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Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **ES3-3022\_Aug14/2**

## CALIBRATION CERTIFICATE (Replacement of No: ES3-3022\_Aug14)

Object **ES3DV2 - SN:3022**

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

CC  
D/M/Y

Calibration date: **August 19, 2014**

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      | 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-13 (No. ES3-3013_Dec13)    | Dec-14                 |
| DAE4                       | SN: 660         | 13-Dec-13 (No. DAE4-660_Dec13)    | Dec-14                 |
| 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-13) | In house check: Oct-14 |

|                                                                                                                                                        |                               |                                   |                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----------------------------------|---------------------------------------------------------------------------------------------------|
| Calibrated by:                                                                                                                                         | Name<br><b>Jeton Kastrati</b> | Function<br>Laboratory Technician | Signature<br> |
| Approved by:                                                                                                                                           | Name<br><b>Katja Pokovic</b>  | Technical Manager                 |              |
| <p>Issued: November 3, 2014</p> <p>This calibration certificate shall not be reproduced except in full without written approval of the laboratory.</p> |                               |                                   |                                                                                                   |



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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

### 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 19, 2014

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 ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 1.00     | 1.04     | 0.96     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                 | 103.0    | 96.3     | 101.6    |               |

### 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    | 181.8    | $\pm 2.7 \%$              |
|               |                                               | Y | 0.0     | 0.0                    | 1.0  |         | 183.0    |                           |
|               |                                               | Z | 0.0     | 0.0                    | 1.0  |         | 192.3    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 2.51    | 63.1                   | 12.7 | 10.00   | 42.6     | $\pm 1.9 \%$              |
|               |                                               | Y | 2.62    | 63.1                   | 12.9 |         | 42.7     |                           |
|               |                                               | Z | 3.12    | 65.7                   | 13.6 |         | 40.4     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.33    | 67.8                   | 19.2 | 2.91    | 145.9    | $\pm 0.9 \%$              |
|               |                                               | Y | 3.13    | 64.9                   | 16.9 |         | 147.4    |                           |
|               |                                               | Z | 3.20    | 66.4                   | 18.2 |         | 139.6    |                           |
| 10012-<br>CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.05    | 70.1                   | 19.8 | 1.87    | 147.2    | $\pm 0.9 \%$              |
|               |                                               | Y | 2.62    | 65.1                   | 16.2 |         | 147.4    |                           |
|               |                                               | Z | 2.85    | 68.2                   | 18.4 |         | 141.7    |                           |
| 10013-<br>CAA | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.10   | 70.9                   | 23.6 | 9.46    | 143.9    | $\pm 3.0 \%$              |
|               |                                               | Y | 11.04   | 70.2                   | 22.9 |         | 144.2    |                           |
|               |                                               | Z | 10.77   | 70.2                   | 23.1 |         | 134.7    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 19.66   | 99.7                   | 28.6 | 9.39    | 126.0    | $\pm 1.9 \%$              |
|               |                                               | Y | 11.04   | 89.6                   | 25.5 |         | 138.9    |                           |
|               |                                               | Z | 10.45   | 88.8                   | 24.9 |         | 137.5    |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 20.19   | 99.6                   | 28.5 | 9.57    | 142.0    | $\pm 2.5 \%$              |
|               |                                               | Y | 10.53   | 88.4                   | 25.0 |         | 145.5    |                           |
|               |                                               | Z | 15.52   | 96.5                   | 27.8 |         | 147.6    |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 31.93   | 99.6                   | 25.2 | 6.56    | 149.5    | $\pm 1.9 \%$              |
|               |                                               | Y | 12.70   | 87.9                   | 22.2 |         | 148.0    |                           |
|               |                                               | Z | 27.00   | 99.8                   | 25.7 |         | 135.3    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 38.32   | 99.8                   | 23.8 | 4.80    | 148.1    | $\pm 2.2 \%$              |
|               |                                               | Y | 9.80    | 83.2                   | 19.3 |         | 138.8    |                           |
|               |                                               | Z | 31.96   | 99.9                   | 24.2 |         | 128.9    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 40.03   | 99.5                   | 22.8 | 3.55    | 130.5    | $\pm 2.2 \%$              |
|               |                                               | Y | 40.27   | 99.6                   | 23.0 |         | 148.1    |                           |
|               |                                               | Z | 43.09   | 99.7                   | 22.5 |         | 140.1    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 38.93   | 99.4                   | 20.4 | 1.16    | 146.7    | $\pm 1.9 \%$              |
|               |                                               | Y | 32.83   | 92.5                   | 17.9 |         | 139.2    |                           |
|               |                                               | Z | 31.94   | 99.5                   | 20.8 |         | 133.1    |                           |
| 10039-<br>CAB | CDMA2000 (1xRTT, RC1)                         | X | 4.66    | 66.8                   | 19.3 | 4.57    | 144.5    | $\pm 1.2 \%$              |
|               |                                               | Y | 4.56    | 65.3                   | 17.9 |         | 137.2    |                           |
|               |                                               | Z | 4.52    | 66.1                   | 18.7 |         | 131.7    |                           |

|           |                                               |   |       |      |      |      |       |        |
|-----------|-----------------------------------------------|---|-------|------|------|------|-------|--------|
| 10081-CAB | CDMA2000 (1xRTT, RC3)                         | X | 3.82  | 66.0 | 18.7 | 3.97 | 140.3 | ±0.9 % |
|           |                                               | Y | 3.77  | 64.5 | 17.3 |      | 133.6 |        |
|           |                                               | Z | 3.79  | 65.7 | 18.4 |      | 128.2 |        |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2)                   | X | 4.40  | 66.2 | 18.5 | 3.98 | 130.9 | ±1.2 % |
|           |                                               | Y | 4.39  | 65.0 | 17.4 |      | 131.1 |        |
|           |                                               | Z | 4.47  | 66.3 | 18.4 |      | 140.0 |        |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.30  | 67.3 | 19.8 | 5.67 | 137.4 | ±1.7 % |
|           |                                               | Y | 6.25  | 66.3 | 18.9 |      | 135.9 |        |
|           |                                               | Z | 6.36  | 67.4 | 19.7 |      | 147.5 |        |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)      | X | 6.14  | 66.8 | 19.6 | 5.80 | 134.6 | ±1.7 % |
|           |                                               | Y | 6.17  | 66.1 | 18.9 |      | 133.9 |        |
|           |                                               | Z | 6.24  | 67.0 | 19.7 |      | 144.5 |        |
| 10110-CAB | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)       | X | 5.82  | 66.3 | 19.4 | 5.75 | 131.2 | ±1.7 % |
|           |                                               | Y | 5.82  | 65.4 | 18.6 |      | 130.3 |        |
|           |                                               | Z | 5.91  | 66.5 | 19.4 |      | 140.4 |        |
| 10114-CAA | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 10.00 | 68.5 | 21.2 | 8.10 | 124.3 | ±2.5 % |
|           |                                               | Y | 9.89  | 67.9 | 20.6 |      | 124.0 |        |
|           |                                               | Z | 10.05 | 68.6 | 21.2 |      | 133.2 |        |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)      | X | 10.01 | 68.6 | 21.2 | 8.07 | 125.8 | ±2.5 % |
|           |                                               | Y | 9.91  | 67.9 | 20.7 |      | 125.8 |        |
|           |                                               | Z | 10.09 | 68.8 | 21.3 |      | 134.7 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)       | X | 9.69  | 75.5 | 26.4 | 9.28 | 144.7 | ±3.3 % |
|           |                                               | Y | 9.09  | 72.7 | 24.6 |      | 143.2 |        |
|           |                                               | Z | 8.54  | 72.0 | 24.5 |      | 124.8 |        |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)       | X | 5.82  | 66.2 | 19.4 | 5.75 | 131.3 | ±1.9 % |
|           |                                               | Y | 6.06  | 66.3 | 19.1 |      | 149.2 |        |
|           |                                               | Z | 5.91  | 66.5 | 19.4 |      | 140.7 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)       | X | 6.27  | 66.9 | 19.7 | 5.82 | 136.5 | ±1.4 % |
|           |                                               | Y | 6.19  | 65.8 | 18.7 |      | 128.4 |        |
|           |                                               | Z | 6.33  | 67.0 | 19.6 |      | 145.4 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)         | X | 4.81  | 66.4 | 19.7 | 5.73 | 134.8 | ±1.7 % |
|           |                                               | Y | 4.92  | 66.1 | 19.1 |      | 149.9 |        |
|           |                                               | Z | 4.78  | 66.4 | 19.6 |      | 141.2 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)         | X | 7.83  | 76.6 | 27.2 | 9.21 | 131.4 | ±3.5 % |
|           |                                               | Y | 7.54  | 74.5 | 25.8 |      | 147.8 |        |
|           |                                               | Z | 7.71  | 76.7 | 27.4 |      | 145.3 |        |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)         | X | 4.90  | 66.9 | 20.0 | 5.72 | 147.6 | ±1.4 % |
|           |                                               | Y | 4.90  | 66.0 | 19.1 |      | 148.0 |        |
|           |                                               | Z | 4.78  | 66.4 | 19.6 |      | 141.6 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)         | X | 4.90  | 66.9 | 20.0 | 5.72 | 148.1 | ±1.4 % |
|           |                                               | Y | 4.89  | 65.9 | 19.0 |      | 146.9 |        |
|           |                                               | Z | 4.80  | 66.5 | 19.7 |      | 142.1 |        |
| 10193-CAA | IEEE 802.11n (HT Greenfield, 6.5 Mbps, BPSK)  | X | 9.80  | 68.7 | 21.4 | 8.09 | 135.1 | ±2.7 % |
|           |                                               | Y | 9.78  | 68.2 | 20.9 |      | 135.5 |        |
|           |                                               | Z | 9.70  | 68.5 | 21.2 |      | 130.2 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)                       | X | 9.79  | 68.7 | 21.4 | 8.10 | 136.4 | ±2.7 % |
|           |                                                               | Y | 9.81  | 68.3 | 20.9 |      | 138.0 |        |
|           |                                                               | Z | 9.72  | 68.6 | 21.3 |      | 132.8 |        |
| 10219-CAA | IEEE 802.11n (HT Mixed, 7.2 Mbps, BPSK)                       | X | 9.68  | 68.6 | 21.3 | 8.03 | 136.0 | ±2.7 % |
|           |                                                               | Y | 9.74  | 68.3 | 21.0 |      | 137.4 |        |
|           |                                                               | Z | 9.62  | 68.5 | 21.2 |      | 132.6 |        |
| 10222-CAA | IEEE 802.11n (HT Mixed, 15 Mbps, BPSK)                        | X | 10.20 | 69.1 | 21.5 | 8.06 | 143.4 | ±2.5 % |
|           |                                                               | Y | 9.91  | 60.0 | 20.7 |      | 125.8 |        |
|           |                                                               | Z | 10.27 | 69.4 | 21.6 |      | 148.4 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                                              | X | 6.87  | 66.9 | 19.6 | 5.97 | 139.5 | ±1.9 % |
|           |                                                               | Y | 7.04  | 66.9 | 19.3 |      | 149.3 |        |
|           |                                                               | Z | 6.89  | 67.0 | 19.5 |      | 143.5 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)                         | X | 7.66  | 75.9 | 26.9 | 9.21 | 126.1 | ±3.0 % |
|           |                                                               | Y | 7.17  | 73.1 | 25.1 |      | 132.1 |        |
|           |                                                               | Z | 7.18  | 74.6 | 26.3 |      | 128.0 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)                       | X | 8.58  | 73.1 | 25.3 | 9.24 | 127.6 | ±3.3 % |
|           |                                                               | Y | 8.22  | 71.0 | 23.7 |      | 126.9 |        |
|           |                                                               | Z | 8.83  | 74.3 | 26.0 |      | 149.8 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK)                      | X | 9.69  | 75.5 | 26.5 | 9.30 | 143.8 | ±3.3 % |
|           |                                                               | Y | 8.88  | 72.0 | 24.2 |      | 135.2 |        |
|           |                                                               | Z | 8.83  | 72.9 | 25.1 |      | 131.3 |        |
| 10274-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.10)                     | X | 5.87  | 67.0 | 19.2 | 4.87 | 141.2 | ±1.4 % |
|           |                                                               | Y | 5.77  | 65.8 | 18.1 |      | 136.0 |        |
|           |                                                               | Z | 5.71  | 66.3 | 18.6 |      | 132.7 |        |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.44  | 67.2 | 19.2 | 3.96 | 147.3 | ±0.9 % |
|           |                                                               | Y | 4.29  | 65.3 | 17.6 |      | 139.2 |        |
|           |                                                               | Z | 4.31  | 66.3 | 18.5 |      | 139.6 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.60  | 67.1 | 19.1 | 3.46 | 137.8 | ±0.7 % |
|           |                                                               | Y | 3.44  | 64.8 | 17.2 |      | 129.6 |        |
|           |                                                               | Z | 3.48  | 66.2 | 18.4 |      | 130.5 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.50  | 66.9 | 18.9 | 3.39 | 139.5 | ±0.7 % |
|           |                                                               | Y | 3.38  | 64.8 | 17.2 |      | 132.0 |        |
|           |                                                               | Z | 3.48  | 66.5 | 18.5 |      | 133.1 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.12  | 66.7 | 19.6 | 5.81 | 133.3 | ±1.9 % |
|           |                                                               | Y | 6.35  | 66.7 | 19.3 |      | 149.3 |        |
|           |                                                               | Z | 6.17  | 66.8 | 19.5 |      | 132.7 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.72  | 67.4 | 20.0 | 6.06 | 138.7 | ±1.7 % |
|           |                                                               | Y | 6.63  | 66.3 | 19.1 |      | 131.4 |        |
|           |                                                               | Z | 6.72  | 67.3 | 19.9 |      | 138.7 |        |
| 10315-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle)     | X | 2.90  | 69.9 | 19.8 | 1.71 | 146.4 | ±0.5 % |
|           |                                                               | Y | 2.54  | 65.2 | 16.5 |      | 139.3 |        |
|           |                                                               | Z | 2.75  | 68.1 | 18.5 |      | 146.4 |        |
| 10316-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 96pc duty cycle) | X | 10.12 | 69.3 | 21.9 | 8.36 | 142.9 | ±3.0 % |
|           |                                                               | Y | 10.01 | 68.5 | 21.3 |      | 135.2 |        |
|           |                                                               | Z | 10.11 | 69.3 | 21.9 |      | 141.7 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.59  | 68.2 | 19.0 | 3.76 | 126.7 | ±0.7 % |
|           |                                                               | Y | 4.59  | 67.2 | 18.0 |      | 142.4 |        |
|           |                                                               | Z | 4.64  | 68.5 | 19.0 |      | 143.0 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.64  | 68.8 | 19.3 | 3.77 | 147.1 | ±0.9 % |
|           |                                                               | Y | 4.47  | 67.1 | 17.9 |      | 139.6 |        |
|           |                                                               | Z | 4.54  | 68.4 | 18.9 |      | 147.2 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.66  | 69.0 | 19.4 | 1.54 | 145.8 | ±0.5 % |
|           |                                                               | Y | 2.40  | 64.8 | 16.2 |      | 140.0 |        |
|           |                                                               | Z | 2.62  | 67.8 | 18.4 |      | 147.2 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.97  | 69.1 | 21.7 | 8.23 | 142.0 | ±3.0 % |
|           |                                                               | Y | 10.08 | 68.9 | 21.4 |      | 145.8 |        |
|           |                                                               | Z | 10.01 | 69.2 | 21.8 |      | 143.3 |        |

