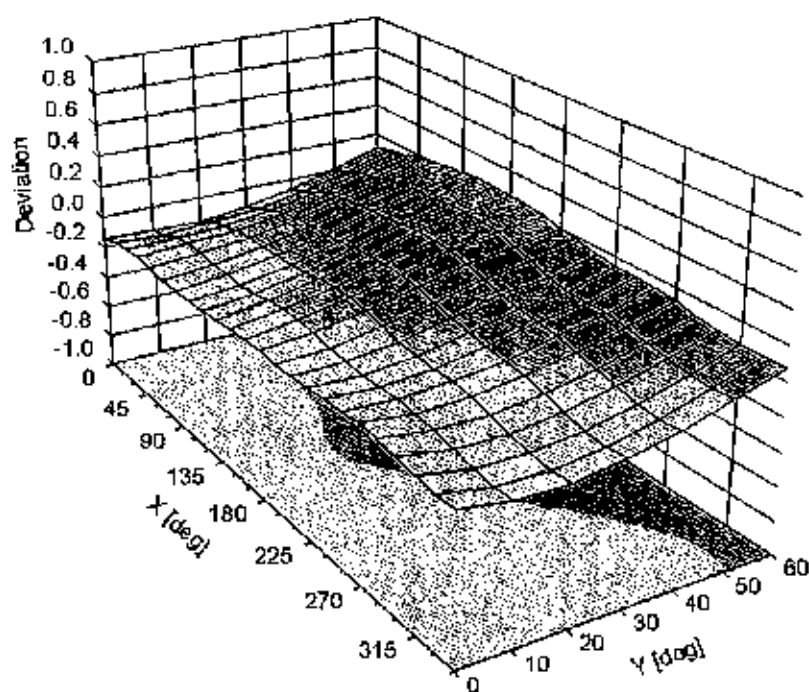
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ),  $f = 900 \text{ MHz}$



**DASY/EASY - Parameters of Probe: ES3DV3 - SN:3333****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -32.8      |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 10 mm      |
| Tip Diameter                                  | 4 mm       |
| Probe Tip to Sensor X Calibration Point       | 2 mm       |
| Probe Tip to Sensor Y Calibration Point       | 2 mm       |
| Probe Tip to Sensor Z Calibration Point       | 2 mm       |
| Recommended Measurement Distance from Surface | 3 mm       |



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 Multilateral Agreement for the recognition of calibration certificates

Client **PC Test**

Certificate No: **EX3-7308\_Jul15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7308**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6**  
**Calibration procedure for dosimetric E-field probes**

Calibration date: **July 21, 2015**

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 E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
|                            |                 |                                   |                        |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

|                |                         |                                   |                       |
|----------------|-------------------------|-----------------------------------|-----------------------|
| Calibrated by: | Name<br>Claudio Leubler | Function<br>Laboratory Technician | Signature<br>         |
| Approved by:   | Katja Pokovic           | Technical Manager                 |                       |
|                |                         |                                   | Issued: July 22, 2015 |

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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 $\varphi$   | $\varphi$ rotation around probe axis                                                                                                                    |
| Polarization $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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  $\vartheta = 0$  ( $f \leq 900$  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  $E^2$ -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.
- DCPx,y,z**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (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>; 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).

# Probe EX3DV4

## SN:7308

Manufactured: March 11, 2014  
Calibrated: July 21, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7308

### Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.50     | 0.60     | 0.45     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 98.7     | 98.5     | 103.0    |               |

### 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    | 157.9    | $\pm 3.3 \%$              |
|           |                                                         | Y | 0.0     | 0.0                          | 1.0  |         | 152.7    |                           |
|           |                                                         | Z | 0.0     | 0.0                          | 1.0  |         | 146.1    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)                    | X | 1.57    | 63.2                         | 12.0 | 10.00   | 44.9     | $\pm 0.9 \%$              |
|           |                                                         | Y | 4.80    | 74.9                         | 16.5 |         | 43.8     |                           |
|           |                                                         | Z | 0.93    | 58.1                         | 8.8  |         | 41.8     |                           |
| 10062-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps)                | X | 10.36   | 69.2                         | 21.9 | 8.68    | 145.4    | $\pm 3.3 \%$              |
|           |                                                         | Y | 10.44   | 69.2                         | 21.9 |         | 144.1    |                           |
|           |                                                         | Z | 9.89    | 68.5                         | 21.5 |         | 130.2    |                           |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)                | X | 10.03   | 68.2                         | 20.8 | 8.07    | 127.1    | $\pm 3.0 \%$              |
|           |                                                         | Y | 10.43   | 69.2                         | 21.4 |         | 148.2    |                           |
|           |                                                         | Z | 10.05   | 68.6                         | 21.1 |         | 138.2    |                           |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)                 | X | 10.03   | 68.9                         | 21.4 | 8.10    | 146.1    | $\pm 3.0 \%$              |
|           |                                                         | Y | 10.09   | 68.9                         | 21.4 |         | 143.5    |                           |
|           |                                                         | Z | 9.59    | 68.3                         | 21.1 |         | 131.0    |                           |
| 10317-AAB | IEEE 802.11a WiFi 5 GHz (OFDM, 6 Mbps, 96pc duty cycle) | X | 10.17   | 69.0                         | 21.6 | 8.36    | 144.5    | $\pm 3.3 \%$              |
|           |                                                         | Y | 10.23   | 69.0                         | 21.6 |         | 141.8    |                           |
|           |                                                         | Z | 9.72    | 68.4                         | 21.3 |         | 130.2    |                           |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)     | X | 10.28   | 69.1                         | 21.6 | 8.37    | 144.6    | $\pm 3.3 \%$              |
|           |                                                         | Y | 10.32   | 69.1                         | 21.6 |         | 142.0    |                           |
|           |                                                         | Z | 9.81    | 68.5                         | 21.3 |         | 129.4    |                           |
| 10401-AAC | IEEE 802.11ac WiFi (40MHz, 64-QAM, 99pc duty cycle)     | X | 10.70   | 68.8                         | 21.5 | 8.60    | 129.8    | $\pm 3.0 \%$              |
|           |                                                         | Y | 10.55   | 68.4                         | 21.2 |         | 123.2    |                           |
|           |                                                         | Z | 10.64   | 69.1                         | 21.6 |         | 140.3    |                           |
| 10402-AAC | IEEE 802.11ac WiFi (80MHz, 64-QAM, 99pc duty cycle)     | X | 10.84   | 69.0                         | 21.4 | 8.53    | 130.1    | $\pm 3.0 \%$              |
|           |                                                         | Y | 10.57   | 68.4                         | 21.0 |         | 123.5    |                           |
|           |                                                         | Z | 10.91   | 69.6                         | 21.7 |         | 142.7    |                           |

|           |                                                           |   |       |      |      |      |       |        |
|-----------|-----------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10417-AAA | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps, 99pc duty cycle) | X | 10.10 | 68.9 | 21.5 | 8.23 | 145.0 | ±3.0 % |
|           |                                                           | Y | 10.15 | 68.9 | 21.5 |      | 142.0 |        |
|           |                                                           | Z | 9.64  | 68.3 | 21.1 |      | 130.3 |        |

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 Pages 6 and 7).

<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.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7308

### 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) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 5250                 | 35.9                               | 4.71                            | 5.20    | 5.20    | 5.20    | 0.35               | 1.80                    | ± 13.1 %  |
| 5600                 | 35.5                               | 5.07                            | 4.65    | 4.65    | 4.65    | 0.40               | 1.80                    | ± 13.1 %  |
| 5750                 | 35.4                               | 5.22                            | 4.86    | 4.86    | 4.86    | 0.40               | 1.80                    | ± 13.1 %  |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7308

### Calibration Parameter Determined in Body 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) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 5250                 | 48.9                               | 5.36                            | 4.63    | 4.63    | 4.63    | 0.40               | 1.90                    | ± 13.1 %  |
| 5600                 | 48.5                               | 5.77                            | 3.92    | 3.92    | 3.92    | 0.50               | 1.90                    | ± 13.1 %  |
| 5750                 | 48.3                               | 5.94                            | 4.24    | 4.24    | 4.24    | 0.50               | 1.90                    | ± 13.1 %  |

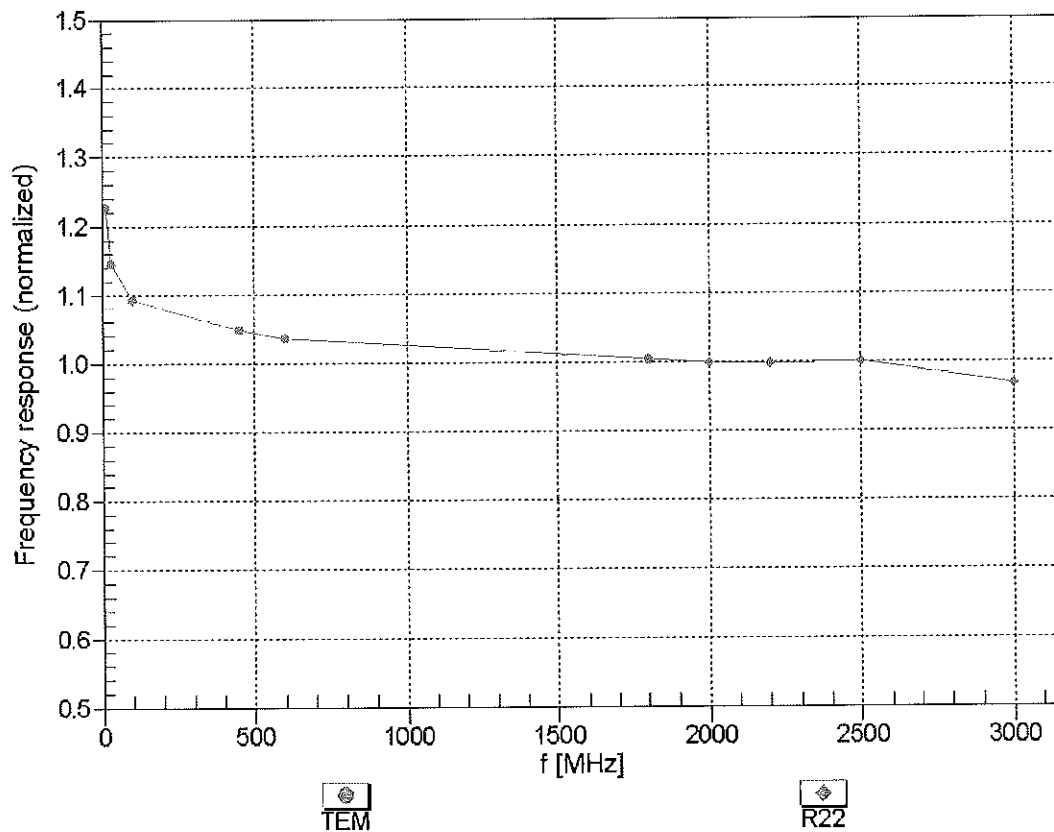
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

## Frequency Response of E-Field

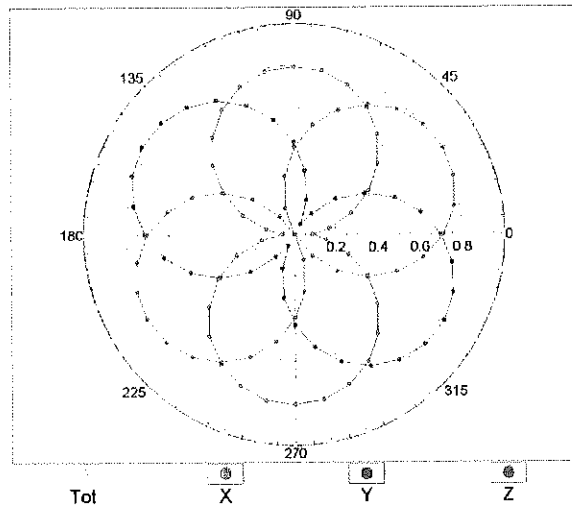
(TEM-Cell:ifi110 EXX, Waveguide: R22)



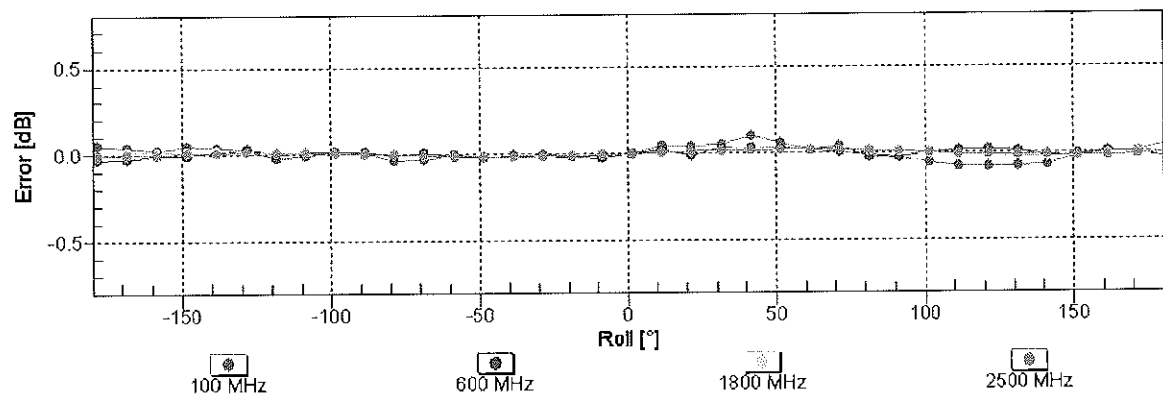
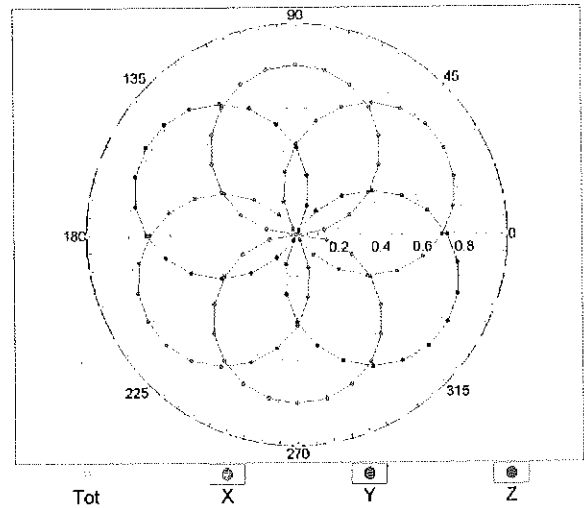
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM

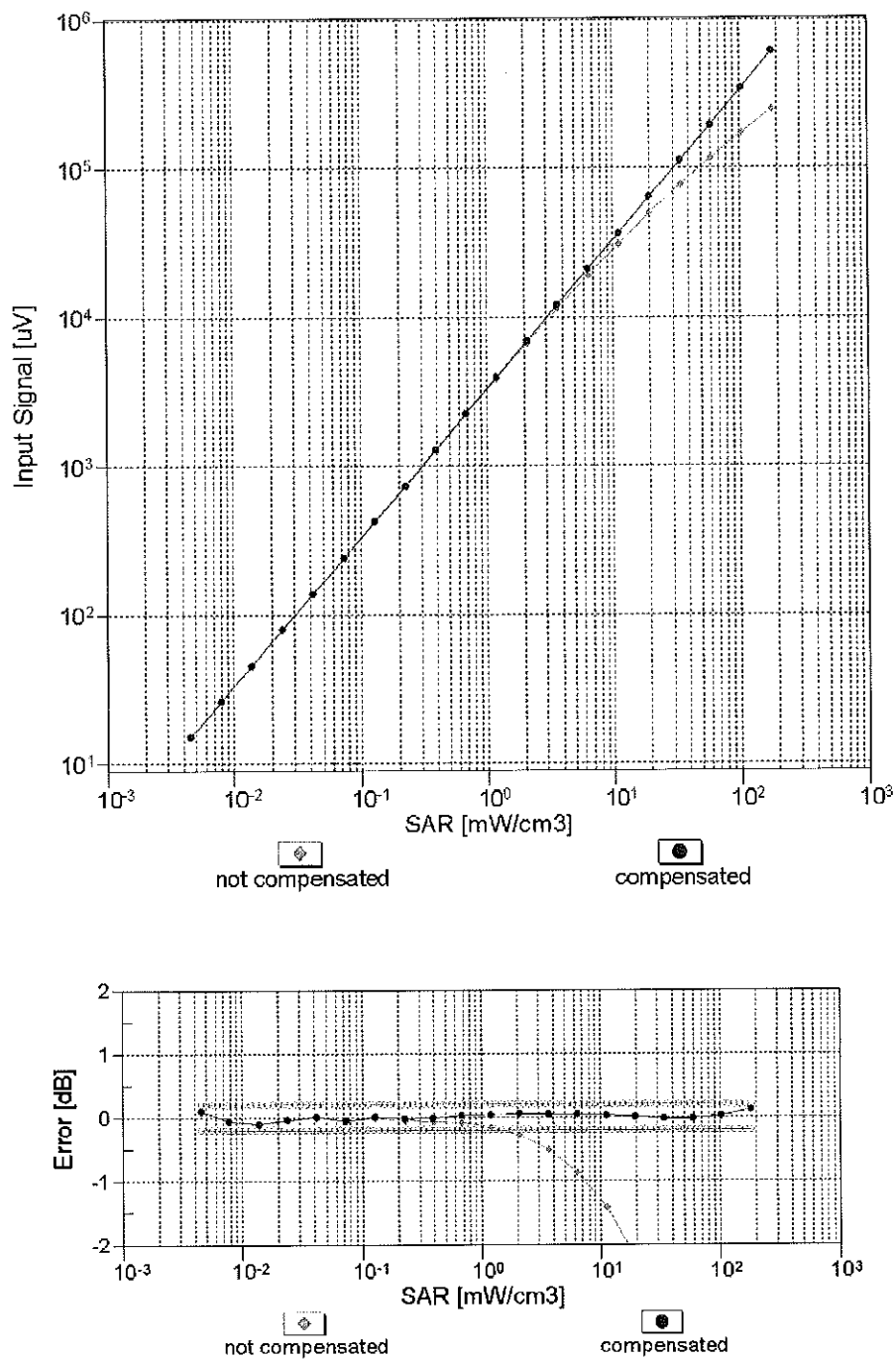


f=1800 MHz,R22



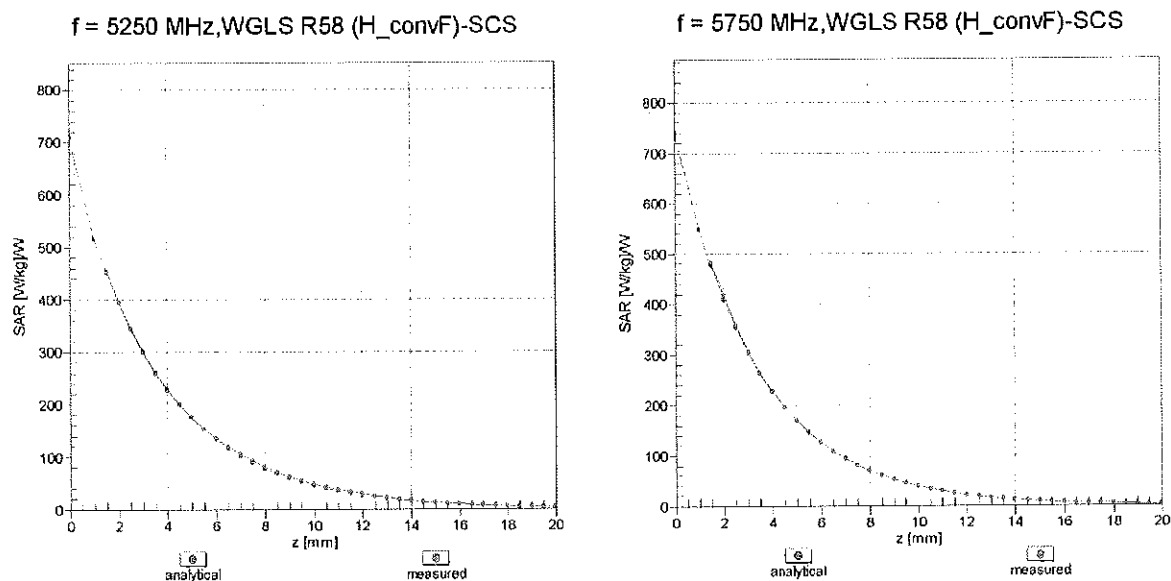
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

## Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$ )



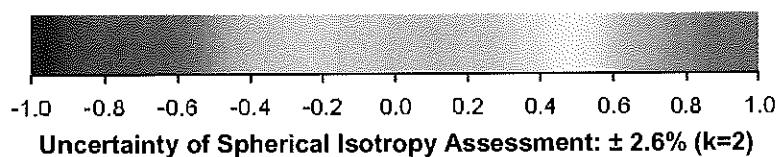
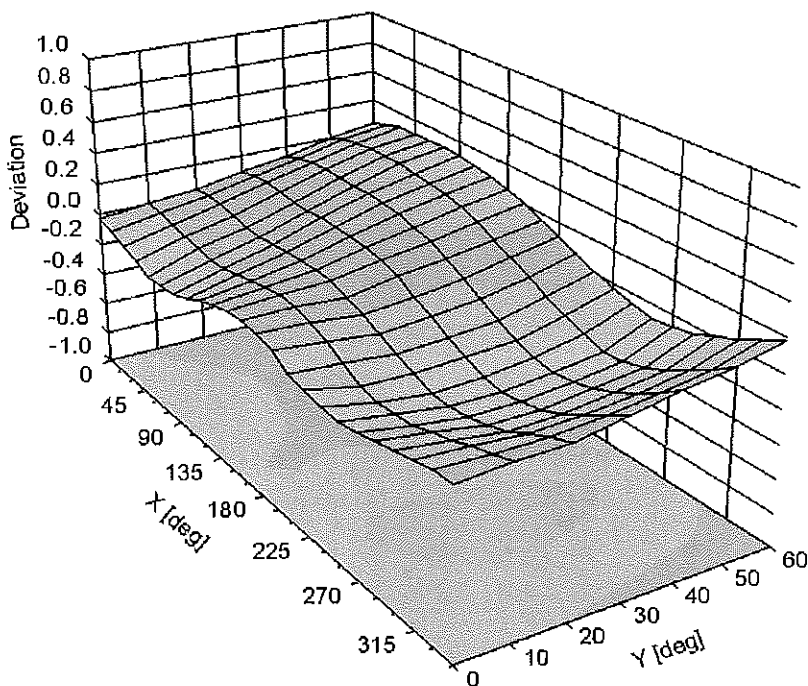
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \vartheta$ ),  $f = 900 \text{ MHz}$



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7308

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 111.5      |
| 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     |



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 **PG Test**

Certificate No: **ES3-3334\_Nov15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3334**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6**  
**Calibration procedure for dosimetric E-field probes**

BV ✓  
 11/24/15

Calibration date: **November 17, 2015**

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 E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US3739J585      | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

|                                                                                                                 | Name            | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|-----------|
| Calibrated by:                                                                                                  | Jeton Kastrioti | Laboratory Technician |           |
| Approved by:                                                                                                    | Katja Pokovic   | Technical Manager     |           |
| Issued: November 17, 2015                                                                                       |                 |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                 |                       |           |



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

## 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 $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- 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  $\vartheta = 0$  ( $f \leq 900$  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  $E^2$ -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 with CW signal (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>; 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).

# Probe ES3DV3

## SN:3334

Manufactured: January 24, 2012  
Calibrated: November 17, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

## Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)    |
|-----------------------------------------------------------|----------|----------|----------|--------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 1.03     | 1.03     | 0.99     | $\pm 10.1\%$ |
| DCP (mV) <sup>B</sup>                                     | 107.6    | 105.3    | 107.9    |              |