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>^</sup> The uncertainties of NormX,Y,Z do not affect the  $E^2$ -field uncertainty inside TSL (see Pages 8 and 9).

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

<sup>^</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) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 41.9                               | 0.89                            | 6.39    | 6.39    | 6.39    | 0.20               | 2.24                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.18    | 6.18    | 6.18    | 0.23               | 1.98                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.04    | 5.04    | 5.04    | 0.51               | 1.35                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 4.85    | 4.85    | 4.85    | 0.38               | 1.66                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.31    | 4.31    | 4.31    | 0.66               | 1.28                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.13    | 4.13    | 4.13    | 0.76               | 1.28                    | ± 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) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 450                  | 56.7                               | 0.94                            | 6.78    | 6.78    | 6.78    | 0.12               | 1.30                    | ± 13.3 %    |
| 600                  | 56.1                               | 0.95                            | 6.72    | 6.72    | 6.72    | 0.05               | 1.20                    | ± 13.3 %    |
| 750                  | 55.5                               | 0.96                            | 6.02    | 6.02    | 6.02    | 0.23               | 2.05                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 5.98    | 5.98    | 5.98    | 0.29               | 1.85                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.70    | 4.70    | 4.70    | 0.66               | 1.25                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.49    | 4.49    | 4.49    | 0.33               | 2.02                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.05    | 4.05    | 4.05    | 0.80               | 1.01                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 3.94    | 3.94    | 3.94    | 0.68               | 1.03                    | ± 12.0 %    |

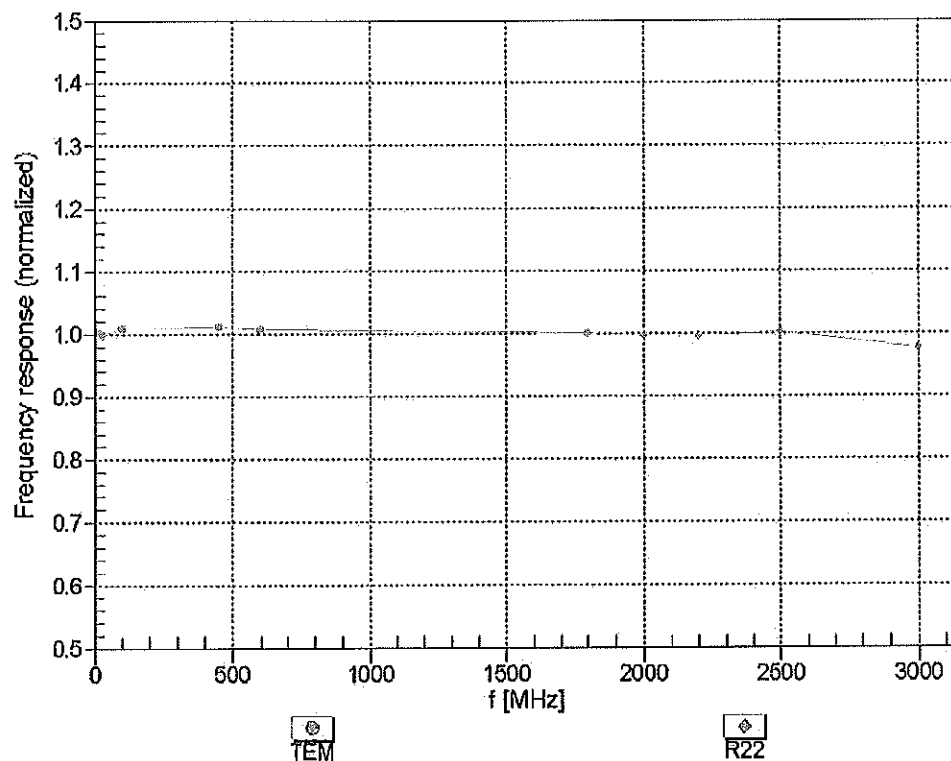
<sup>c</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below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

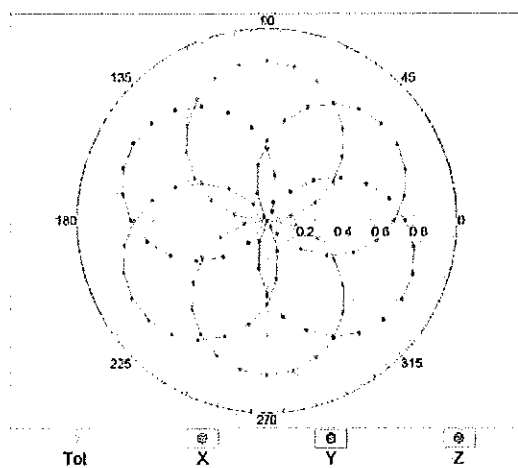
(TEM-Cell:ifi110 EXX, Waveguide: R22)



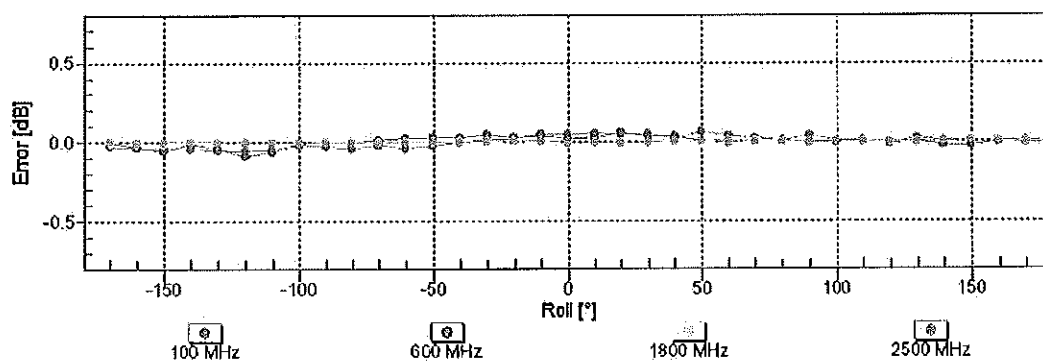
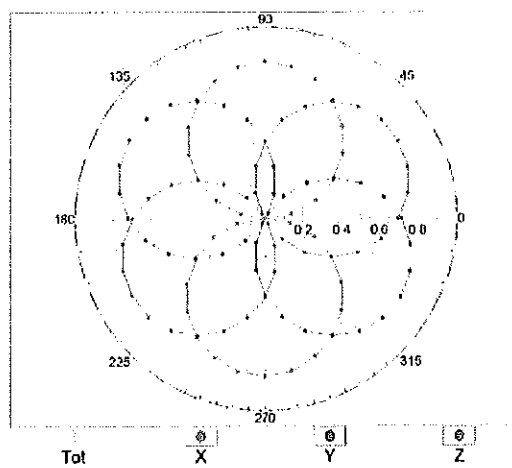
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM

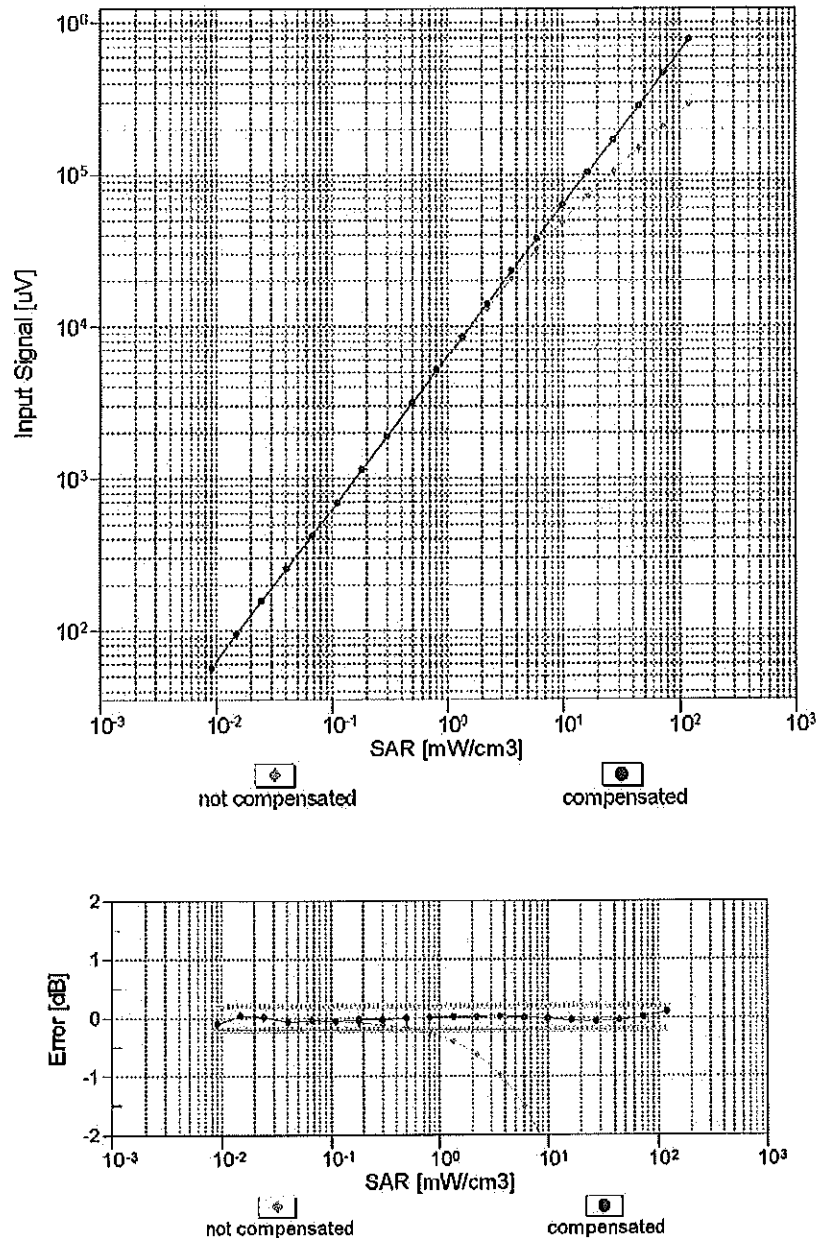


f=1800 MHz,R22



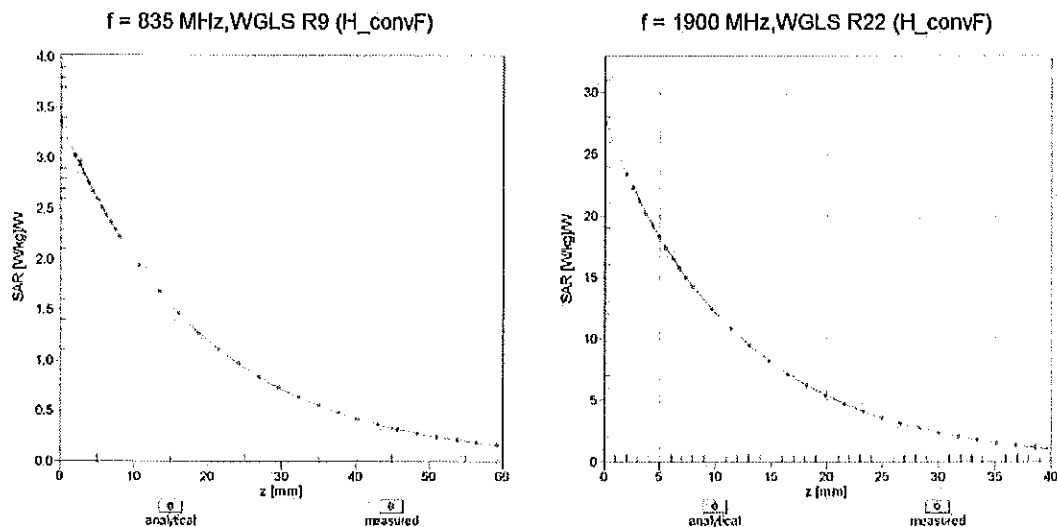
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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



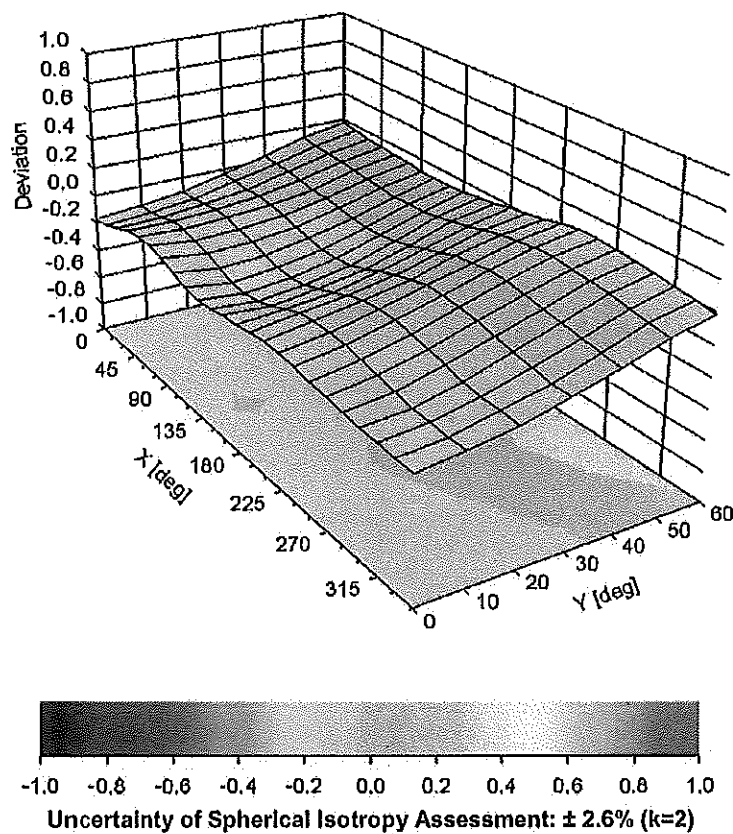
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



**DASY/EASY - Parameters of Probe: ES3DV2 - SN:3022****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -80.3      |
| 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: **ES3-3209\_Mar15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3209**

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.



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Accreditation No.: **SCS 0108**

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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  $E^2$ -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:3209

Manufactured: October 14, 2008  
Calibrated: March 19, 2015

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3209

## Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---------------------------------------|----------|----------|----------|-----------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 1.35     | 1.33     | 1.14     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                 | 102.0    | 100.9    | 103.3    |           |

## 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    | 214.5    | ±3.5 %                    |
|           |                                               | Y | 0.0     | 0.0                    | 1.0  |         | 192.6    |                           |
|           |                                               | Z | 0.0     | 0.0                    | 1.0  |         | 199.1    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)          | X | 2.61    | 65.1                   | 12.2 | 10.00   | 42.3     | ±1.7 %                    |
|           |                                               | Y | 1.39    | 57.8                   | 8.9  |         | 42.7     |                           |
|           |                                               | Z | 4.57    | 70.3                   | 14.0 |         | 38.3     |                           |
| 10011-CAB | UMTS-FDD (WCDMA)                              | X | 3.12    | 66.3                   | 18.1 | 2.91    | 130.3    | ±0.7 %                    |
|           |                                               | Y | 3.08    | 65.6                   | 17.5 |         | 132.2    |                           |
|           |                                               | Z | 3.32    | 67.7                   | 19.0 |         | 137.6    |                           |
| 10012-CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 2.54    | 66.8                   | 17.8 | 1.87    | 131.1    | ±0.7 %                    |
|           |                                               | Y | 2.67    | 67.1                   | 17.7 |         | 131.6    |                           |
|           |                                               | Z | 2.85    | 69.2                   | 19.1 |         | 138.0    |                           |
| 10013-CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.78   | 70.5                   | 23.4 | 9.46    | 146.9    | ±2.7 %                    |
|           |                                               | Y | 10.39   | 69.2                   | 22.5 |         | 123.5    |                           |
|           |                                               | Z | 10.50   | 69.9                   | 23.1 |         | 128.4    |                           |
| 10021-DAB | GSM-FDD (TDMA, GMSK)                          | X | 3.65    | 74.2                   | 17.7 | 9.39    | 130.0    | ±1.9 %                    |
|           |                                               | Y | 6.62    | 83.5                   | 22.0 |         | 149.4    |                           |
|           |                                               | Z | 4.25    | 76.8                   | 19.2 |         | 136.2    |                           |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 3.95    | 75.3                   | 18.4 | 9.57    | 138.8    | ±2.5 %                    |
|           |                                               | Y | 4.99    | 78.2                   | 19.8 |         | 143.3    |                           |
|           |                                               | Z | 4.11    | 75.8                   | 18.9 |         | 129.3    |                           |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 6.44    | 80.3                   | 17.7 | 6.56    | 135.0    | ±1.7 %                    |
|           |                                               | Y | 3.76    | 73.7                   | 16.0 |         | 144.2    |                           |
|           |                                               | Z | 11.61   | 88.5                   | 20.7 |         | 148.0    |                           |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 43.77   | 99.9                   | 21.8 | 4.80    | 131.8    | ±1.7 %                    |
|           |                                               | Y | 13.95   | 87.5                   | 19.0 |         | 142.7    |                           |
|           |                                               | Z | 39.96   | 99.9                   | 22.1 |         | 145.6    |                           |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 62.88   | 99.8                   | 20.4 | 3.55    | 144.5    | ±2.2 %                    |
|           |                                               | Y | 2.45    | 70.4                   | 12.9 |         | 130.3    |                           |
|           |                                               | Z | 80.83   | 99.9                   | 19.9 |         | 135.1    |                           |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 0.32    | 58.4                   | 4.3  | 1.16    | 144.1    | ±1.9 %                    |
|           |                                               | Y | 16.25   | 79.9                   | 12.1 |         | 129.5    |                           |
|           |                                               | Z | 95.90   | 91.1                   | 14.4 |         | 134.6    |                           |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.32    | 67.4                   | 19.8 | 5.67    | 138.3    | ±1.4 %                    |
|           |                                               | Y | 6.35    | 67.3                   | 19.5 |         | 144.4    |                           |
|           |                                               | Z | 6.20    | 67.1                   | 19.6 |         | 127.7    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 8.72  | 73.1 | 25.3 | 9.29 | 138.6 | ±2.7 % |
|           |                                          | Y | 8.88  | 72.9 | 24.9 |      | 147.9 |        |
|           |                                          | Z | 8.48  | 72.3 | 24.9 |      | 127.4 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.14  | 66.9 | 19.6 | 5.80 | 136.2 | ±1.7 % |
|           |                                          | Y | 6.20  | 66.8 | 19.4 |      | 142.8 |        |
|           |                                          | Z | 6.10  | 66.8 | 19.6 |      | 126.2 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.05 | 68.9 | 21.4 | 8.07 | 126.8 | ±2.2 % |
|           |                                          | Y | 9.98  | 68.5 | 21.1 |      | 132.4 |        |
|           |                                          | Z | 10.23 | 69.4 | 21.7 |      | 140.4 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 8.16  | 72.2 | 25.0 | 9.28 | 133.6 | ±2.7 % |
|           |                                          | Y | 8.33  | 72.0 | 24.5 |      | 142.6 |        |
|           |                                          | Z | 8.40  | 73.1 | 25.6 |      | 147.5 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 5.83  | 66.5 | 19.4 | 5.75 | 133.1 | ±1.4 % |
|           |                                          | Y | 5.89  | 66.3 | 19.2 |      | 139.3 |        |
|           |                                          | Z | 6.00  | 67.2 | 19.9 |      | 146.5 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.26  | 66.9 | 19.6 | 5.82 | 138.8 | ±1.7 % |
|           |                                          | Y | 6.34  | 67.0 | 19.5 |      | 145.1 |        |
|           |                                          | Z | 6.22  | 66.9 | 19.7 |      | 128.8 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 4.77  | 66.7 | 19.8 | 5.73 | 135.9 | ±1.4 % |
|           |                                          | Y | 4.89  | 66.6 | 19.5 |      | 141.8 |        |
|           |                                          | Z | 4.85  | 66.8 | 19.9 |      | 128.3 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 6.77  | 75.0 | 26.9 | 9.21 | 144.2 | ±2.5 % |
|           |                                          | Y | 6.56  | 72.6 | 25.2 |      | 131.1 |        |
|           |                                          | Z | 6.68  | 74.0 | 26.4 |      | 137.1 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 4.80  | 66.9 | 19.9 | 5.72 | 135.2 | ±1.4 % |
|           |                                          | Y | 4.87  | 66.5 | 19.5 |      | 140.6 |        |
|           |                                          | Z | 5.03  | 67.7 | 20.4 |      | 149.4 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.77  | 66.7 | 19.8 | 5.72 | 134.7 | ±1.2 % |
|           |                                          | Y | 4.88  | 66.5 | 19.5 |      | 140.6 |        |
|           |                                          | Z | 4.84  | 66.8 | 19.9 |      | 127.8 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.97  | 69.5 | 21.9 | 8.10 | 145.2 | ±2.2 % |
|           |                                          | Y | 9.60  | 68.2 | 21.0 |      | 125.1 |        |
|           |                                          | Z | 9.80  | 69.1 | 21.7 |      | 133.9 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 6.95  | 67.5 | 19.8 | 5.97 | 147.3 | ±1.4 % |
|           |                                          | Y | 6.73  | 66.4 | 19.1 |      | 128.7 |        |
|           |                                          | Z | 6.89  | 67.4 | 19.8 |      | 137.2 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 6.85  | 75.4 | 27.2 | 9.21 | 146.0 | ±2.5 % |
|           |                                          | Y | 6.54  | 72.5 | 25.1 |      | 131.6 |        |
|           |                                          | Z | 6.76  | 74.4 | 26.6 |      | 138.2 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 7.58  | 71.3 | 24.6 | 9.24 | 126.6 | ±2.5 % |
|           |                                          | Y | 7.73  | 71.1 | 24.2 |      | 133.3 |        |
|           |                                          | Z | 7.82  | 72.4 | 25.3 |      | 139.0 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 8.18  | 72.2 | 25.1 | 9.30 | 133.6 | ±2.7 % |
|           |                                          | Y | 8.35  | 72.0 | 24.6 |      | 141.1 |        |
|           |                                          | Z | 8.42  | 73.2 | 25.6 |      | 147.0 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.22  | 66.1 | 18.4 | 3.96 | 128.8 | ±0.9 % |
|           |                                                               | Y | 4.24  | 65.9 | 18.1 |      | 133.8 |        |
|           |                                                               | Z | 4.39  | 67.1 | 19.0 |      | 141.7 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.51  | 66.7 | 18.6 | 3.46 | 140.9 | ±0.7 % |
|           |                                                               | Y | 3.52  | 66.2 | 18.1 |      | 143.4 |        |
|           |                                                               | Z | 3.58  | 67.2 | 19.0 |      | 131.7 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.45  | 66.7 | 18.5 | 3.39 | 142.0 | ±0.7 % |
|           |                                                               | Y | 3.50  | 66.4 | 18.2 |      | 146.9 |        |
|           |                                                               | Z | 3.61  | 67.8 | 19.3 |      | 132.2 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.15  | 66.9 | 19.6 | 5.81 | 136.3 | ±1.4 % |
|           |                                                               | Y | 6.20  | 66.8 | 19.4 |      | 140.3 |        |
|           |                                                               | Z | 6.11  | 66.8 | 19.6 |      | 126.6 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.80  | 67.8 | 20.1 | 6.06 | 143.2 | ±1.7 % |
|           |                                                               | Y | 6.80  | 67.5 | 19.9 |      | 147.4 |        |
|           |                                                               | Z | 6.71  | 67.6 | 20.1 |      | 131.9 |        |
| 10400-AAB | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 10.31 | 70.0 | 22.4 | 8.37 | 147.9 | ±3.0 % |
|           |                                                               | Y | 9.88  | 68.5 | 21.3 |      | 127.2 |        |
|           |                                                               | Z | 10.13 | 69.5 | 22.1 |      | 135.8 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.60  | 68.6 | 18.9 | 3.76 | 128.2 | ±0.5 % |
|           |                                                               | Y | 4.58  | 67.9 | 18.4 |      | 134.2 |        |
|           |                                                               | Z | 4.86  | 69.6 | 19.5 |      | 142.6 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.57  | 68.9 | 19.1 | 3.77 | 149.7 | ±0.5 % |
|           |                                                               | Y | 4.51  | 68.0 | 18.5 |      | 132.3 |        |
|           |                                                               | Z | 4.78  | 69.6 | 19.5 |      | 140.3 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.47  | 67.0 | 17.9 | 1.54 | 128.1 | ±0.7 % |
|           |                                                               | Y | 2.46  | 66.4 | 17.4 |      | 132.5 |        |
|           |                                                               | Z | 2.72  | 69.1 | 19.2 |      | 140.6 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.12 | 69.7 | 22.1 | 8.23 | 146.8 | ±2.7 % |
|           |                                                               | Y | 9.66  | 68.2 | 21.1 |      | 125.0 |        |
|           |                                                               | Z | 9.91  | 69.2 | 21.8 |      | 134.3 |        |