## 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    | 192.1    | $\pm 2.7\%$               |
|               |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 183.6    |                           |
|               |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 183.3    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 2.27    | 60.1                         | 10.2 | 10.00   | 38.6     | $\pm 1.4\%$               |
|               |                                               | Y | 1.99    | 59.3                         | 10.2 |         | 38.4     |                           |
|               |                                               | Z | 5.38    | 67.8                         | 12.9 |         | 37.2     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.40    | 68.0                         | 18.9 | 2.91    | 131.7    | $\pm 0.5\%$               |
|               |                                               | Y | 3.27    | 67.0                         | 18.2 |         | 130.2    |                           |
|               |                                               | Z | 3.41    | 68.3                         | 19.1 |         | 148.5    |                           |
| 10012-<br>CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 2.93    | 68.9                         | 18.7 | 1.87    | 132.9    | $\pm 0.7\%$               |
|               |                                               | Y | 3.12    | 69.6                         | 18.8 |         | 130.2    |                           |
|               |                                               | Z | 3.24    | 71.1                         | 19.7 |         | 128.2    |                           |
| 10013-<br>CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.90   | 70.3                         | 23.0 | 9.46    | 133.5    | $\pm 3.3\%$               |
|               |                                               | Y | 10.53   | 69.0                         | 22.1 |         | 124.6    |                           |
|               |                                               | Z | 11.14   | 71.2                         | 23.6 |         | 147.1    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 15.05   | 91.0                         | 24.4 | 9.39    | 139.5    | $\pm 1.9\%$               |
|               |                                               | Y | 10.11   | 85.5                         | 23.3 |         | 131.9    |                           |
|               |                                               | Z | 11.84   | 87.6                         | 23.4 |         | 130.0    |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 10.42   | 84.9                         | 22.6 | 9.57    | 131.5    | $\pm 3.0\%$               |
|               |                                               | Y | 13.29   | 89.7                         | 24.6 |         | 141.1    |                           |
|               |                                               | Z | 14.17   | 90.2                         | 24.2 |         | 148.7    |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 11.26   | 83.1                         | 19.4 | 6.56    | 140.7    | $\pm 1.9\%$               |
|               |                                               | Y | 26.29   | 95.5                         | 23.8 |         | 134.7    |                           |
|               |                                               | Z | 16.82   | 88.9                         | 21.3 |         | 131.6    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 64.74   | 99.9                         | 22.2 | 4.80    | 131.5    | $\pm 2.2\%$               |
|               |                                               | Y | 56.71   | 99.8                         | 22.7 |         | 124.7    |                           |
|               |                                               | Z | 63.10   | 99.9                         | 22.2 |         | 124.1    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 62.11   | 99.6                         | 21.6 | 3.55    | 146.1    | $\pm 1.9\%$               |
|               |                                               | Y | 77.61   | 99.8                         | 21.2 |         | 132.0    |                           |
|               |                                               | Z | 72.33   | 99.7                         | 21.2 |         | 133.3    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 96.24   | 92.7                         | 15.9 | 1.16    | 137.2    | $\pm 1.7\%$               |
|               |                                               | Y | 95.69   | 93.1                         | 16.2 |         | 129.5    |                           |
|               |                                               | Z | 98.67   | 94.1                         | 16.4 |         | 149.7    |                           |
| 10100-<br>CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.14    | 66.8                         | 19.2 | 5.67    | 126.2    | $\pm 1.7\%$               |
|               |                                               | Y | 6.21    | 66.8                         | 19.1 |         | 139.9    |                           |
|               |                                               | Z | 6.41    | 67.9                         | 19.9 |         | 145.9    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.07 | 75.4 | 25.8 | 9.29 | 138.2 | ±2.5 % |
|           |                                          | Y | 9.54  | 73.3 | 24.5 |      | 130.5 |        |
|           |                                          | Z | 9.84  | 75.1 | 25.8 |      | 130.6 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.34  | 67.6 | 19.8 | 5.80 | 149.5 | ±1.4 % |
|           |                                          | Y | 6.13  | 66.6 | 19.1 |      | 132.1 |        |
|           |                                          | Z | 6.19  | 67.2 | 19.7 |      | 137.8 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.13 | 68.9 | 21.2 | 8.07 | 138.8 | ±2.7 % |
|           |                                          | Y | 10.16 | 68.9 | 21.1 |      | 149.6 |        |
|           |                                          | Z | 9.96  | 68.7 | 21.1 |      | 127.1 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 9.42  | 74.4 | 25.5 | 9.28 | 132.9 | ±3.0 % |
|           |                                          | Y | 9.50  | 74.0 | 25.0 |      | 143.7 |        |
|           |                                          | Z | 9.01  | 73.4 | 25.0 |      | 126.5 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 6.03  | 67.1 | 19.6 | 5.75 | 145.5 | ±1.4 % |
|           |                                          | Y | 5.81  | 66.0 | 18.9 |      | 128.9 |        |
|           |                                          | Z | 5.91  | 66.8 | 19.5 |      | 135.1 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.19  | 66.5 | 19.2 | 5.82 | 126.7 | ±1.4 % |
|           |                                          | Y | 6.20  | 66.4 | 19.0 |      | 132.8 |        |
|           |                                          | Z | 6.39  | 67.5 | 19.8 |      | 141.1 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 5.05  | 67.6 | 20.0 | 5.73 | 146.8 | ±1.4 % |
|           |                                          | Y | 4.82  | 66.2 | 19.2 |      | 132.2 |        |
|           |                                          | Z | 4.96  | 67.4 | 20.0 |      | 143.8 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 8.88  | 79.7 | 28.3 | 9.21 | 147.9 | ±3.0 % |
|           |                                          | Y | 8.00  | 76.1 | 26.2 |      | 138.9 |        |
|           |                                          | Z | 8.39  | 78.5 | 27.8 |      | 141.5 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 4.99  | 67.3 | 19.9 | 5.72 | 140.7 | ±1.2 % |
|           |                                          | Y | 4.80  | 66.2 | 19.1 |      | 131.3 |        |
|           |                                          | Z | 4.90  | 67.1 | 19.8 |      | 136.1 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.99  | 67.3 | 19.9 | 5.72 | 145.4 | ±1.4 % |
|           |                                          | Y | 4.81  | 66.2 | 19.2 |      | 130.9 |        |
|           |                                          | Z | 4.89  | 67.1 | 19.8 |      | 136.0 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.78  | 68.8 | 21.3 | 8.10 | 131.0 | ±2.5 % |
|           |                                          | Y | 9.73  | 68.4 | 21.0 |      | 140.7 |        |
|           |                                          | Z | 9.94  | 69.4 | 21.6 |      | 146.6 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 6.88  | 66.9 | 19.3 | 5.97 | 133.9 | ±1.7 % |
|           |                                          | Y | 6.96  | 67.1 | 19.3 |      | 144.8 |        |
|           |                                          | Z | 6.71  | 66.6 | 19.2 |      | 125.7 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 9.00  | 80.2 | 28.5 | 9.21 | 148.2 | ±3.0 % |
|           |                                          | Y | 7.73  | 75.1 | 25.7 |      | 131.6 |        |
|           |                                          | Z | 8.27  | 78.2 | 27.7 |      | 136.1 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 9.59  | 76.3 | 26.7 | 9.24 | 144.1 | ±2.7 % |
|           |                                          | Y | 8.74  | 72.9 | 24.5 |      | 133.4 |        |
|           |                                          | Z | 9.14  | 75.2 | 26.1 |      | 136.9 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.25  | 73.9 | 25.3 | 9.30 | 124.8 | ±3.0 % |
|           |                                          | Y | 9.40  | 73.7 | 24.9 |      | 142.1 |        |
|           |                                          | Z | 9.86  | 76.1 | 26.5 |      | 145.3 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.38  | 66.9 | 18.7 | 3.96 | 133.3 | ±0.9 % |
|           |                                                               | Y | 4.44  | 66.9 | 18.6 |      | 148.2 |        |
|           |                                                               | Z | 4.30  | 66.7 | 18.6 |      | 128.9 |        |
| 10291-AAB | CDMA2000, RC3, SQ55, Full Rate                                | X | 3.68  | 67.3 | 18.7 | 3.46 | 145.8 | ±0.7 % |
|           |                                                               | Y | 3.58  | 66.6 | 18.2 |      | 136.3 |        |
|           |                                                               | Z | 3.62  | 67.3 | 18.8 |      | 139.4 |        |
| 10292-AAB | CDMA2000, RC3, SQ32, Full Rate                                | X | 3.73  | 68.0 | 19.1 | 3.39 | 147.5 | ±0.7 % |
|           |                                                               | Y | 3.55  | 66.7 | 18.3 |      | 138.5 |        |
|           |                                                               | Z | 3.60  | 67.6 | 18.9 |      | 143.0 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.30  | 67.4 | 19.7 | 5.81 | 141.4 | ±1.2 % |
|           |                                                               | Y | 6.11  | 66.5 | 19.1 |      | 130.3 |        |
|           |                                                               | Z | 6.17  | 67.0 | 19.5 |      | 136.8 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.88  | 68.0 | 20.1 | 6.06 | 147.0 | ±1.7 % |
|           |                                                               | Y | 6.68  | 67.1 | 19.5 |      | 136.0 |        |
|           |                                                               | Z | 6.75  | 67.7 | 20.0 |      | 141.6 |        |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 9.97  | 68.8 | 21.4 | 8.37 | 126.9 | ±2.7 % |
|           |                                                               | Y | 10.07 | 68.9 | 21.4 |      | 143.6 |        |
|           |                                                               | Z | 10.21 | 69.7 | 22.0 |      | 147.4 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.77  | 68.5 | 18.8 | 3.76 | 134.9 | ±0.5 % |
|           |                                                               | Y | 4.69  | 68.1 | 18.5 |      | 126.7 |        |
|           |                                                               | Z | 4.74  | 68.8 | 18.9 |      | 129.4 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.72  | 68.7 | 18.8 | 3.77 | 132.9 | ±0.7 % |
|           |                                                               | Y | 4.78  | 68.9 | 18.9 |      | 147.4 |        |
|           |                                                               | Z | 4.63  | 68.7 | 18.9 |      | 127.1 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.72  | 68.9 | 18.8 | 1.54 | 131.9 | ±0.5 % |
|           |                                                               | Y | 2.65  | 68.0 | 18.1 |      | 145.9 |        |
|           |                                                               | Z | 2.72  | 69.3 | 19.0 |      | 127.3 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.81  | 68.6 | 21.2 | 8.23 | 131.6 | ±2.7 % |
|           |                                                               | Y | 9.90  | 68.7 | 21.2 |      | 144.1 |        |
|           |                                                               | Z | 9.97  | 69.3 | 21.7 |      | 146.0 |        |

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 Pages 7 and 8).

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

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

### Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) <sup>c</sup> | Relative Permittivity <sup>e</sup> | Conductivity (S/m) <sup>e</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>g</sup> | Depth (mm) <sup>c</sup> | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 6                    | 55.5                               | 0.75                            | 6.13    | 6.13    | 6.13    | 0.00               | 1.00                    | ± 13.3 %  |
| 13                   | 55.5                               | 0.75                            | 5.76    | 5.76    | 5.76    | 0.00               | 1.00                    | ± 13.3 %  |
| 750                  | 41.9                               | 0.89                            | 6.56    | 6.56    | 6.56    | 0.24               | 2.36                    | ± 12.0 %  |
| 835                  | 41.5                               | 0.90                            | 6.37    | 6.37    | 6.37    | 0.37               | 1.70                    | ± 12.0 %  |
| 1750                 | 40.1                               | 1.37                            | 5.39    | 5.39    | 5.39    | 0.58               | 1.32                    | ± 12.0 %  |
| 1900                 | 40.0                               | 1.40                            | 5.18    | 5.18    | 5.18    | 0.77               | 1.20                    | ± 12.0 %  |
| 2300                 | 39.5                               | 1.67                            | 4.85    | 4.85    | 4.85    | 0.71               | 1.28                    | ± 12.0 %  |
| 2450                 | 39.2                               | 1.80                            | 4.58    | 4.58    | 4.58    | 0.79               | 1.17                    | ± 12.0 %  |
| 2600                 | 39.0                               | 1.96                            | 4.46    | 4.46    | 4.46    | 0.80               | 1.26                    | ± 12.0 %  |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

### Calibration Parameter Determined in Body 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) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750                  | 55.5                               | 0.96                            | 6.37    | 6.37    | 6.37    | 0.74               | 1.22                    | ± 12.0 %  |
| 835                  | 55.2                               | 0.97                            | 6.24    | 6.24    | 6.24    | 0.31               | 1.94                    | ± 12.0 %  |
| 1750                 | 53.4                               | 1.49                            | 5.03    | 5.03    | 5.03    | 0.50               | 1.57                    | ± 12.0 %  |
| 1900                 | 53.3                               | 1.52                            | 4.84    | 4.84    | 4.84    | 0.50               | 1.58                    | ± 12.0 %  |
| 2300                 | 52.9                               | 1.81                            | 4.61    | 4.61    | 4.61    | 0.74               | 1.23                    | ± 12.0 %  |
| 2450                 | 52.7                               | 1.95                            | 4.45    | 4.45    | 4.45    | 0.74               | 1.20                    | ± 12.0 %  |
| 2600                 | 52.5                               | 2.16                            | 4.29    | 4.29    | 4.29    | 0.80               | 1.20                    | ± 12.0 %  |

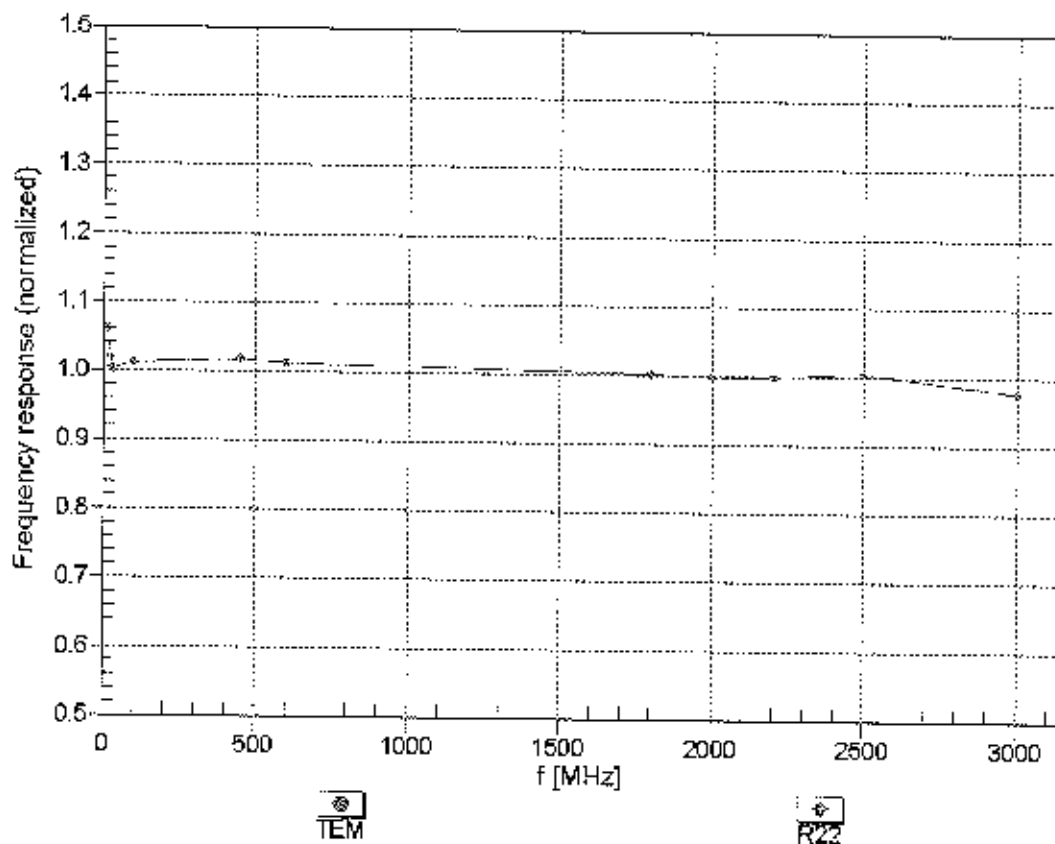
<sup>c</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