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 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:3209

### 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                            | 6.34    | 6.34    | 6.34    | 0.29               | 2.02                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.04    | 6.04    | 6.04    | 0.23               | 2.57                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.23    | 5.23    | 5.23    | 0.80               | 1.08                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.05    | 5.05    | 5.05    | 0.10               | 2.40                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 4.76    | 4.76    | 4.76    | 0.70               | 1.27                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.53    | 4.53    | 4.53    | 0.80               | 1.22                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.36    | 4.36    | 4.36    | 0.75               | 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:3209

### Calibration Parameter Determined in Body Tissue Simulating Media

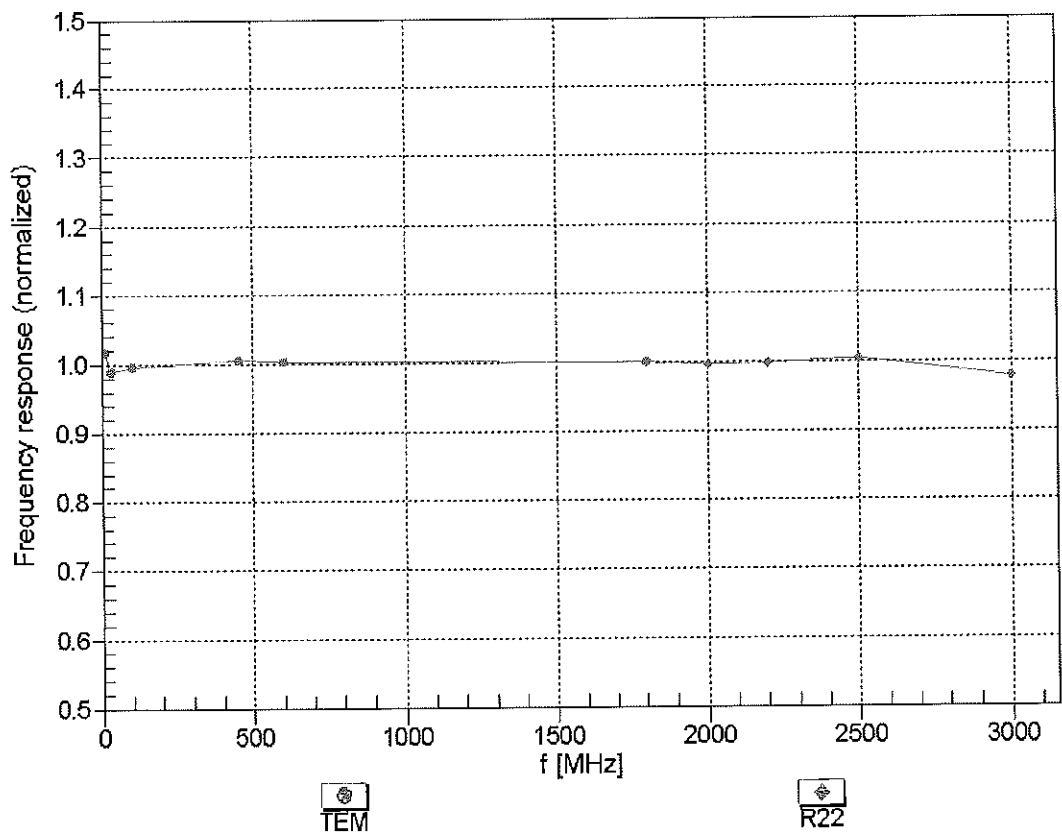
| f (MHz) <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 55.5                               | 0.96                            | 6.12    | 6.12    | 6.12    | 0.34               | 1.81                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.07    | 6.07    | 6.07    | 0.37               | 1.79                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.86    | 4.86    | 4.86    | 0.67               | 1.43                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.57    | 4.57    | 4.57    | 0.57               | 1.53                    | ± 12.0 %    |
| 2300                 | 52.9                               | 1.81                            | 4.28    | 4.28    | 4.28    | 0.80               | 1.19                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.12    | 4.12    | 4.12    | 0.72               | 1.15                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 3.92    | 3.92    | 3.92    | 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.

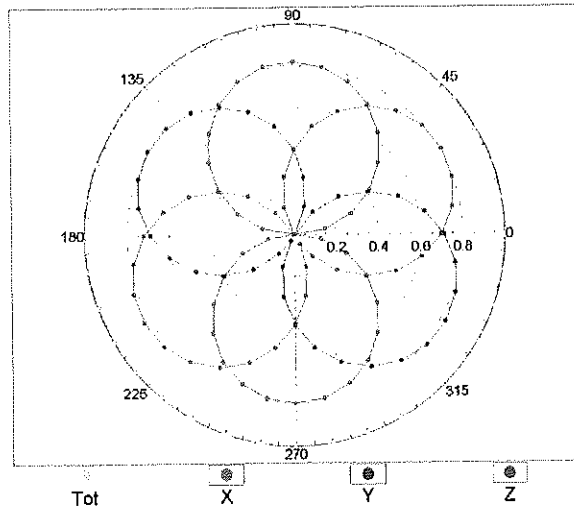
**Frequency Response of E-Field**  
(TEM-Cell:ifi110 EXX, Waveguide: R22)



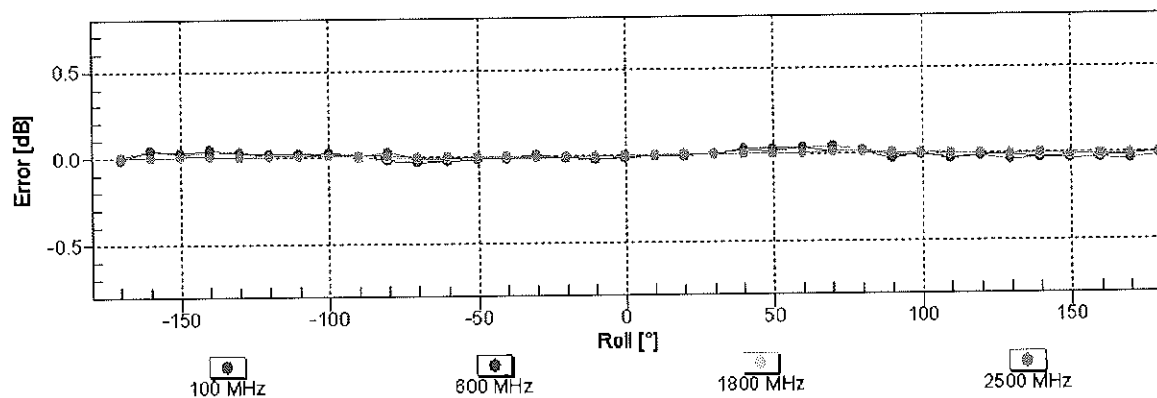
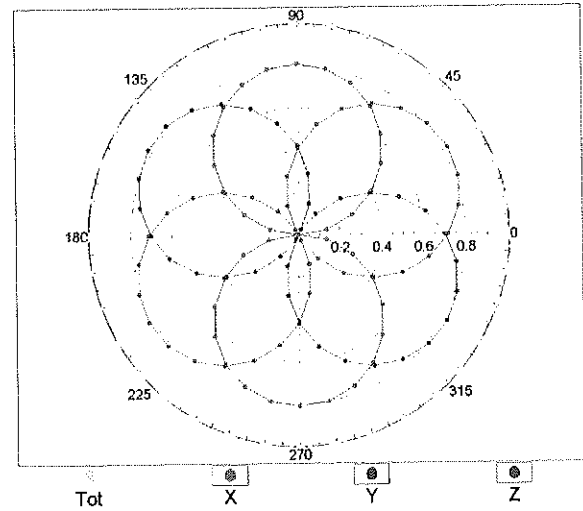
**Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)**

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

f=600 MHz,TEM



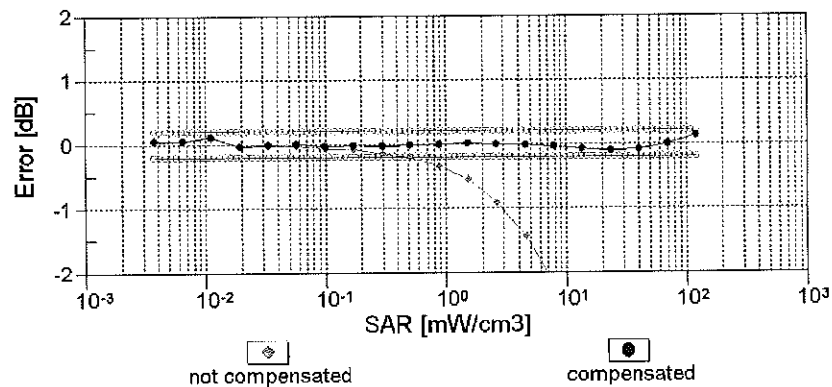
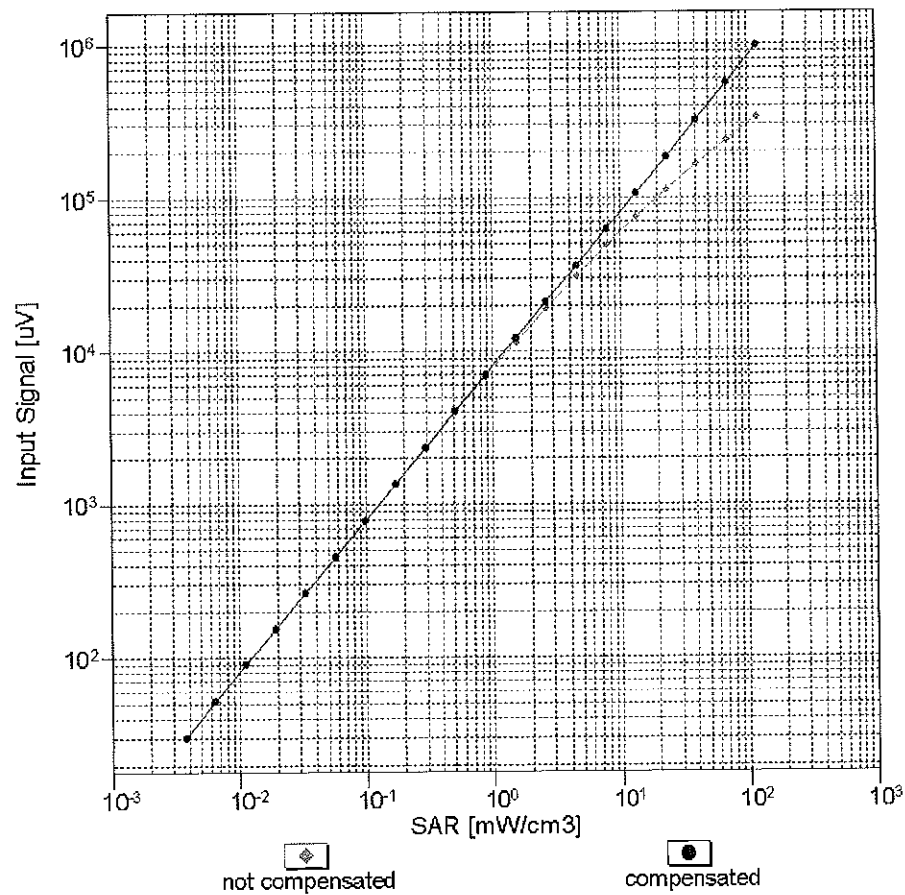
f=1800 MHz,R22



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

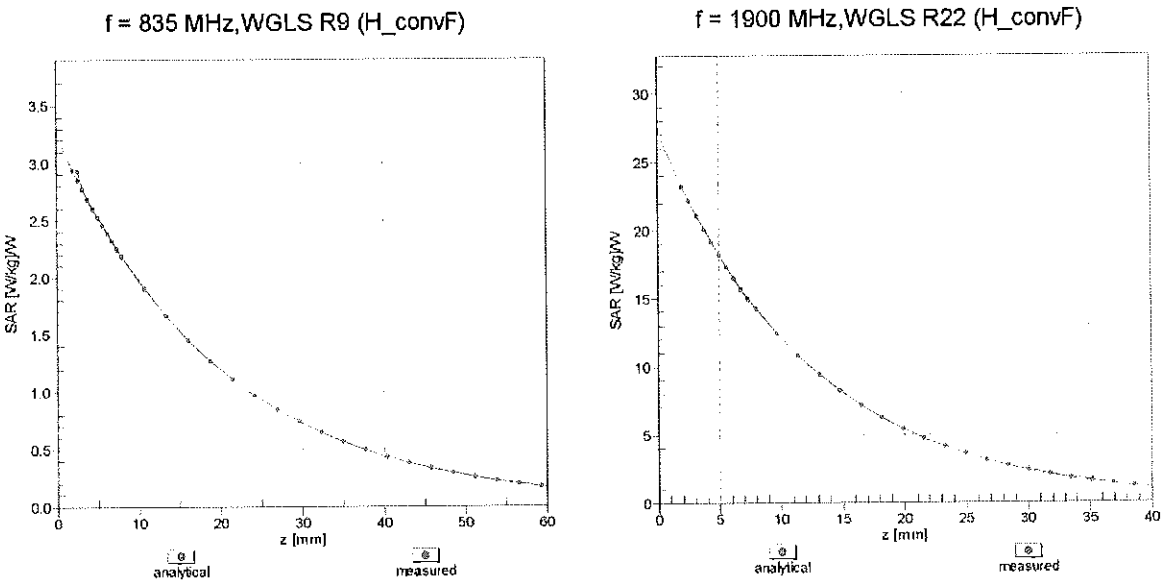


**Dynamic Range f(SAR<sub>head</sub>)**  
(TEM cell , f<sub>eval</sub>= 1900 MHz)

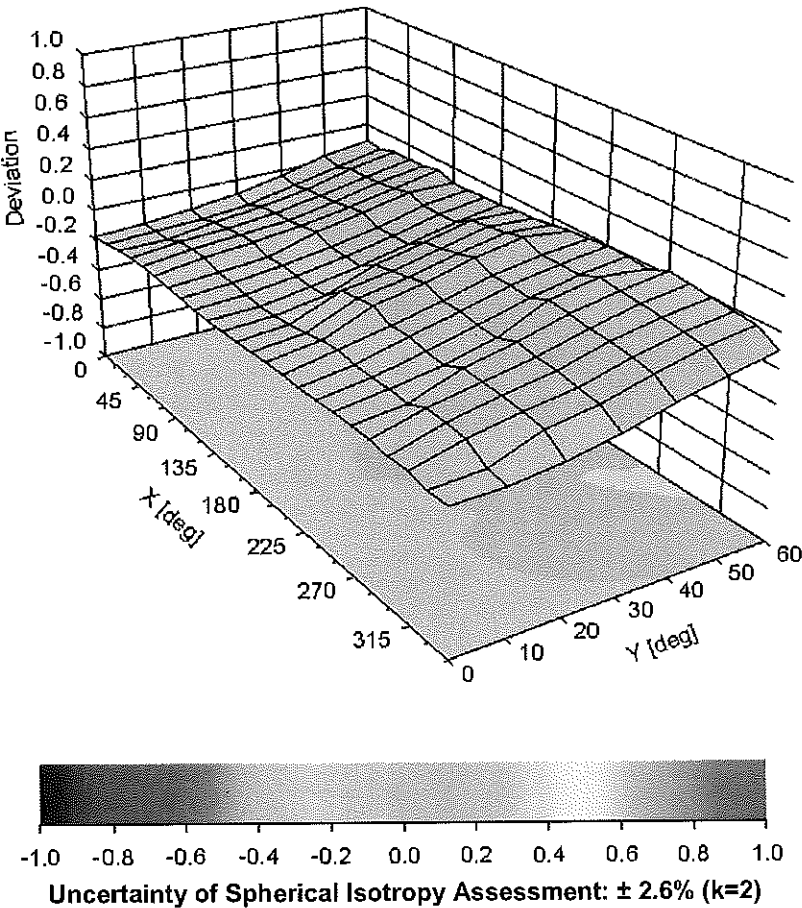


**Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )**

# Conversion Factor Assessment



## Deviation from Isotropy in Liquid Error ( $\phi$ , $\theta$ ), f = 900 MHz



## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3209

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -40.3      |
| 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: **ES3-3258\_Feb15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3258**

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

PN ✓  
 3/6/15

Calibration date: **February 27, 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>Claudio Leubler</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: February 27, 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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 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).

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3258

## Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 1.29     | 1.17     | 1.01     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 101.9    | 104.5    | 92.0     |               |

## 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    | 186.8    | $\pm 3.0 \%$              |
|               |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 179.5    |                           |
|               |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 198.4    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 4.70    | 64.5                         | 13.6 | 10.00   | 43.6     | $\pm 2.2 \%$              |
|               |                                               | Y | 1.69    | 57.9                         | 9.8  |         | 40.8     |                           |
|               |                                               | Z | 1.36    | 61.6                         | 10.5 |         | 58.3     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.23    | 66.3                         | 18.0 | 2.91    | 131.8    | $\pm 1.2 \%$              |
|               |                                               | Y | 3.40    | 67.3                         | 18.3 |         | 140.6    |                           |
|               |                                               | Z | 3.40    | 67.4                         | 19.0 |         | 139.4    |                           |
| 10012-<br>CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 2.96    | 67.7                         | 17.9 | 1.87    | 134.2    | $\pm 0.7 \%$              |
|               |                                               | Y | 3.06    | 69.0                         | 18.5 |         | 141.2    |                           |
|               |                                               | Z | 2.58    | 67.5                         | 18.9 |         | 138.1    |                           |
| 10013-<br>CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 12.10   | 72.1                         | 24.0 | 9.46    | 139.7    | $\pm 3.3 \%$              |
|               |                                               | Y | 11.17   | 70.7                         | 23.2 |         | 138.6    |                           |
|               |                                               | Z | 11.13   | 70.3                         | 23.5 |         | 139.1    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 29.84   | 99.9                         | 28.9 | 9.39    | 130.2    | $\pm 1.9 \%$              |
|               |                                               | Y | 10.50   | 86.9                         | 23.8 |         | 142.5    |                           |
|               |                                               | Z | 2.45    | 67.0                         | 12.9 |         | 144.1    |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 28.34   | 99.7                         | 29.1 | 9.57    | 119.3    | $\pm 3.3 \%$              |
|               |                                               | Y | 10.00   | 85.7                         | 23.2 |         | 131.8    |                           |
|               |                                               | Z | 3.08    | 71.4                         | 16.0 |         | 138.3    |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 44.08   | 99.6                         | 25.8 | 6.56    | 118.9    | $\pm 2.5 \%$              |
|               |                                               | Y | 11.63   | 85.2                         | 20.7 |         | 147.3    |                           |
|               |                                               | Z | 25.69   | 99.7                         | 23.4 |         | 141.6    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 57.19   | 100.0                        | 24.3 | 4.80    | 127.3    | $\pm 1.7 \%$              |
|               |                                               | Y | 46.70   | 99.7                         | 23.1 |         | 141.3    |                           |
|               |                                               | Z | 11.63   | 87.8                         | 18.3 |         | 135.6    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 63.03   | 99.9                         | 23.1 | 3.55    | 132.4    | $\pm 1.7 \%$              |
|               |                                               | Y | 43.32   | 97.5                         | 21.5 |         | 149.6    |                           |
|               |                                               | Z | 0.59    | 59.3                         | 4.9  |         | 148.4    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 79.78   | 100.0                        | 20.4 | 1.16    | 137.7    | $\pm 1.9 \%$              |
|               |                                               | Y | 95.25   | 97.5                         | 18.1 |         | 139.0    |                           |
|               |                                               | Z | 0.21    | 58.7                         | 2.5  |         | 149.8    |                           |
| 10100-<br>CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.64    | 68.2                         | 20.0 | 5.67    | 146.3    | $\pm 1.4 \%$              |
|               |                                               | Y | 6.22    | 66.7                         | 19.1 |         | 127.5    |                           |
|               |                                               | Z | 6.65    | 67.9                         | 20.3 |         | 129.0    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 12.42 | 78.6 | 27.2 | 9.29 | 126.0 | ±3.0 % |
|           |                                          | Y | 9.78  | 74.1 | 25.0 |      | 141.1 |        |
|           |                                          | Z | 8.68  | 72.3 | 24.8 |      | 127.4 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.57  | 67.9 | 20.0 | 5.80 | 144.7 | ±1.4 % |
|           |                                          | Y | 6.19  | 66.6 | 19.2 |      | 126.9 |        |
|           |                                          | Z | 6.50  | 67.4 | 20.1 |      | 128.3 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.56 | 69.6 | 21.7 | 8.07 | 136.4 | ±2.5 % |
|           |                                          | Y | 10.21 | 69.0 | 21.2 |      | 142.8 |        |
|           |                                          | Z | 10.95 | 70.3 | 22.4 |      | 149.6 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 11.31 | 76.6 | 26.2 | 9.28 | 124.3 | ±3.0 % |
|           |                                          | Y | 9.26  | 73.5 | 24.9 |      | 136.5 |        |
|           |                                          | Z | 8.51  | 72.6 | 25.3 |      | 147.8 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 6.23  | 67.2 | 19.7 | 5.75 | 144.5 | ±1.4 % |
|           |                                          | Y | 6.12  | 67.0 | 19.5 |      | 146.5 |        |
|           |                                          | Z | 6.17  | 66.8 | 19.7 |      | 126.0 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.65  | 67.6 | 19.8 | 5.82 | 149.6 | ±1.4 % |
|           |                                          | Y | 6.28  | 66.5 | 19.1 |      | 128.2 |        |
|           |                                          | Z | 6.49  | 66.9 | 19.7 |      | 130.6 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 5.25  | 67.1 | 19.8 | 5.73 | 149.2 | ±2.7 % |
|           |                                          | Y | 4.91  | 66.4 | 19.3 |      | 127.6 |        |
|           |                                          | Z | 5.18  | 67.5 | 20.3 |      | 129.2 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 13.26 | 87.2 | 31.5 | 9.21 | 141.5 | ±3.5 % |
|           |                                          | Y | 8.12  | 76.7 | 26.7 |      | 148.3 |        |
|           |                                          | Z | 6.24  | 71.2 | 25.1 |      | 133.0 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 5.24  | 67.1 | 19.8 | 5.72 | 144.4 | ±1.4 % |
|           |                                          | Y | 5.07  | 67.2 | 19.7 |      | 148.4 |        |
|           |                                          | Z | 5.39  | 68.3 | 20.9 |      | 149.2 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 5.23  | 67.0 | 19.7 | 5.72 | 147.7 | ±1.4 % |
|           |                                          | Y | 5.08  | 67.2 | 19.7 |      | 147.7 |        |
|           |                                          | Z | 5.32  | 68.0 | 20.7 |      | 149.9 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 10.20 | 69.2 | 21.6 | 8.10 | 132.2 | ±2.5 % |
|           |                                          | Y | 9.77  | 68.4 | 21.0 |      | 132.4 |        |
|           |                                          | Z | 10.50 | 69.7 | 22.2 |      | 142.9 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 7.05  | 66.7 | 19.3 | 5.97 | 134.8 | ±1.7 % |
|           |                                          | Y | 6.99  | 67.1 | 19.3 |      | 137.4 |        |
|           |                                          | Z | 7.25  | 67.1 | 19.9 |      | 143.2 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 12.72 | 85.8 | 30.7 | 9.21 | 144.2 | ±3.0 % |
|           |                                          | Y | 7.30  | 73.7 | 25.2 |      | 124.4 |        |
|           |                                          | Z | 6.37  | 71.8 | 25.5 |      | 135.4 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 12.64 | 81.1 | 28.7 | 9.24 | 142.0 | ±3.3 % |
|           |                                          | Y | 8.41  | 72.0 | 24.2 |      | 125.6 |        |
|           |                                          | Z | 7.90  | 71.5 | 24.9 |      | 139.7 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 11.35 | 76.9 | 26.5 | 9.30 | 118.8 | ±2.7 % |
|           |                                          | Y | 9.17  | 73.2 | 24.7 |      | 135.1 |        |
|           |                                          | Z | 8.55  | 72.7 | 25.4 |      | 146.4 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.42  | 66.3 | 18.4 | 3.96 | 134.0 | ±1.2 % |
|           |                                                               | Y | 4.49  | 66.9 | 18.6 |      | 140.3 |        |
|           |                                                               | Z | 4.67  | 67.6 | 19.5 |      | 142.8 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.71  | 66.6 | 18.4 | 3.46 | 147.8 | ±0.9 % |
|           |                                                               | Y | 3.74  | 67.2 | 18.6 |      | 130.4 |        |
|           |                                                               | Z | 3.70  | 66.6 | 18.9 |      | 131.8 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.68  | 66.8 | 18.5 | 3.39 | 147.7 | ±0.7 % |
|           |                                                               | Y | 3.60  | 66.7 | 18.3 |      | 132.8 |        |
|           |                                                               | Z | 3.66  | 66.5 | 18.7 |      | 133.8 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.55  | 67.8 | 20.0 | 5.81 | 143.8 | ±1.7 % |
|           |                                                               | Y | 6.39  | 67.3 | 19.6 |      | 147.3 |        |
|           |                                                               | Z | 6.60  | 67.6 | 20.3 |      | 129.4 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 7.16  | 68.5 | 20.4 | 6.06 | 149.6 | ±1.4 % |
|           |                                                               | Y | 6.69  | 67.0 | 19.4 |      | 129.6 |        |
|           |                                                               | Z | 7.28  | 68.5 | 20.8 |      | 136.6 |        |
| 10400-AAB | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)           | X | 10.51 | 69.6 | 22.0 | 8.37 | 132.9 | ±2.7 % |
|           |                                                               | Y | 10.08 | 68.8 | 21.3 |      | 135.5 |        |
|           |                                                               | Z | 10.91 | 70.2 | 22.7 |      | 147.0 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.65  | 66.6 | 18.0 | 3.76 | 140.7 | ±2.2 % |
|           |                                                               | Y | 4.93  | 68.8 | 18.8 |      | 143.5 |        |
|           |                                                               | Z | 4.99  | 68.3 | 19.2 |      | 148.7 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.53  | 66.5 | 17.8 | 3.77 | 138.3 | ±0.7 % |
|           |                                                               | Y | 4.85  | 68.9 | 18.8 |      | 140.2 |        |
|           |                                                               | Z | 4.58  | 66.5 | 18.2 |      | 145.3 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.43  | 66.1 | 17.4 | 1.54 | 133.0 | ±1.9 % |
|           |                                                               | Y | 2.72  | 68.0 | 18.0 |      | 138.1 |        |
|           |                                                               | Z | 2.54  | 67.6 | 18.8 |      | 139.4 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.18 | 69.0 | 21.5 | 8.23 | 132.1 | ±2.5 % |
|           |                                                               | Y | 9.90  | 68.6 | 21.2 |      | 134.4 |        |
|           |                                                               | Z | 10.65 | 69.8 | 22.4 |      | 144.7 |        |