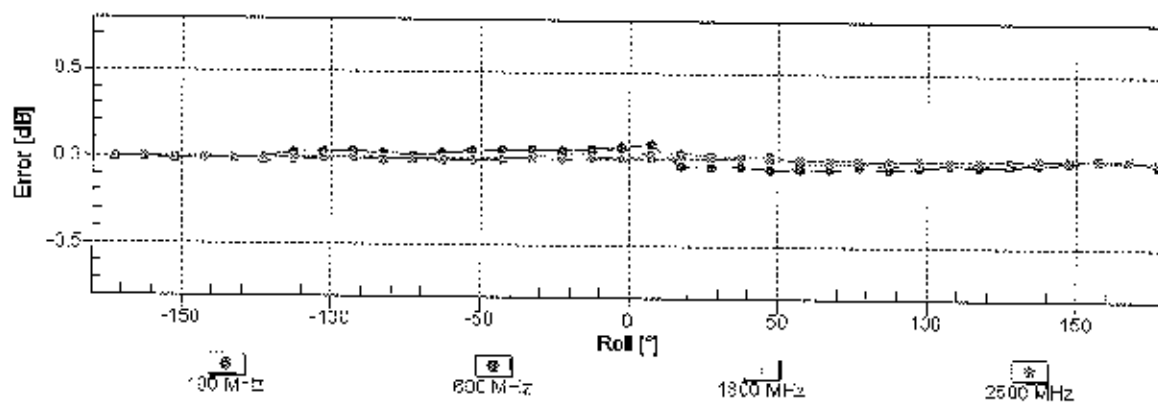
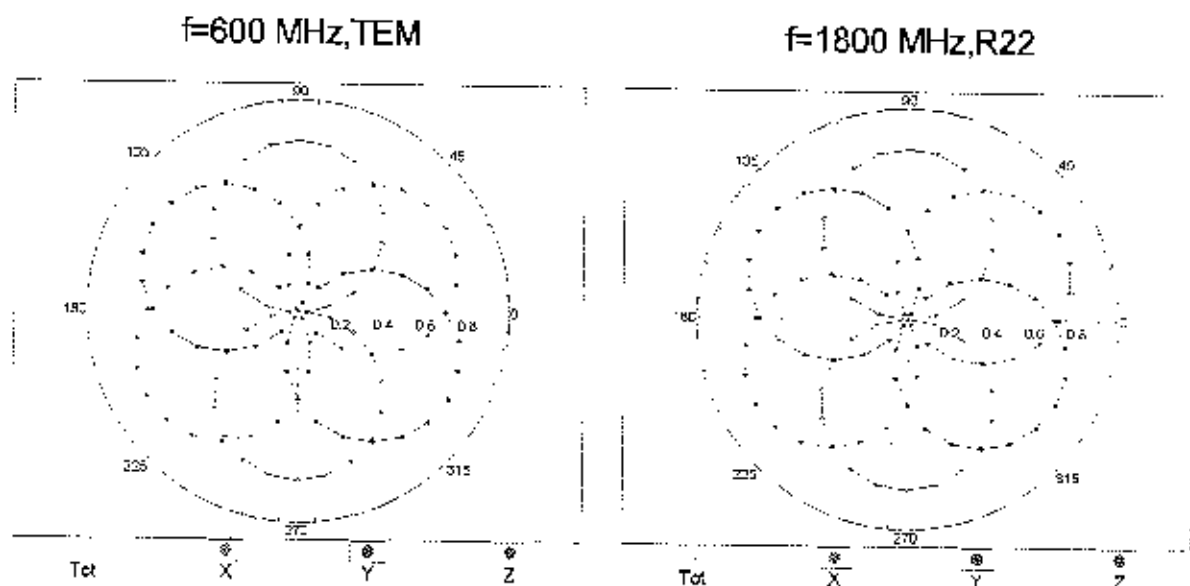
## Frequency Response of E-Field

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



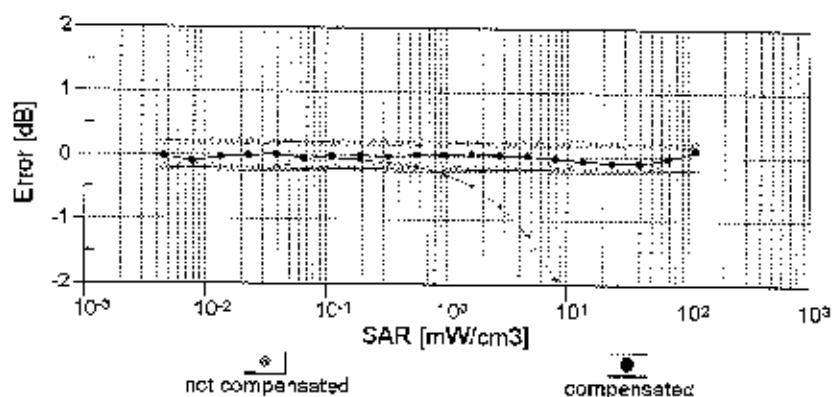
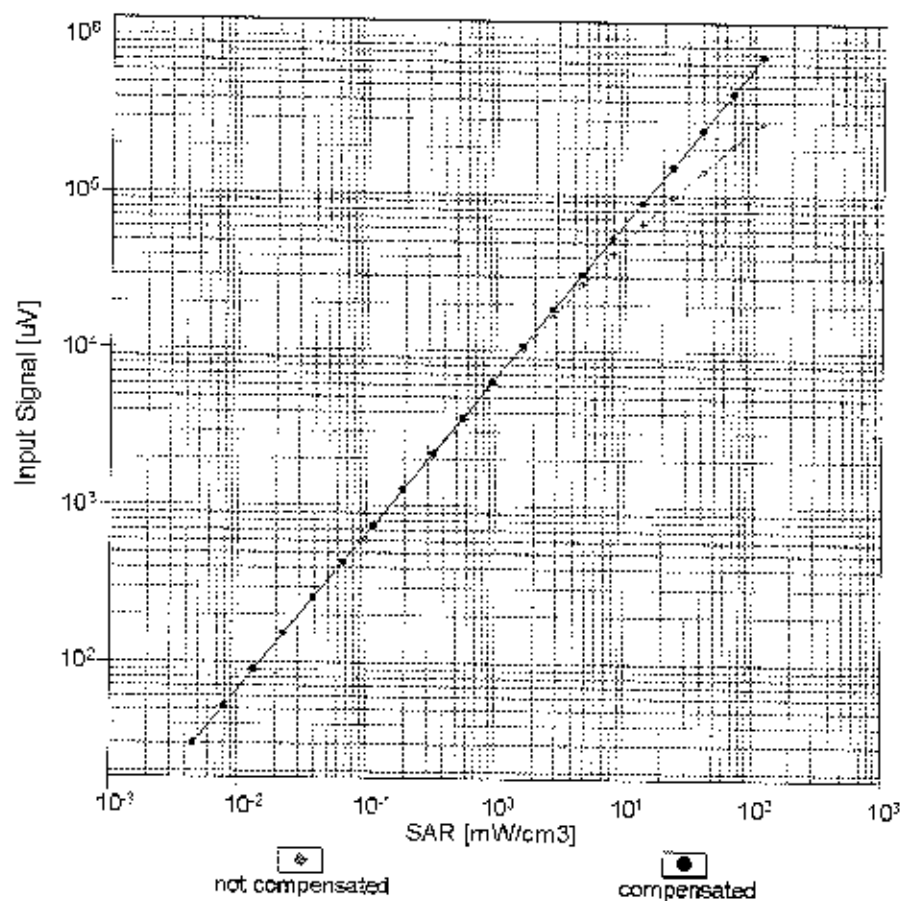
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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



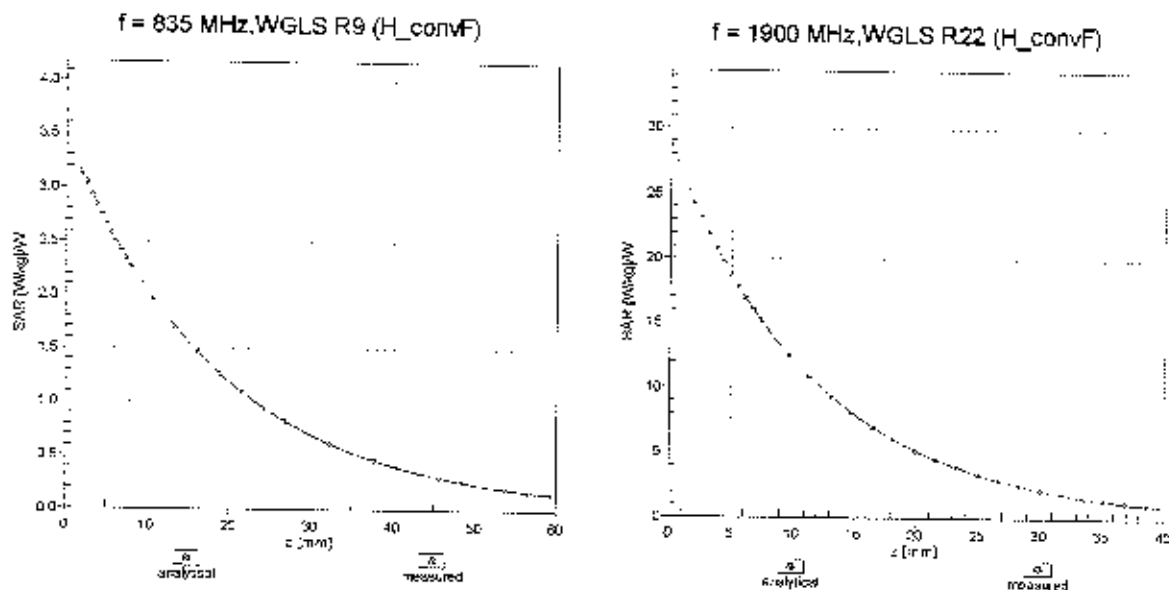
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

# Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$ )



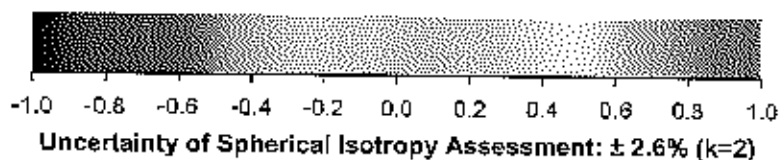
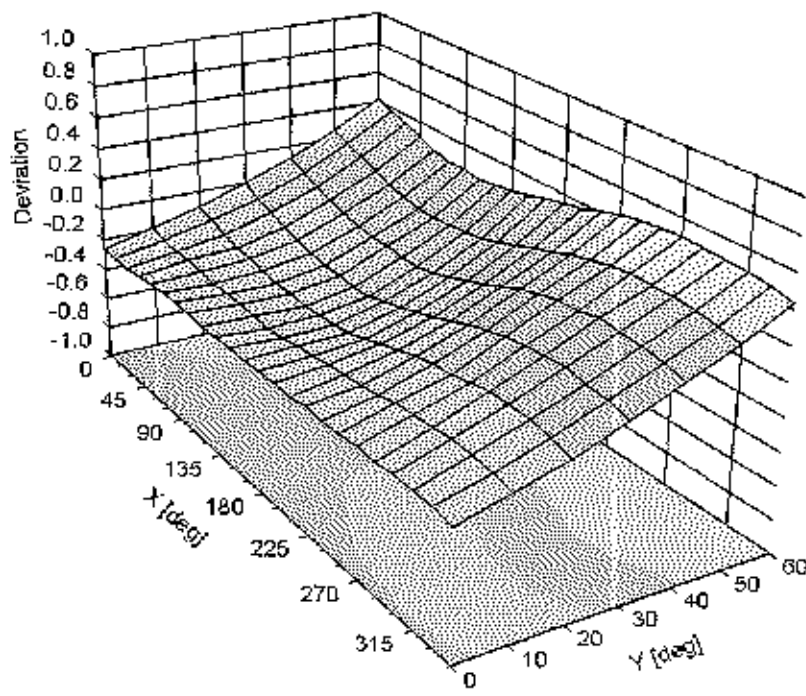
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ),  $f = 900 \text{ MHz}$



Uncertainty of Spherical Isotropy Assessment:  $\pm 2.6\%$  ( $k=2$ )

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 17.4       |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 10 mm      |
| Tip Diameter                                  | 4 mm       |
| Probe Tip to Sensor X Calibration Point       | 2 mm       |
| Probe Tip to Sensor Y Calibration Point       | 2 mm       |
| Probe Tip to Sensor Z Calibration Point       | 2 mm       |
| Recommended Measurement Distance from Surface | 3 mm       |



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **ES3-3263\_May15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3263**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v6**  
**Calibration procedure for dosimetric E-field probes**

Calibration date: **May 20, 2015**

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 E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

|                |                              |                                          |               |
|----------------|------------------------------|------------------------------------------|---------------|
| Calibrated by: | Name<br><b>Leif Klysner</b>  | Function<br><b>Laboratory Technician</b> | Signature<br> |
| Approved by:   | Name<br><b>Katja Pokovic</b> | Function<br><b>Technical Manager</b>     | Signature<br> |

Issued: May 19, 2015

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

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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 $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

## Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  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  $E^2$ -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 with CW signal (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>; 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).