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

<sup>A</sup> The uncertainties of 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:3258

### 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                            | 6.45    | 6.45    | 6.45    | 0.48               | 1.43                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.21    | 6.21    | 6.21    | 0.40               | 1.59                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.27    | 5.27    | 5.27    | 0.66               | 1.25                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.15    | 5.15    | 5.15    | 0.75               | 1.20                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 5.06    | 5.06    | 5.06    | 0.73               | 1.31                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.61    | 4.61    | 4.61    | 0.69               | 1.36                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.38    | 4.38    | 4.38    | 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:3258

### Calibration Parameter Determined in Body Tissue Simulating Media

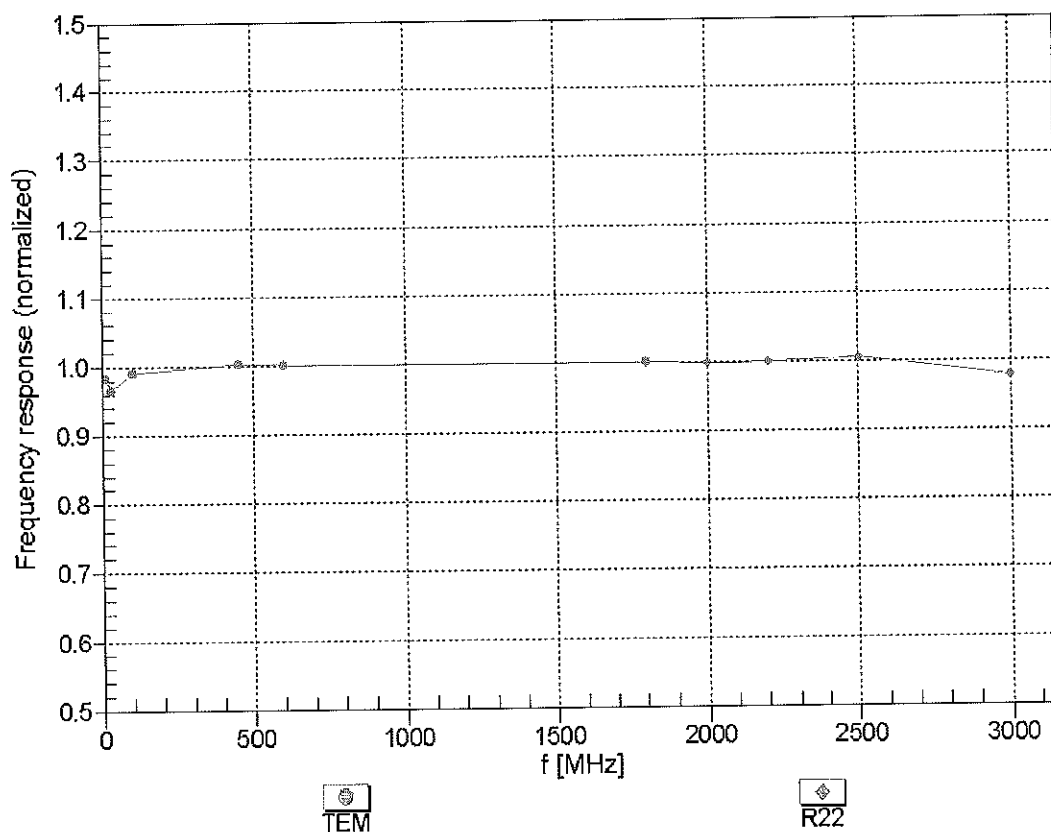
| f (MHz) <sup>C</sup> | Relative Permittivity <sup>F</sup> | Conductivity (S/m) <sup>F</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>G</sup> | Depth <sup>G</sup> (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 55.5                               | 0.96                            | 6.13    | 6.13    | 6.13    | 0.47               | 1.51                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.16    | 6.16    | 6.16    | 0.63               | 1.25                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.88    | 4.88    | 4.88    | 0.75               | 1.39                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.64    | 4.64    | 4.64    | 0.71               | 1.34                    | ± 12.0 %    |
| 2300                 | 52.9                               | 1.81                            | 4.77    | 4.77    | 4.77    | 0.80               | 1.18                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.17    | 4.17    | 4.17    | 0.80               | 1.09                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 3.95    | 3.95    | 3.95    | 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.

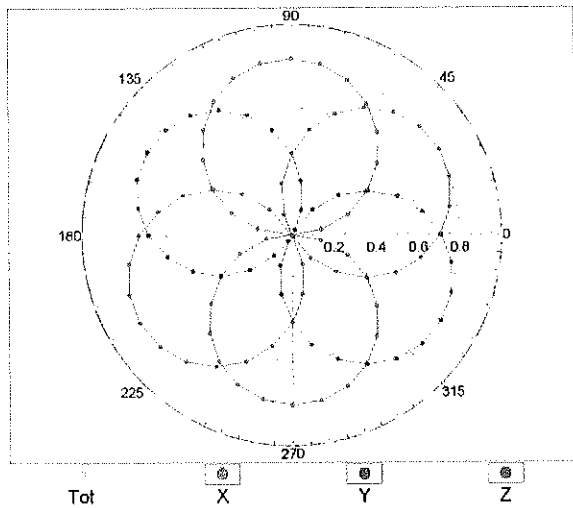
## Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



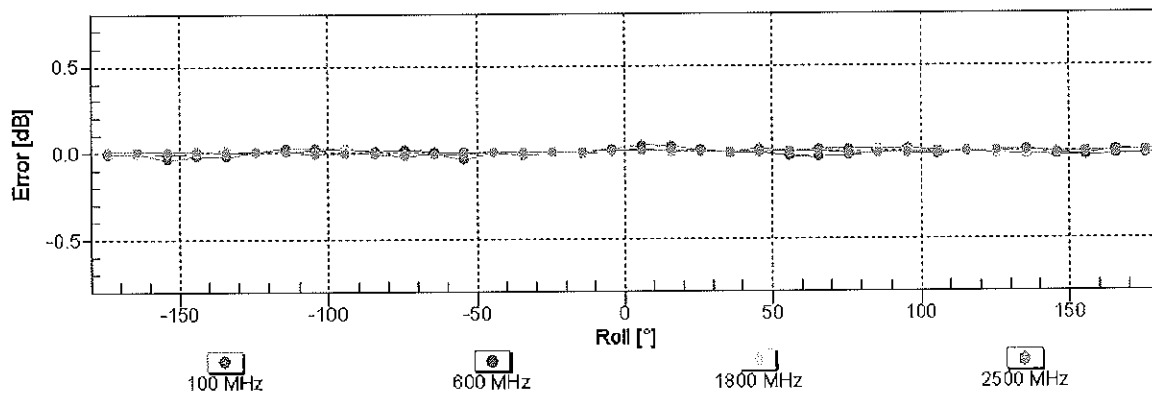
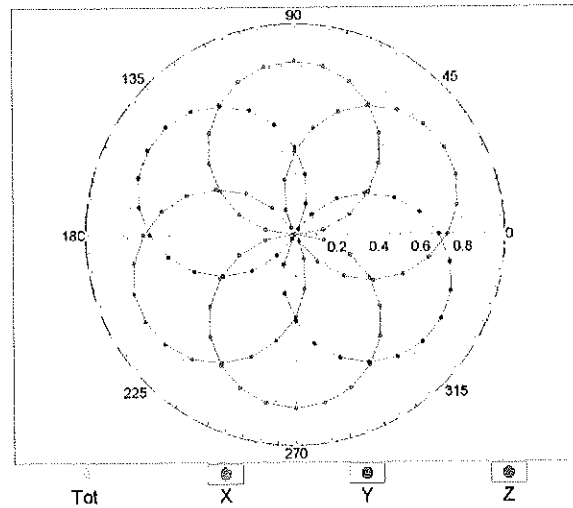
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM

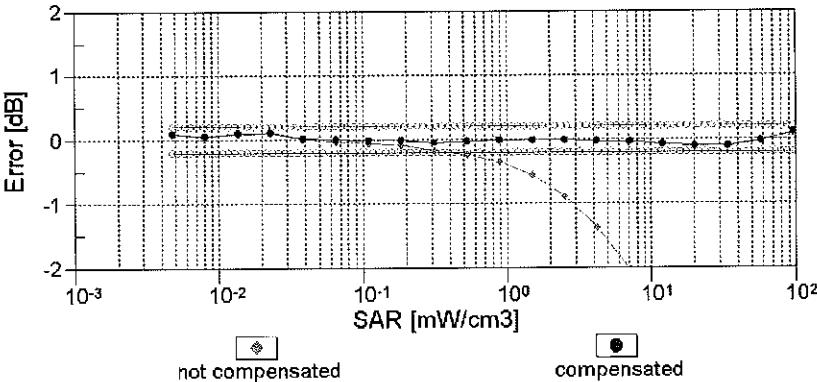
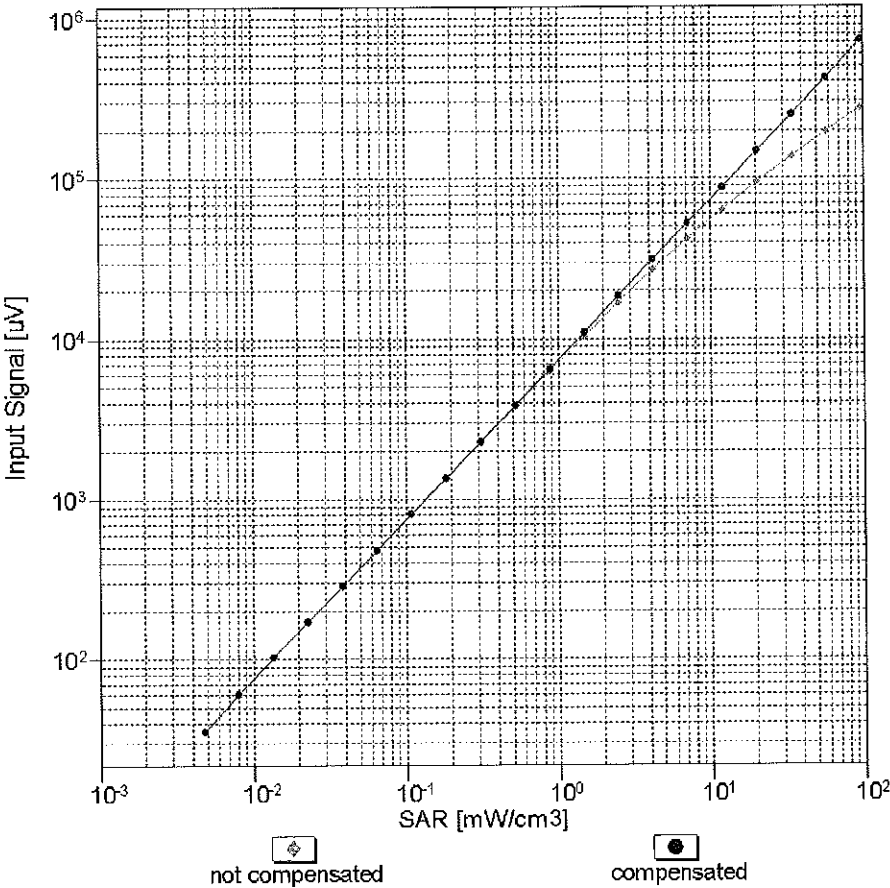


f=1800 MHz,R22



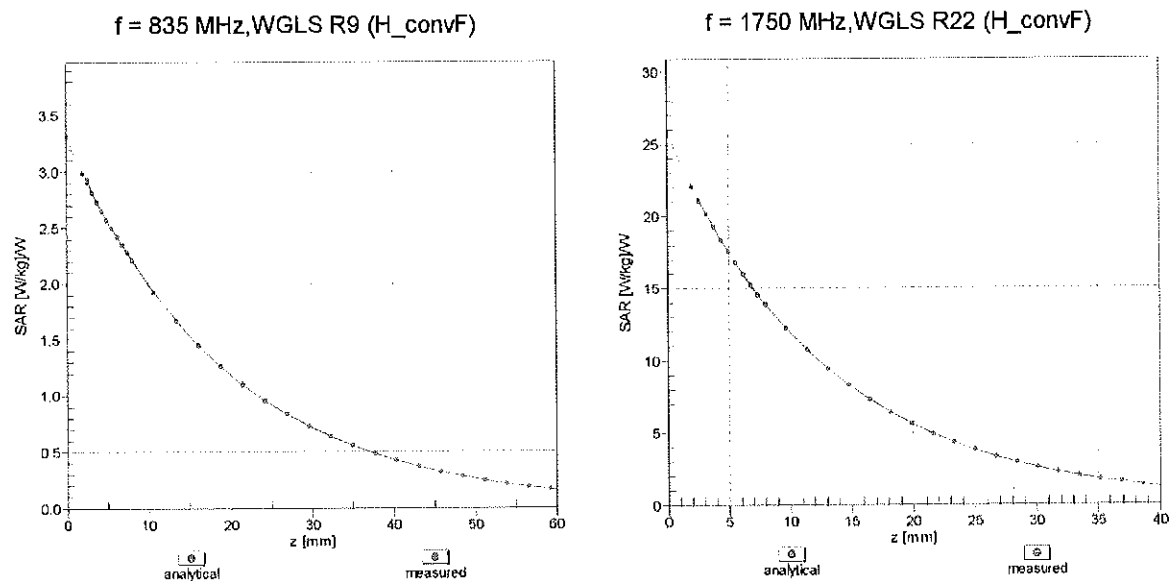
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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