# Probe ES3DV3

## SN:3263

Manufactured: January 25, 2010  
Calibrated: May 20, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3263

## Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 1.21     | 1.25     | 1.13     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 106.1    | 103.6    | 108.3    |               |

## 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    | 205.3    | $\pm 3.3 \%$              |
|           |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 207.3    |                           |
|           |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 199.5    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)          | X | 1.83    | 58.4                         | 9.4  | 10.00   | 41.2     | $\pm 1.4 \%$              |
|           |                                               | Y | 3.88    | 63.3                         | 12.9 |         | 47.5     |                           |
|           |                                               | Z | 1.42    | 56.8                         | 8.7  |         | 39.5     |                           |
| 10011-CAB | UMTS-FDD (WCDMA)                              | X | 3.27    | 67.4                         | 18.6 | 2.91    | 140.1    | $\pm 0.7 \%$              |
|           |                                               | Y | 3.39    | 67.5                         | 18.7 |         | 142.7    |                           |
|           |                                               | Z | 3.32    | 67.6                         | 18.6 |         | 136.9    |                           |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 2.85    | 68.8                         | 18.8 | 1.87    | 142.2    | $\pm 0.7 \%$              |
|           |                                               | Y | 3.38    | 70.7                         | 19.5 |         | 144.8    |                           |
|           |                                               | Z | 3.07    | 70.0                         | 19.1 |         | 138.1    |                           |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.99   | 70.8                         | 23.4 | 9.46    | 135.9    | $\pm 2.5 \%$              |
|           |                                               | Y | 11.36   | 70.3                         | 22.8 |         | 124.7    |                           |
|           |                                               | Z | 10.57   | 70.0                         | 22.9 |         | 129.4    |                           |
| 10021-DAB | GSM-FDD (TDMA, GMSK)                          | X | 9.38    | 84.7                         | 22.1 | 9.39    | 139.8    | $\pm 1.9 \%$              |
|           |                                               | Y | 27.79   | 100.0                        | 28.7 |         | 129.4    |                           |
|           |                                               | Z | 9.29    | 86.8                         | 23.8 |         | 134.5    |                           |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 9.63    | 84.9                         | 22.1 | 9.57    | 134.1    | $\pm 2.5 \%$              |
|           |                                               | Y | 25.29   | 98.2                         | 28.2 |         | 124.0    |                           |
|           |                                               | Z | 9.65    | 87.7                         | 24.3 |         | 128.2    |                           |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 16.20   | 88.9                         | 21.0 | 6.56    | 145.2    | $\pm 1.4 \%$              |
|           |                                               | Y | 41.82   | 99.7                         | 25.6 |         | 128.5    |                           |
|           |                                               | Z | 24.57   | 96.8                         | 24.1 |         | 142.0    |                           |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 55.77   | 99.6                         | 22.1 | 4.80    | 138.5    | $\pm 2.2 \%$              |
|           |                                               | Y | 53.39   | 99.7                         | 23.9 |         | 140.5    |                           |
|           |                                               | Z | 40.28   | 99.6                         | 23.2 |         | 134.3    |                           |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 81.43   | 99.8                         | 20.7 | 3.55    | 148.6    | $\pm 1.7 \%$              |
|           |                                               | Y | 60.49   | 99.7                         | 22.9 |         | 146.0    |                           |
|           |                                               | Z | 62.69   | 99.6                         | 21.2 |         | 145.0    |                           |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 96.06   | 93.7                         | 16.0 | 1.16    | 140.3    | $\pm 1.9 \%$              |
|           |                                               | Y | 77.08   | 99.9                         | 20.1 |         | 149.0    |                           |
|           |                                               | Z | 99.64   | 99.9                         | 18.6 |         | 138.0    |                           |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.24    | 67.2                         | 19.6 | 5.67    | 131.7    | $\pm 1.4 \%$              |
|           |                                               | Y | 6.39    | 67.3                         | 19.5 |         | 133.8    |                           |
|           |                                               | Z | 6.19    | 67.2                         | 19.6 |         | 126.8    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.13 | 76.3 | 26.6 | 9.29 | 142.6 | ±2.7 % |
|           |                                          | Y | 12.07 | 77.9 | 26.6 |      | 138.9 |        |
|           |                                          | Z | 9.41  | 74.3 | 25.6 |      | 134.1 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.13  | 66.9 | 19.5 | 5.80 | 129.6 | ±1.4 % |
|           |                                          | Y | 6.35  | 67.1 | 19.5 |      | 133.7 |        |
|           |                                          | Z | 6.39  | 68.0 | 20.1 |      | 150.0 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.34 | 69.6 | 21.7 | 8.07 | 147.0 | ±1.9 % |
|           |                                          | Y | 10.05 | 68.3 | 20.9 |      | 123.4 |        |
|           |                                          | Z | 10.08 | 69.1 | 21.3 |      | 138.2 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 9.44  | 75.3 | 26.3 | 9.28 | 137.0 | ±3.5 % |
|           |                                          | Y | 11.36 | 76.9 | 26.3 |      | 134.5 |        |
|           |                                          | Z | 8.85  | 73.5 | 25.3 |      | 130.3 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 5.79  | 66.2 | 19.2 | 5.75 | 126.9 | ±1.2 % |
|           |                                          | Y | 6.05  | 66.5 | 19.3 |      | 130.9 |        |
|           |                                          | Z | 5.92  | 66.9 | 19.5 |      | 145.5 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.25  | 66.9 | 19.5 | 5.82 | 131.8 | ±1.4 % |
|           |                                          | Y | 6.47  | 67.0 | 19.5 |      | 135.4 |        |
|           |                                          | Z | 6.09  | 66.5 | 19.3 |      | 127.5 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 4.78  | 66.7 | 19.7 | 5.73 | 130.0 | ±1.2 % |
|           |                                          | Y | 5.14  | 66.7 | 19.5 |      | 135.0 |        |
|           |                                          | Z | 4.83  | 67.1 | 19.9 |      | 147.9 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 8.63  | 80.4 | 29.1 | 9.21 | 147.7 | ±2.7 % |
|           |                                          | Y | 9.72  | 78.5 | 27.2 |      | 123.9 |        |
|           |                                          | Z | 7.63  | 76.7 | 27.2 |      | 142.5 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 4.75  | 66.6 | 19.6 | 5.72 | 128.2 | ±1.2 % |
|           |                                          | Y | 5.12  | 66.6 | 19.5 |      | 134.3 |        |
|           |                                          | Z | 4.87  | 67.1 | 19.9 |      | 148.0 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.76  | 66.6 | 19.6 | 5.72 | 127.9 | ±1.2 % |
|           |                                          | Y | 5.12  | 66.6 | 19.5 |      | 134.5 |        |
|           |                                          | Z | 4.87  | 67.3 | 20.0 |      | 147.0 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.87  | 69.1 | 21.6 | 8.10 | 135.8 | ±2.2 % |
|           |                                          | Y | 10.19 | 69.1 | 21.4 |      | 145.3 |        |
|           |                                          | Z | 9.65  | 68.8 | 21.3 |      | 130.5 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 6.90  | 67.2 | 19.5 | 5.97 | 139.2 | ±1.7 % |
|           |                                          | Y | 7.22  | 67.3 | 19.6 |      | 148.0 |        |
|           |                                          | Z | 6.75  | 67.0 | 19.4 |      | 134.1 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 8.68  | 80.6 | 29.2 | 9.21 | 148.0 | ±3.0 % |
|           |                                          | Y | 9.82  | 78.8 | 27.3 |      | 125.0 |        |
|           |                                          | Z | 7.85  | 77.6 | 27.7 |      | 143.5 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 8.56  | 73.7 | 25.6 | 9.24 | 126.6 | ±3.5 % |
|           |                                          | Y | 10.58 | 76.0 | 25.9 |      | 126.3 |        |
|           |                                          | Z | 8.84  | 74.8 | 26.1 |      | 146.7 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.24  | 74.6 | 25.9 | 9.30 | 133.6 | ±3.3 % |
|           |                                          | Y | 11.38 | 76.9 | 26.2 |      | 134.3 |        |
|           |                                          | Z | 8.79  | 73.2 | 25.1 |      | 128.6 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.39  | 67.0 | 18.9 | 3.96 | 143.8 | ±0.9 % |
|           |                                                               | Y | 4.55  | 67.1 | 18.8 |      | 147.3 |        |
|           |                                                               | Z | 4.42  | 67.4 | 19.0 |      | 139.9 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.59  | 67.2 | 18.9 | 3.46 | 132.2 | ±0.5 % |
|           |                                                               | Y | 3.68  | 66.7 | 18.5 |      | 136.0 |        |
|           |                                                               | Z | 3.57  | 67.1 | 18.6 |      | 128.5 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.50  | 67.0 | 18.7 | 3.39 | 134.0 | ±0.7 % |
|           |                                                               | Y | 3.62  | 66.6 | 18.4 |      | 138.6 |        |
|           |                                                               | Z | 3.50  | 67.2 | 18.7 |      | 129.8 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.11  | 66.8 | 19.4 | 5.81 | 127.7 | ±1.4 % |
|           |                                                               | Y | 6.33  | 67.0 | 19.5 |      | 132.1 |        |
|           |                                                               | Z | 6.28  | 67.6 | 19.9 |      | 146.6 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.71  | 67.5 | 19.9 | 6.06 | 134.2 | ±1.7 % |
|           |                                                               | Y | 6.93  | 67.7 | 19.9 |      | 138.0 |        |
|           |                                                               | Z | 6.57  | 67.2 | 19.6 |      | 128.0 |        |
| 10400-AAC | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 10.17 | 69.5 | 21.9 | 8.37 | 138.5 | ±2.5 % |
|           |                                                               | Y | 10.55 | 69.5 | 21.8 |      | 148.0 |        |
|           |                                                               | Z | 9.92  | 69.0 | 21.6 |      | 132.5 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.79  | 69.2 | 19.1 | 3.76 | 144.1 | ±0.7 % |
|           |                                                               | Y | 4.71  | 67.0 | 18.2 |      | 129.2 |        |
|           |                                                               | Z | 4.72  | 69.3 | 19.2 |      | 139.3 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.69  | 69.2 | 19.2 | 3.77 | 142.1 | ±0.7 % |
|           |                                                               | Y | 4.71  | 67.5 | 18.5 |      | 126.7 |        |
|           |                                                               | Z | 4.51  | 68.6 | 18.8 |      | 137.3 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.55  | 68.0 | 18.5 | 1.54 | 141.7 | ±0.7 % |
|           |                                                               | Y | 2.67  | 68.4 | 18.6 |      | 144.0 |        |
|           |                                                               | Z | 2.98  | 70.8 | 19.5 |      | 138.0 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.01 | 69.3 | 21.8 | 8.23 | 137.3 | ±2.5 % |
|           |                                                               | Y | 10.31 | 69.3 | 21.6 |      | 146.0 |        |
|           |                                                               | Z | 9.69  | 68.8 | 21.4 |      | 129.9 |        |

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 NormX,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 7 and 8).

<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.

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3263

### 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                            | 6.27    | 6.27    | 6.27    | 0.29               | 1.87                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.18    | 6.18    | 6.18    | 0.49               | 1.42                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.27    | 5.27    | 5.27    | 0.49               | 1.46                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 4.96    | 4.96    | 4.96    | 0.66               | 1.28                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 4.63    | 4.63    | 4.63    | 0.58               | 1.41                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.40    | 4.40    | 4.40    | 0.71               | 1.34                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.25    | 4.25    | 4.25    | 0.80               | 1.25                    | ± 12.0 %    |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3263

### Calibration Parameter Determined in Body 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                  | 55.5                               | 0.96                            | 6.07    | 6.07    | 6.07    | 0.53               | 1.42                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.08    | 6.08    | 6.08    | 0.57               | 1.36                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.88    | 4.88    | 4.88    | 0.54               | 1.50                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.66    | 4.66    | 4.66    | 0.56               | 1.51                    | ± 12.0 %    |
| 2300                 | 52.9                               | 1.81                            | 4.42    | 4.42    | 4.42    | 0.69               | 1.33                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.28    | 4.28    | 4.28    | 0.80               | 1.08                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 4.11    | 4.11    | 4.11    | 0.80               | 1.09                    | ± 12.0 %    |