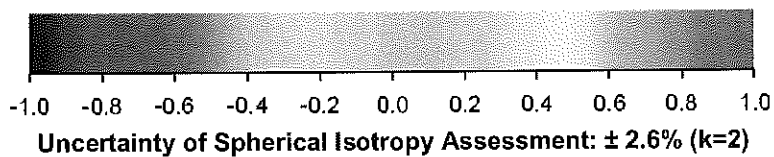
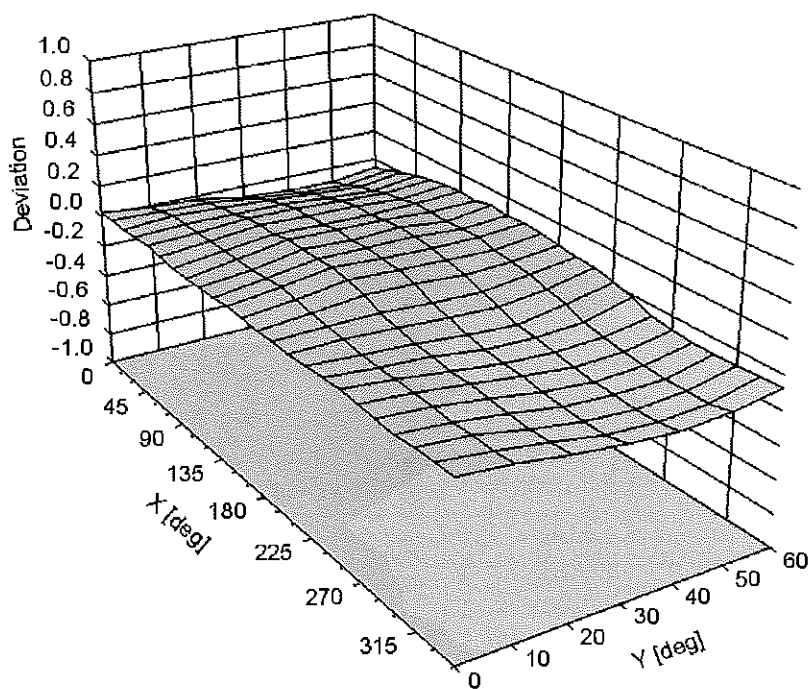
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3258

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -114.2     |
| 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 108**

Client **PC Test**

Certificate No: **ES3-3288\_Sep14/2**

# **CALIBRATION CERTIFICATE (Replacement of No:ES3-3288\_Sep14)**

Object **ES3DV3 - SN:3288**

Calibration procedure(s)

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

**CC**  
**10/12/14**

Calibration date:

**September 24, 2014**

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      | 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-13 (No. ES3-3013_Dec13)    | Dec-14                 |
| DAE4                       | SN: 660         | 13-Dec-13 (No. DAE4-660_Dec13)    | Dec-14                 |
| 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-13) | In house check: Oct-14 |

|                                                                                                                 | Name          | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|---------------|-----------------------|-----------|
| Calibrated by:                                                                                                  | Leif Klysner  | Laboratory Technician |           |
| Approved by:                                                                                                    | Katja Pokovic | Technical Manager     |           |
| Issued: November 3, 2014                                                                                        |               |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |               |                       |           |





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

### 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:3288

|               |                    |
|---------------|--------------------|
| Manufactured: | July 6, 2010       |
| Repaired:     | September 18, 2014 |
| Calibrated:   | September 24, 2014 |

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

# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

## Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|---------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 1.05     | 1.16     | 0.92     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                 | 105.1    | 104.6    | 106.7    |               |

## 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    | 195.8    | $\pm 3.5 \%$              |
|               |                                               | Y | 0.0     | 0.0                    | 1.0  |         | 175.9    |                           |
|               |                                               | Z | 0.0     | 0.0                    | 1.0  |         | 177.1    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 2.71    | 61.9                   | 11.4 | 10.00   | 40.3     | $\pm 2.2 \%$              |
|               |                                               | Y | 2.37    | 60.2                   | 11.2 |         | 42.6     |                           |
|               |                                               | Z | 1.54    | 56.6                   | 8.9  |         | 41.2     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.29    | 67.1                   | 18.4 | 2.91    | 133.8    | $\pm 0.5 \%$              |
|               |                                               | Y | 3.43    | 67.9                   | 18.9 |         | 139.5    |                           |
|               |                                               | Z | 3.45    | 68.1                   | 18.9 |         | 141.3    |                           |
| 10012-<br>CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 2.99    | 68.9                   | 18.6 | 1.87    | 135.1    | $\pm 0.7 \%$              |
|               |                                               | Y | 3.59    | 72.4                   | 20.4 |         | 140.7    |                           |
|               |                                               | Z | 3.54    | 72.4                   | 20.3 |         | 143.0    |                           |
| 10013-<br>CAA | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.15   | 70.8                   | 23.3 | 9.46    | 132.3    | $\pm 3.5 \%$              |
|               |                                               | Y | 11.29   | 70.8                   | 23.2 |         | 141.1    |                           |
|               |                                               | Z | 11.07   | 70.7                   | 23.2 |         | 139.2    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 14.71   | 90.5                   | 24.5 | 9.39    | 149.0    | $\pm 1.9 \%$              |
|               |                                               | Y | 16.40   | 92.8                   | 26.0 |         | 131.3    |                           |
|               |                                               | Z | 11.34   | 87.2                   | 23.6 |         | 126.1    |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 15.91   | 92.2                   | 25.3 | 9.57    | 138.9    | $\pm 2.5 \%$              |
|               |                                               | Y | 21.25   | 96.9                   | 27.2 |         | 142.0    |                           |
|               |                                               | Z | 11.68   | 87.2                   | 23.5 |         | 145.9    |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 38.62   | 99.8                   | 24.7 | 6.56    | 123.8    | $\pm 2.2 \%$              |
|               |                                               | Y | 36.71   | 99.7                   | 25.2 |         | 128.1    |                           |
|               |                                               | Z | 36.56   | 99.4                   | 24.5 |         | 129.5    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 56.60   | 99.6                   | 22.6 | 4.80    | 138.8    | $\pm 1.9 \%$              |
|               |                                               | Y | 46.94   | 99.9                   | 23.7 |         | 149.9    |                           |
|               |                                               | Z | 51.17   | 99.8                   | 22.9 |         | 144.9    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 70.88   | 100.0                  | 21.6 | 3.55    | 147.5    | $\pm 1.9 \%$              |
|               |                                               | Y | 52.58   | 99.8                   | 22.6 |         | 129.4    |                           |
|               |                                               | Z | 76.98   | 99.8                   | 21.2 |         | 128.7    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 98.89   | 99.5                   | 18.9 | 1.16    | 135.8    | $\pm 1.4 \%$              |
|               |                                               | Y | 78.39   | 99.6                   | 19.5 |         | 141.7    |                           |
|               |                                               | Z | 95.21   | 95.5                   | 17.1 |         | 143.4    |                           |
| 10039-<br>CAB | CDMA2000 (1xRTT, RC1)                         | X | 4.72    | 66.7                   | 18.9 | 4.57    | 133.7    | $\pm 0.9 \%$              |
|               |                                               | Y | 4.85    | 67.1                   | 19.1 |         | 137.7    |                           |
|               |                                               | Z | 4.81    | 67.4                   | 19.2 |         | 141.9    |                           |

|           |                                               |   |       |      |      |      |       |        |
|-----------|-----------------------------------------------|---|-------|------|------|------|-------|--------|
| 10081-CAB | CDMA2000 (1xRTT, RC3)                         | X | 3.91  | 66.3 | 18.6 | 3.97 | 129.5 | ±0.7 % |
|           |                                               | Y | 4.00  | 66.6 | 18.7 |      | 133.7 |        |
|           |                                               | Z | 3.99  | 66.8 | 18.8 |      | 137.5 |        |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2)                   | X | 4.63  | 66.9 | 18.7 | 3.98 | 141.4 | ±0.7 % |
|           |                                               | Y | 4.78  | 67.5 | 19.0 |      | 147.7 |        |
|           |                                               | Z | 4.57  | 66.8 | 18.6 |      | 127.8 |        |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.59  | 68.2 | 20.1 | 5.67 | 149.2 | ±1.4 % |
|           |                                               | Y | 6.36  | 67.3 | 19.6 |      | 130.7 |        |
|           |                                               | Z | 6.36  | 67.5 | 19.6 |      | 133.6 |        |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)      | X | 6.44  | 67.8 | 20.0 | 5.80 | 146.6 | ±1.4 % |
|           |                                               | Y | 6.23  | 66.8 | 19.4 |      | 128.8 |        |
|           |                                               | Z | 6.24  | 67.1 | 19.6 |      | 131.4 |        |
| 10110-CAB | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)       | X | 6.08  | 67.1 | 19.6 | 5.75 | 143.2 | ±1.4 % |
|           |                                               | Y | 6.20  | 67.4 | 19.8 |      | 148.0 |        |
|           |                                               | Z | 5.92  | 66.6 | 19.3 |      | 128.5 |        |
| 10114-CAA | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 10.32 | 69.3 | 21.5 | 8.10 | 137.0 | ±2.2 % |
|           |                                               | Y | 10.31 | 69.1 | 21.4 |      | 143.5 |        |
|           |                                               | Z | 10.37 | 69.5 | 21.6 |      | 146.1 |        |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)      | X | 10.35 | 69.4 | 21.6 | 8.07 | 138.3 | ±2.2 % |
|           |                                               | Y | 10.36 | 69.3 | 21.4 |      | 146.4 |        |
|           |                                               | Z | 10.42 | 69.6 | 21.6 |      | 149.0 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)       | X | 9.95  | 75.7 | 26.2 | 9.28 | 134.9 | ±3.3 % |
|           |                                               | Y | 10.37 | 76.0 | 26.1 |      | 146.6 |        |
|           |                                               | Z | 9.77  | 75.4 | 26.0 |      | 142.5 |        |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)       | X | 6.12  | 67.2 | 19.7 | 5.75 | 144.9 | ±1.4 % |
|           |                                               | Y | 6.21  | 67.4 | 19.8 |      | 148.8 |        |
|           |                                               | Z | 5.91  | 66.5 | 19.3 |      | 128.7 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)       | X | 6.28  | 66.7 | 19.4 | 5.82 | 125.5 | ±1.2 % |
|           |                                               | Y | 6.37  | 66.8 | 19.4 |      | 129.7 |        |
|           |                                               | Z | 6.36  | 67.1 | 19.6 |      | 132.9 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)         | X | 5.08  | 67.6 | 20.2 | 5.73 | 147.0 | ±1.2 % |
|           |                                               | Y | 4.95  | 66.6 | 19.6 |      | 128.6 |        |
|           |                                               | Z | 4.91  | 66.9 | 19.8 |      | 131.2 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)         | X | 8.18  | 77.2 | 27.2 | 9.21 | 123.4 | ±2.7 % |
|           |                                               | Y | 8.37  | 76.6 | 26.6 |      | 129.5 |        |
|           |                                               | Z | 7.97  | 76.7 | 26.9 |      | 128.7 |        |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)         | X | 5.05  | 67.4 | 20.1 | 5.72 | 146.2 | ±1.4 % |
|           |                                               | Y | 5.10  | 67.3 | 20.0 |      | 142.8 |        |
|           |                                               | Z | 4.87  | 66.7 | 19.6 |      | 129.6 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)         | X | 5.04  | 67.4 | 20.0 | 5.72 | 145.5 | ±1.2 % |
|           |                                               | Y | 5.12  | 67.4 | 20.0 |      | 143.4 |        |
|           |                                               | Z | 4.87  | 66.7 | 19.6 |      | 129.9 |        |
| 10193-CAA | IEEE 802.11n (HT Greenfield, 6.5 Mbps, BPSK)  | X | 9.92  | 68.9 | 21.4 | 8.09 | 131.0 | ±2.2 % |
|           |                                               | Y | 9.84  | 68.5 | 21.1 |      | 130.0 |        |
|           |                                               | Z | 9.94  | 69.0 | 21.4 |      | 138.6 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)                       | X | 9.90  | 68.9 | 21.4 | 8.10 | 130.8 | ±2.2 % |
|           |                                                               | Y | 9.81  | 68.4 | 21.0 |      | 131.4 |        |
|           |                                                               | Z | 9.95  | 69.1 | 21.5 |      | 140.5 |        |
| 10219-CAA | IEEE 802.11n (HT Mixed, 7.2 Mbps, BPSK)                       | X | 9.81  | 68.8 | 21.3 | 8.03 | 130.0 | ±2.2 % |
|           |                                                               | Y | 9.89  | 68.9 | 21.3 |      | 138.1 |        |
|           |                                                               | Z | 9.89  | 69.1 | 21.5 |      | 140.5 |        |
| 10222-CAA | IEEE 802.11n (HT Mixed, 15 Mbps, BPSK)                        | X | 10.25 | 69.2 | 21.4 | 8.06 | 137.1 | ±2.2 % |
|           |                                                               | Y | 10.30 | 69.2 | 21.4 |      | 144.4 |        |
|           |                                                               | Z | 10.38 | 69.6 | 21.6 |      | 148.4 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                                              | X | 6.90  | 66.8 | 19.3 | 5.97 | 132.8 | ±1.4 % |
|           |                                                               | Y | 7.09  | 67.3 | 19.6 |      | 142.0 |        |
|           |                                                               | Z | 7.04  | 67.4 | 19.6 |      | 143.5 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)                         | X | 9.61  | 81.9 | 29.6 | 9.21 | 149.3 | ±2.7 % |
|           |                                                               | Y | 8.66  | 77.6 | 27.1 |      | 133.7 |        |
|           |                                                               | Z | 8.20  | 77.5 | 27.3 |      | 132.2 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)                       | X | 9.16  | 74.5 | 25.8 | 9.24 | 126.3 | ±3.0 % |
|           |                                                               | Y | 9.62  | 75.0 | 25.8 |      | 137.4 |        |
|           |                                                               | Z | 9.16  | 74.8 | 25.9 |      | 135.2 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK)                      | X | 9.97  | 75.7 | 26.3 | 9.30 | 133.7 | ±3.3 % |
|           |                                                               | Y | 10.38 | 75.9 | 26.1 |      | 146.1 |        |
|           |                                                               | Z | 9.91  | 75.7 | 26.3 |      | 143.8 |        |
| 10274-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.10)                     | X | 5.86  | 66.6 | 18.7 | 4.87 | 129.9 | ±0.9 % |
|           |                                                               | Y | 6.01  | 67.1 | 19.0 |      | 135.7 |        |
|           |                                                               | Z | 5.95  | 67.1 | 19.0 |      | 139.4 |        |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.40  | 66.7 | 18.6 | 3.96 | 136.4 | ±0.7 % |
|           |                                                               | Y | 4.55  | 67.3 | 19.0 |      | 138.3 |        |
|           |                                                               | Z | 4.56  | 67.6 | 19.1 |      | 144.3 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.64  | 66.9 | 18.7 | 3.46 | 127.4 | ±0.5 % |
|           |                                                               | Y | 3.77  | 67.6 | 19.1 |      | 130.2 |        |
|           |                                                               | Z | 3.72  | 67.5 | 19.0 |      | 134.4 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.58  | 67.0 | 18.7 | 3.39 | 128.4 | ±0.5 % |
|           |                                                               | Y | 3.73  | 67.7 | 19.1 |      | 132.7 |        |
|           |                                                               | Z | 3.69  | 67.8 | 19.1 |      | 136.1 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.43  | 67.7 | 19.9 | 5.81 | 145.5 | ±1.4 % |
|           |                                                               | Y | 6.49  | 67.7 | 19.9 |      | 149.5 |        |
|           |                                                               | Z | 6.23  | 67.0 | 19.6 |      | 129.5 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.74  | 67.3 | 19.8 | 6.06 | 126.7 | ±1.4 % |
|           |                                                               | Y | 6.83  | 67.5 | 19.8 |      | 132.9 |        |
|           |                                                               | Z | 6.81  | 67.6 | 19.9 |      | 135.8 |        |
| 10315-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle)     | X | 3.00  | 69.9 | 19.4 | 1.71 | 133.9 | ±0.5 % |
|           |                                                               | Y | 3.30  | 71.5 | 20.1 |      | 141.0 |        |
|           |                                                               | Z | 3.22  | 71.4 | 20.0 |      | 142.9 |        |
| 10316-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 96pc duty cycle) | X | 10.17 | 69.2 | 21.8 | 8.36 | 130.5 | ±2.5 % |
|           |                                                               | Y | 10.20 | 69.1 | 21.6 |      | 138.4 |        |
|           |                                                               | Z | 10.20 | 69.4 | 21.8 |      | 140.7 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.75  | 68.3 | 18.8 | 3.76 | 138.5 | ±0.7 % |
|           |                                                               | Y | 5.00  | 69.1 | 19.2 |      | 146.7 |        |
|           |                                                               | Z | 4.92  | 69.2 | 19.1 |      | 148.5 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.73  | 68.6 | 18.9 | 3.77 | 136.3 | ±0.7 % |
|           |                                                               | Y | 4.97  | 69.4 | 19.4 |      | 143.7 |        |
|           |                                                               | Z | 4.91  | 69.6 | 19.3 |      | 146.0 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.65  | 68.1 | 18.5 | 1.54 | 135.2 | ±0.5 % |
|           |                                                               | Y | 3.05  | 70.8 | 19.9 |      | 140.7 |        |
|           |                                                               | Z | 2.87  | 69.8 | 19.3 |      | 144.8 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.00 | 69.0 | 21.5 | 8.23 | 130.8 | ±2.2 % |
|           |                                                               | Y | 10.06 | 68.9 | 21.4 |      | 138.6 |        |
|           |                                                               | Z | 10.08 | 69.3 | 21.7 |      | 141.6 |        |