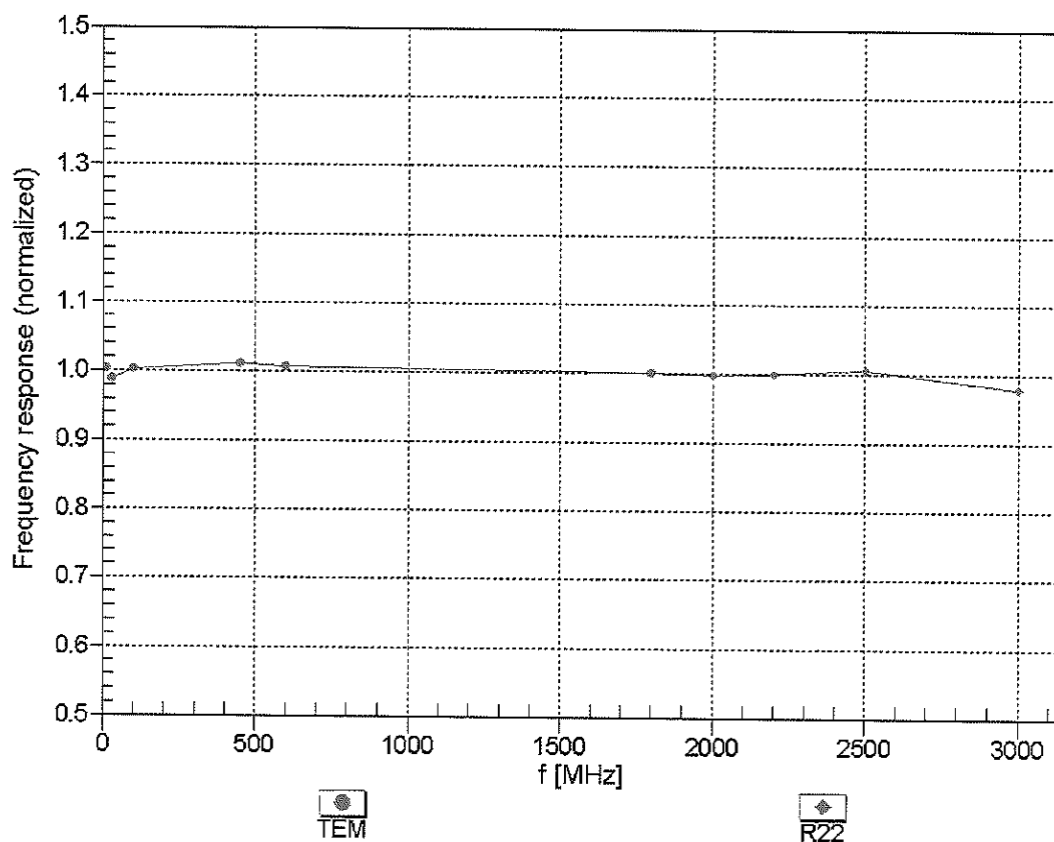
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

## Frequency Response of E-Field

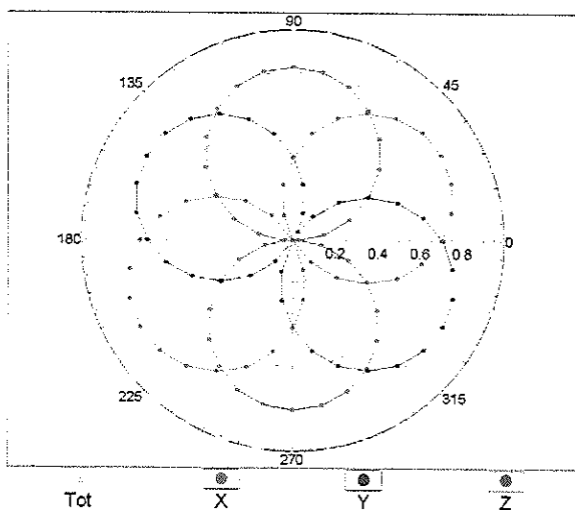
(TEM-Cell:ifi110 EXX, Waveguide: R22)



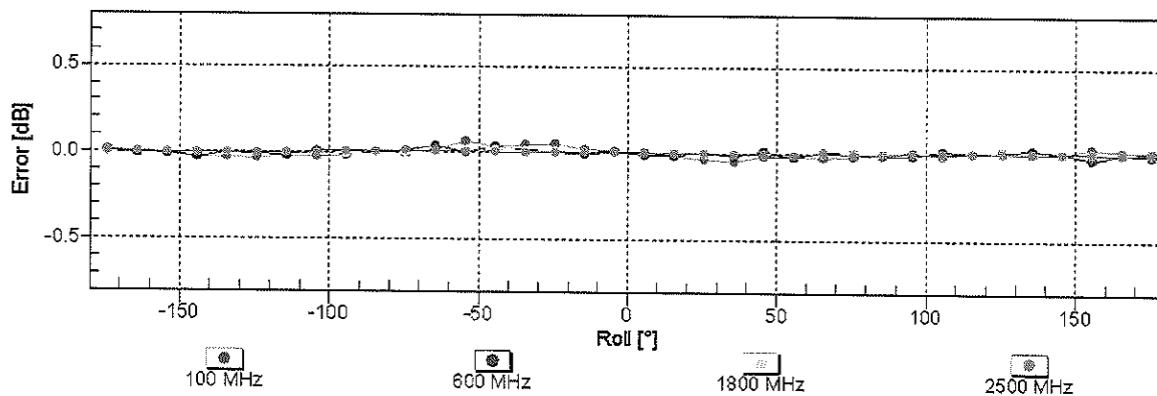
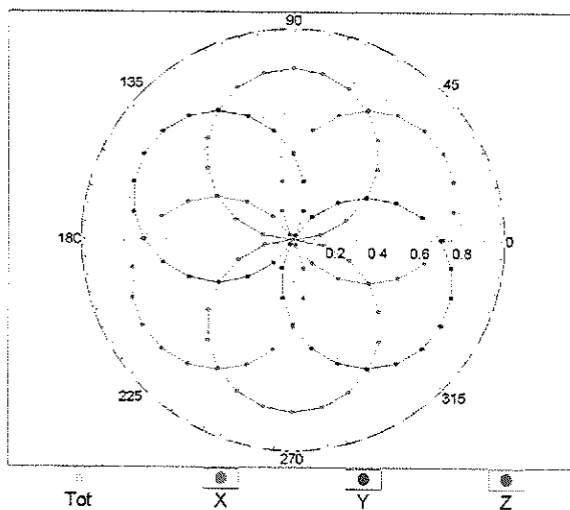
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM

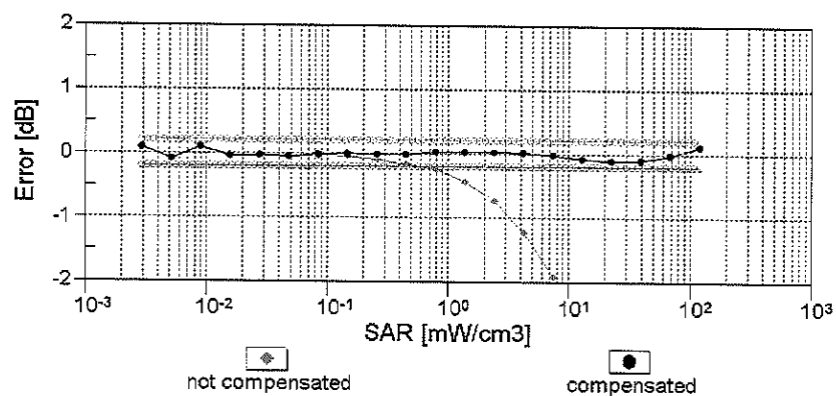
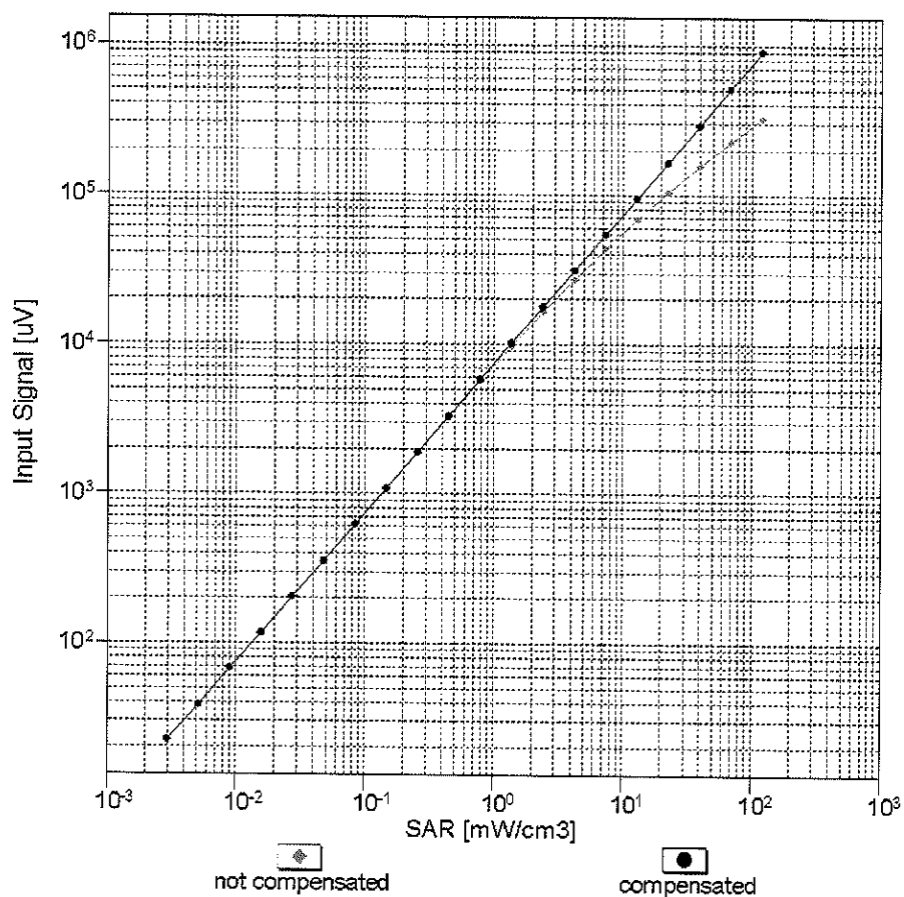


f=1800 MHz,R22



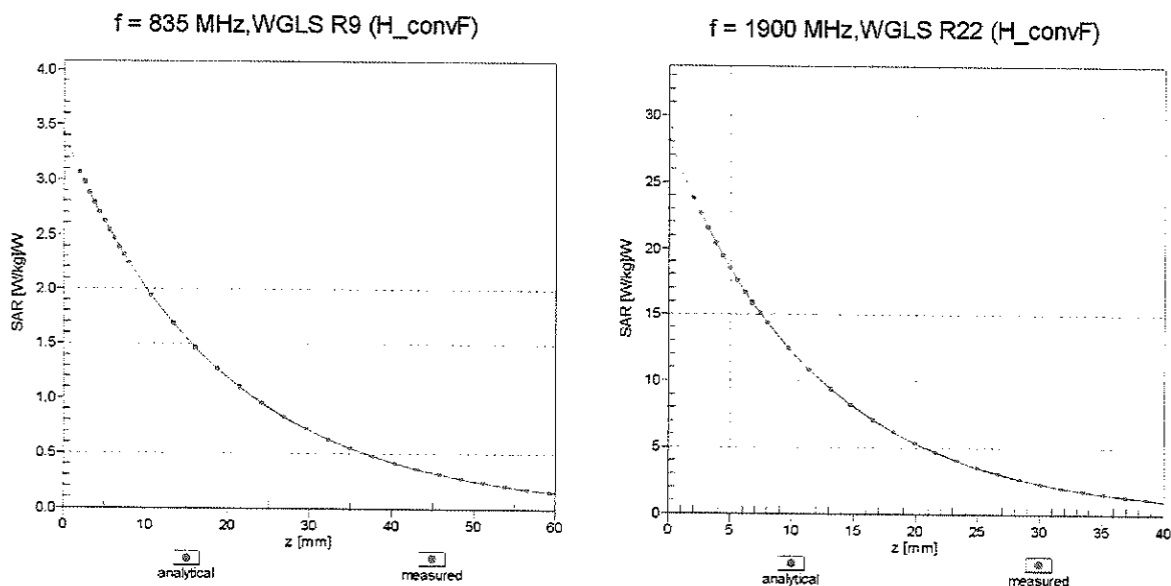
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

# Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell , $f_{\text{eval}} = 1900 \text{ MHz}$ )



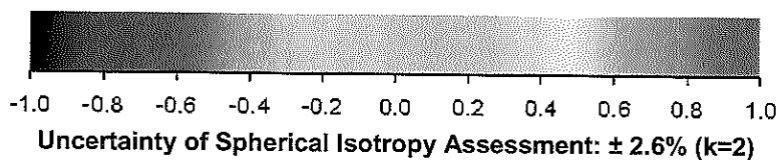
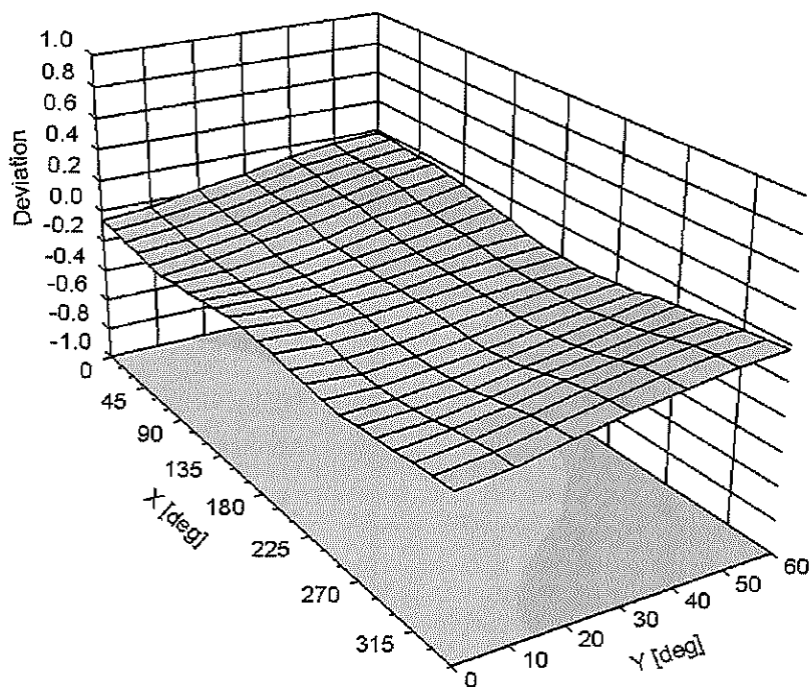
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \theta$ ),  $f = 900 \text{ MHz}$



## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3263

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 65.6       |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 10 mm      |
| Tip Diameter                                  | 4 mm       |
| Probe Tip to Sensor X Calibration Point       | 2 mm       |
| Probe Tip to Sensor Y Calibration Point       | 2 mm       |
| Probe Tip to Sensor Z Calibration Point       | 2 mm       |
| Recommended Measurement Distance from Surface | 3 mm       |



Accredited by the Swiss Accreditation Service (SAS)

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **EX3-7357\_Apr15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7357**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6  
Calibration procedure for dosimetric E-field probes**

*PN ✓  
05/05/15*

Calibration date: **April 23, 2015**

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 E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

|                                                                                                                 | Name            | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|-----------|
| Calibrated by:                                                                                                  | Claudio Leubler | Laboratory Technician |           |
| Approved by:                                                                                                    | Katja Pokovic   | Technical Manager     |           |
| Issued: April 23, 2015                                                                                          |                 |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                 |                       |           |



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Accreditation No.: **SCS 0108**

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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 $\vartheta$ | $\vartheta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\vartheta = 0$ 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, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  ( $f \leq 900$  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  $E^2$ -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 with CW signal (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>; 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).

# Probe EX3DV4

## SN:7357

Manufactured: February 5, 2015  
Calibrated: April 23, 2015

Calibrated for DASY/EASY Systems  
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: EX3DV4 - SN:7357

## Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.41     | 0.49     | 0.42     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 103.9    | 96.9     | 101.6    |               |

## 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>C</sup><br>(k=2) |
|---------------|-----------------------------------------------|---|---------|------------------------------|-------|---------|----------|---------------------------|
| 0             | CW                                            | X | 0.0     | 0.0                          | 1.0   | 0.00    | 146.9    | $\pm 3.3 \%$              |
|               |                                               | Y | 0.0     | 0.0                          | 1.0   |         | 157.7    |                           |
|               |                                               | Z | 0.0     | 0.0                          | 1.0   |         | 138.2    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 0.83    | 57.1                         | 8.0   | 10.00   | 45.6     | $\pm 0.7 \%$              |
|               |                                               | Y | 1.12    | 59.0                         | 9.6   |         | 45.6     |                           |
|               |                                               | Z | 0.93    | 58.4                         | 8.9   |         | 43.4     |                           |
| 10012-<br>CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.61    | 73.9                         | 21.5  | 1.87    | 133.3    | $\pm 0.9 \%$              |
|               |                                               | Y | 2.64    | 66.3                         | 17.3  |         | 127.2    |                           |
|               |                                               | Z | 3.06    | 70.4                         | 19.9  |         | 149.2    |                           |
| 10013-<br>CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.42   | 68.9                         | 22.1  | 9.46    | 142.7    | $\pm 3.3 \%$              |
|               |                                               | Y | 10.68   | 69.5                         | 22.6  |         | 140.9    |                           |
|               |                                               | Z | 10.33   | 68.6                         | 21.9  |         | 134.3    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 0.06    | 0.0                          | 100.0 | 1.16    | 149.4    | $\pm 3.5 \%$              |
|               |                                               | Y | 0.26    | 57.7                         | 4.5   |         | 143.7    |                           |
|               |                                               | Z | 0.05    | 0.6                          | 100.0 |         | 143.3    |                           |
| 10062-<br>CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps)      | X | 10.19   | 68.8                         | 21.5  | 8.68    | 144.0    | $\pm 3.5 \%$              |
|               |                                               | Y | 10.40   | 69.2                         | 21.8  |         | 145.6    |                           |
|               |                                               | Z | 10.11   | 68.5                         | 21.4  |         | 138.3    |                           |
| 10103-<br>CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 7.21    | 67.1                         | 21.4  | 9.29    | 132.3    | $\pm 1.9 \%$              |
|               |                                               | Y | 7.94    | 69.4                         | 22.8  |         | 136.4    |                           |
|               |                                               | Z | 7.15    | 66.8                         | 21.3  |         | 145.0    |                           |
| 10117-<br>CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)      | X | 10.10   | 68.5                         | 20.9  | 8.07    | 131.3    | $\pm 2.5 \%$              |
|               |                                               | Y | 10.12   | 68.3                         | 20.8  |         | 128.9    |                           |
|               |                                               | Z | 9.95    | 68.0                         | 20.6  |         | 124.4    |                           |
| 10151-<br>CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)       | X | 6.97    | 67.1                         | 21.5  | 9.28    | 148.9    | $\pm 1.9 \%$              |
|               |                                               | Y | 7.50    | 68.7                         | 22.5  |         | 130.8    |                           |
|               |                                               | Z | 6.89    | 66.6                         | 21.3  |         | 141.8    |                           |
| 10172-<br>CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)         | X | 5.57    | 68.9                         | 22.9  | 9.21    | 141.8    | $\pm 1.9 \%$              |
|               |                                               | Y | 5.84    | 69.6                         | 23.4  |         | 139.9    |                           |
|               |                                               | Z | 5.43    | 68.1                         | 22.5  |         | 134.4    |                           |
| 10196-<br>CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)       | X | 9.69    | 68.2                         | 20.8  | 8.10    | 124.8    | $\pm 3.3 \%$              |
|               |                                               | Y | 10.09   | 69.0                         | 21.4  |         | 148.5    |                           |
|               |                                               | Z | 9.90    | 68.6                         | 21.1  |         | 143.9    |                           |
| 10237-<br>CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)         | X | 5.57    | 69.0                         | 22.9  | 9.21    | 140.3    | $\pm 1.9 \%$              |
|               |                                               | Y | 5.85    | 69.6                         | 23.4  |         | 141.2    |                           |
|               |                                               | Z | 5.43    | 68.0                         | 22.4  |         | 133.8    |                           |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)                       | X | 6.62  | 67.0 | 21.6 | 9.24 | 143.6 | ±2.2 % |
|           |                                                               | Y | 7.21  | 68.9 | 22.9 |      | 144.8 |        |
|           |                                                               | Z | 6.54  | 66.4 | 21.3 |      | 137.3 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK)                      | X | 7.00  | 67.1 | 21.6 | 9.30 | 149.1 | ±1.9 % |
|           |                                                               | Y | 7.52  | 68.7 | 22.6 |      | 128.6 |        |
|           |                                                               | Z | 6.91  | 66.6 | 21.3 |      | 142.7 |        |
| 10317-AAB | IEEE 802.11a WiFi 5 GHz (OFDM, 6 Mbps, 99pc duty cycle)       | X | 9.81  | 68.2 | 21.0 | 8.36 | 123.5 | ±3.3 % |
|           |                                                               | Y | 10.26 | 69.1 | 21.6 |      | 148.1 |        |
|           |                                                               | Z | 10.06 | 68.7 | 21.3 |      | 144.2 |        |
| 10400-AAB | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 9.88  | 68.2 | 21.0 | 8.37 | 123.6 | ±2.7 % |
|           |                                                               | Y | 9.94  | 68.1 | 21.0 |      | 124.7 |        |
|           |                                                               | Z | 10.15 | 68.8 | 21.3 |      | 144.7 |        |
| 10401-AAB | IEEE 802.11ac WiFi (40MHz, 64-QAM, 99pc duty cycle)           | X | 10.61 | 68.7 | 21.2 | 8.60 | 132.4 | ±3.0 % |
|           |                                                               | Y | 10.82 | 69.0 | 21.5 |      | 134.7 |        |
|           |                                                               | Z | 10.54 | 68.4 | 21.1 |      | 126.8 |        |
| 10402-AAB | IEEE 802.11ac WiFi (80MHz, 64-QAM, 99pc duty cycle)           | X | 10.66 | 68.6 | 21.1 | 8.53 | 133.5 | ±3.0 % |
|           |                                                               | Y | 11.03 | 69.4 | 21.5 |      | 136.6 |        |
|           |                                                               | Z | 10.56 | 68.3 | 20.9 |      | 126.5 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 4.15  | 76.8 | 22.5 | 1.54 | 130.0 | ±0.9 % |
|           |                                                               | Y | 2.63  | 66.8 | 17.4 |      | 129.6 |        |
|           |                                                               | Z | 3.25  | 72.3 | 20.7 |      | 147.1 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.99  | 68.7 | 21.2 | 8.23 | 146.6 | ±3.3 % |
|           |                                                               | Y | 10.19 | 69.0 | 21.5 |      | 149.3 |        |
|           |                                                               | Z | 9.96  | 68.6 | 21.2 |      | 141.2 |        |
| 10417-AAA | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps, 99pc duty cycle)     | X | 10.02 | 68.8 | 21.3 | 8.23 | 148.2 | ±2.7 % |
|           |                                                               | Y | 9.78  | 68.0 | 20.9 |      | 124.2 |        |
|           |                                                               | Z | 9.96  | 68.6 | 21.2 |      | 142.5 |        |

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 NormX,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 6 and 7).

<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.

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7357

### 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) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 2450                 | 39.2                               | 1.80                            | 7.31    | 7.31    | 7.31    | 0.36               | 0.80                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 7.06    | 7.06    | 7.06    | 0.38               | 0.80                    | ± 12.0 %    |
| 5200                 | 36.0                               | 4.66                            | 5.14    | 5.14    | 5.14    | 0.40               | 1.80                    | ± 13.1 %    |
| 5300                 | 35.9                               | 4.76                            | 4.93    | 4.93    | 4.93    | 0.40               | 1.80                    | ± 13.1 %    |
| 5500                 | 35.6                               | 4.96                            | 4.70    | 4.70    | 4.70    | 0.40               | 1.80                    | ± 13.1 %    |
| 5600                 | 35.5                               | 5.07                            | 4.38    | 4.38    | 4.38    | 0.45               | 1.80                    | ± 13.1 %    |
| 5800                 | 35.3                               | 5.27                            | 4.41    | 4.41    | 4.41    | 0.45               | 1.80                    | ± 13.1 %    |

<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. Above 5 GHz frequency validity can be extended to ± 110 MHz.

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7357

### Calibration Parameter Determined in Body 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) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 2450                 | 52.7                               | 1.95                            | 6.95    | 6.95    | 6.95    | 0.26               | 0.99                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 6.68    | 6.68    | 6.68    | 0.28               | 0.99                    | ± 12.0 %    |
| 5200                 | 49.0                               | 5.30                            | 4.27    | 4.27    | 4.27    | 0.50               | 1.90                    | ± 13.1 %    |
| 5300                 | 48.9                               | 5.42                            | 4.11    | 4.11    | 4.11    | 0.50               | 1.90                    | ± 13.1 %    |
| 5500                 | 48.6                               | 5.65                            | 3.83    | 3.83    | 3.83    | 0.50               | 1.90                    | ± 13.1 %    |
| 5600                 | 48.5                               | 5.77                            | 3.72    | 3.72    | 3.72    | 0.55               | 1.90                    | ± 13.1 %    |
| 5800                 | 48.2                               | 6.00                            | 3.82    | 3.82    | 3.82    | 0.55               | 1.90                    | ± 13.1 %    |

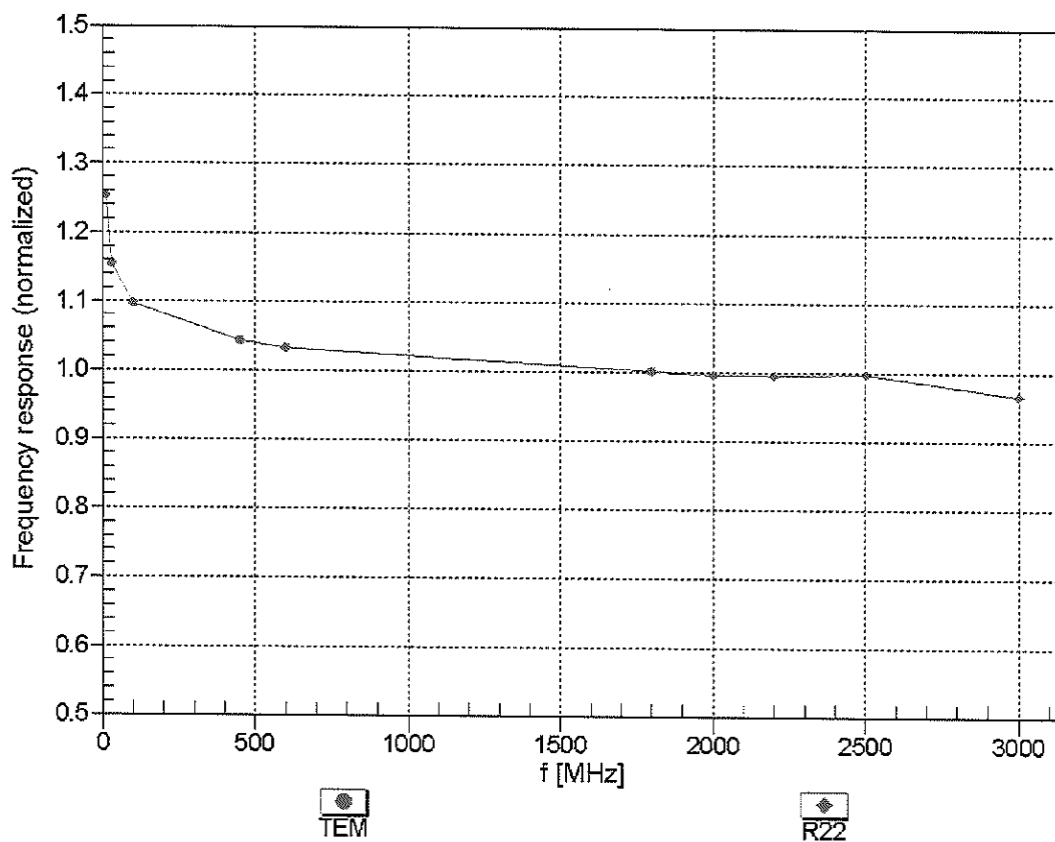
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

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

## Frequency Response of E-Field

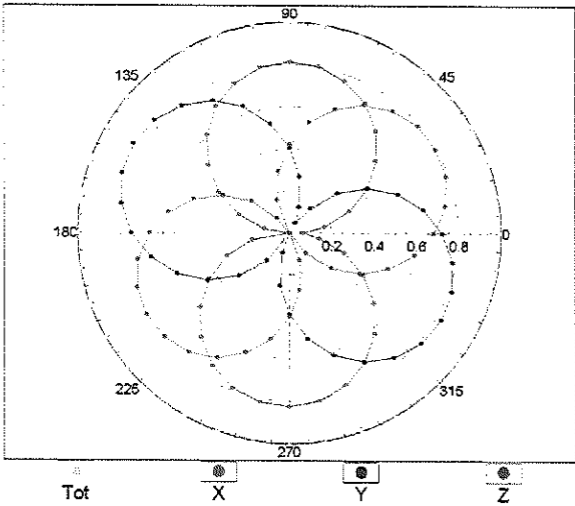
(TEM-Cell:ifi110 EXX, Waveguide: R22)



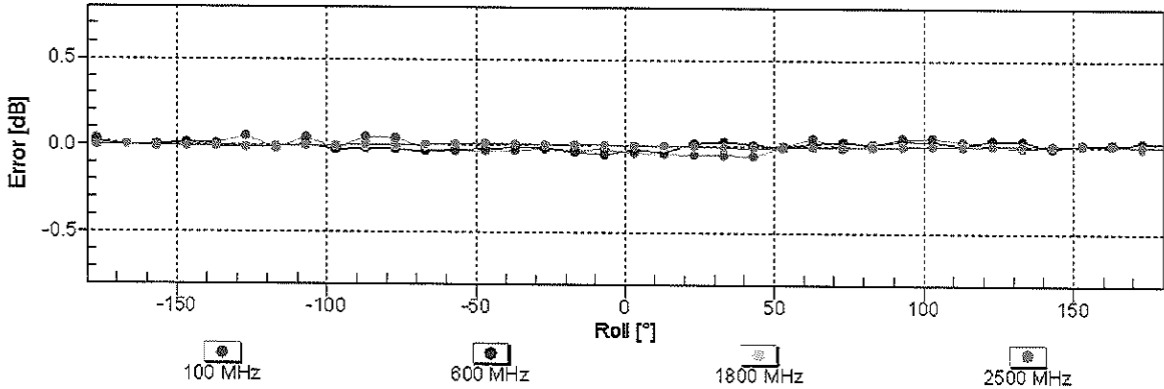
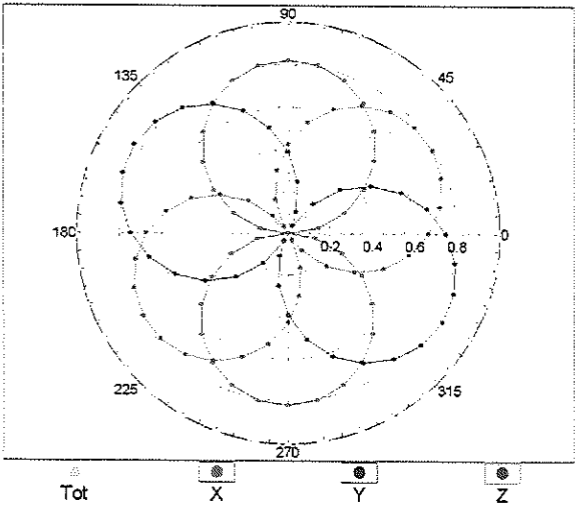
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

Receiving Pattern ( $\phi$ ),  $\vartheta = 0^\circ$

f=600 MHz,TEM



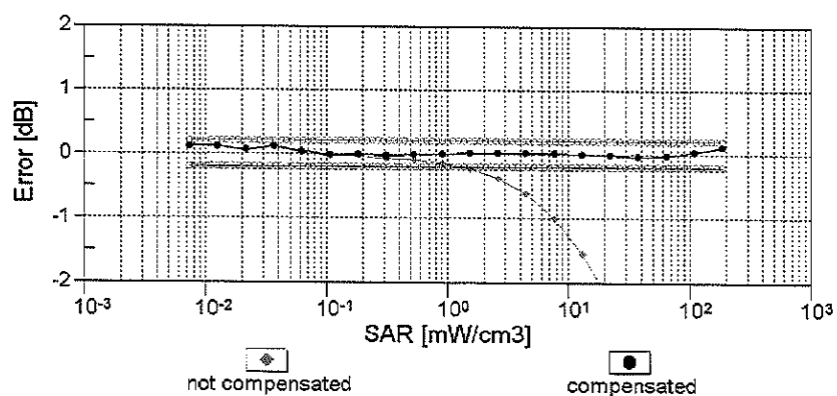
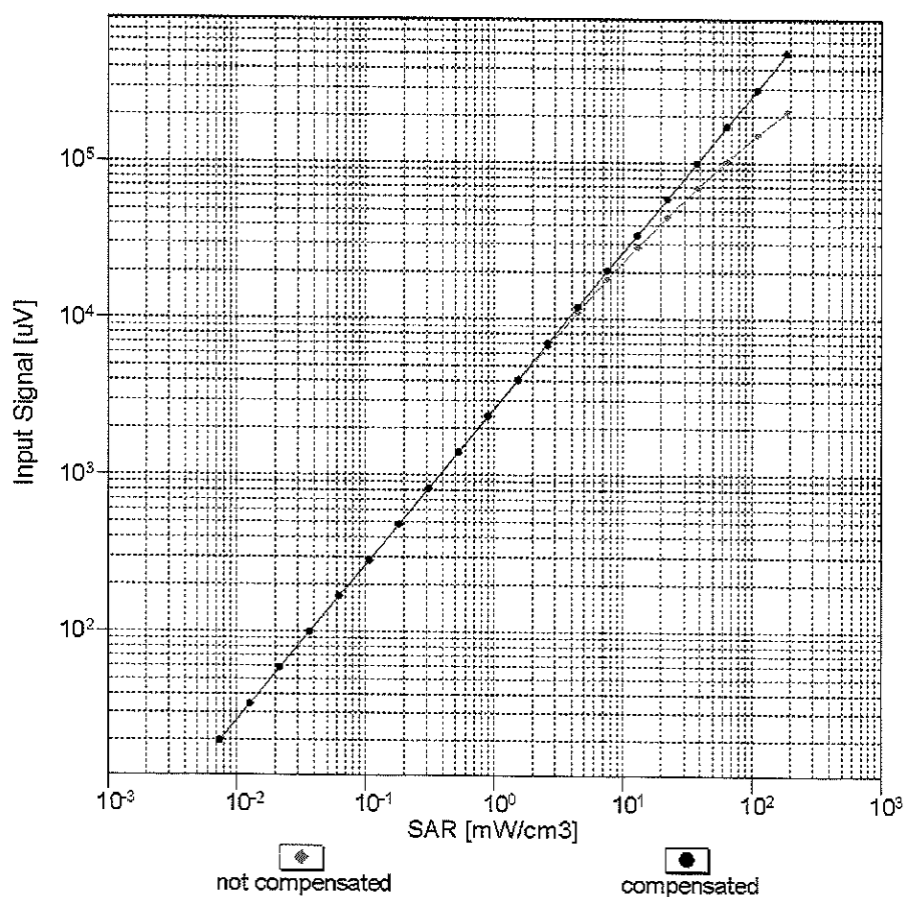
f=1800 MHz,R22



Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

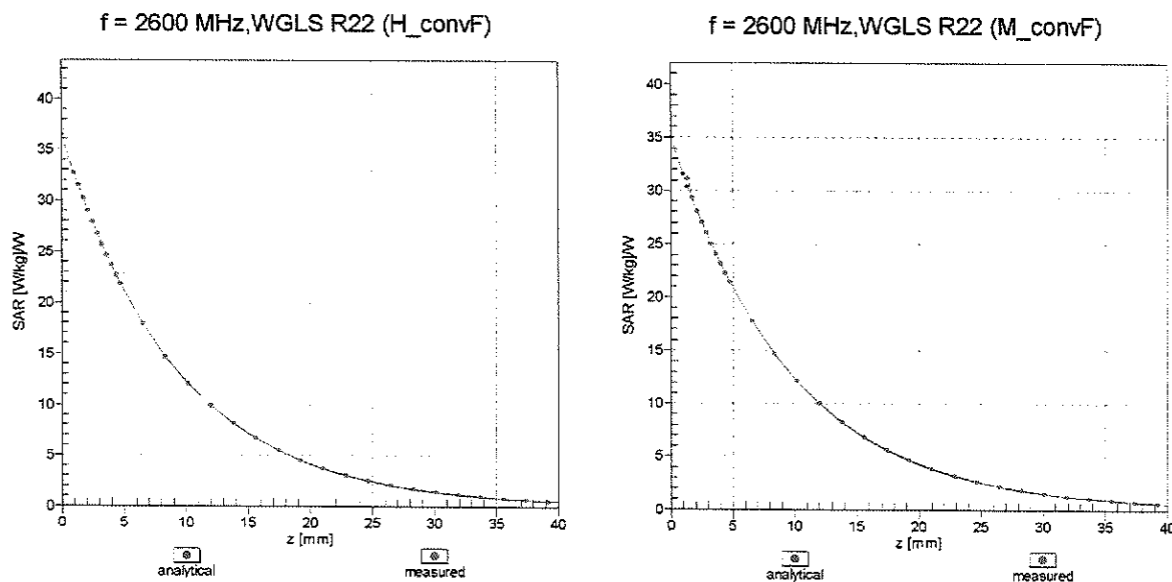
## Dynamic Range f(SAR<sub>head</sub>)

(TEM cell , f<sub>eval</sub>= 1900 MHz)



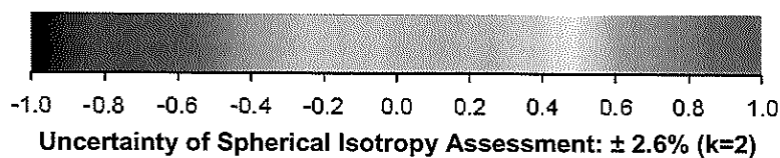
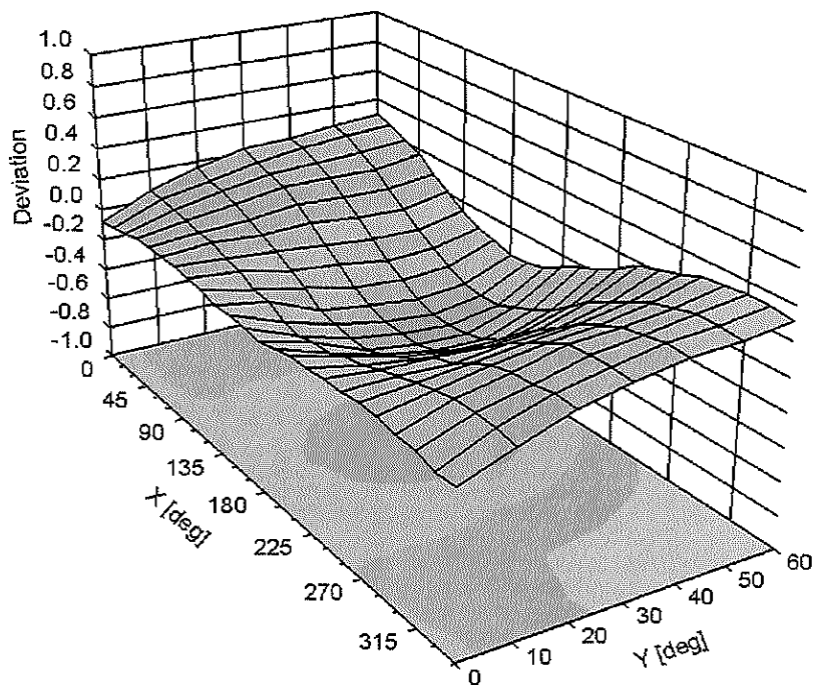
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

Error ( $\phi, \vartheta$ ),  $f = 900 \text{ MHz}$



## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7357

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 13.1       |
| 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     |