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 8 and 9).

<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:3288

### 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) | Uct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|------------|
| 750                  | 41.9                               | 0.89                            | 6.81    | 6.81    | 6.81    | 0.37               | 1.70                    | ± 12.0 %   |
| 835                  | 41.5                               | 0.90                            | 6.51    | 6.51    | 6.51    | 0.45               | 1.52                    | ± 12.0 %   |
| 1750                 | 40.1                               | 1.37                            | 5.38    | 5.38    | 5.38    | 0.44               | 1.58                    | ± 12.0 %   |
| 1900                 | 40.0                               | 1.40                            | 5.17    | 5.17    | 5.17    | 0.80               | 1.18                    | ± 12.0 %   |
| 2450                 | 39.2                               | 1.80                            | 4.56    | 4.56    | 4.56    | 0.80               | 1.21                    | ± 12.0 %   |
| 2600                 | 39.0                               | 1.96                            | 4.44    | 4.44    | 4.44    | 0.80               | 1.22                    | ± 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:3288

### 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                            | 6.38    | 6.38    | 6.38    | 0.31               | 1.89                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.32    | 6.32    | 6.32    | 0.55               | 1.39                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 5.03    | 5.03    | 5.03    | 0.57               | 1.44                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.82    | 4.82    | 4.82    | 0.51               | 1.54                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.36    | 4.36    | 4.36    | 0.71               | 1.07                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 4.22    | 4.22    | 4.22    | 0.80               | 1.07                    | ± 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.

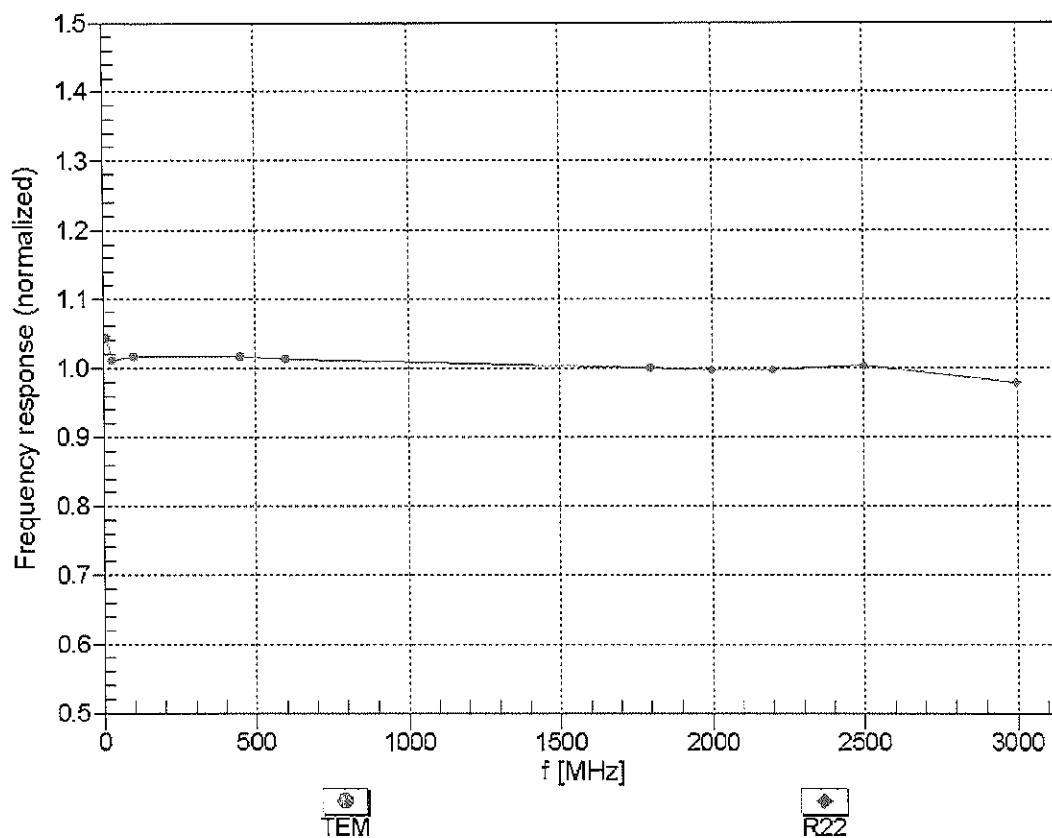
<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

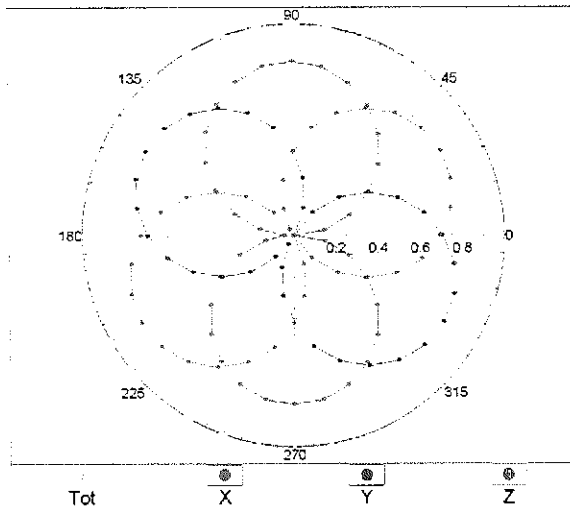
(TEM-Cell:ifi110 EXX, Waveguide: R22)



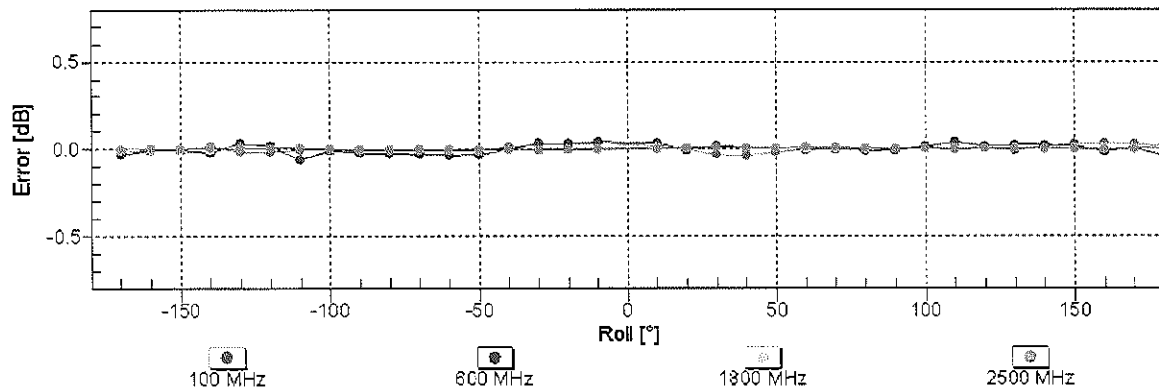
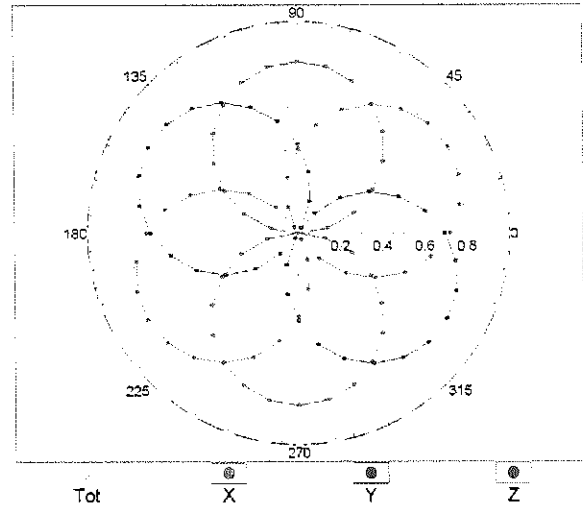
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

$f=600$  MHz, TEM

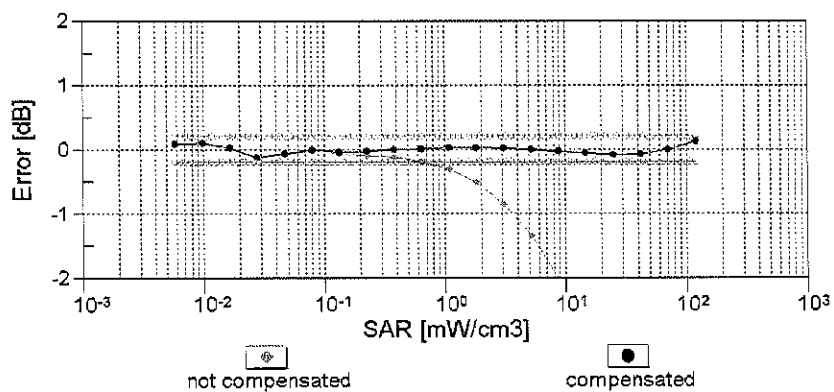
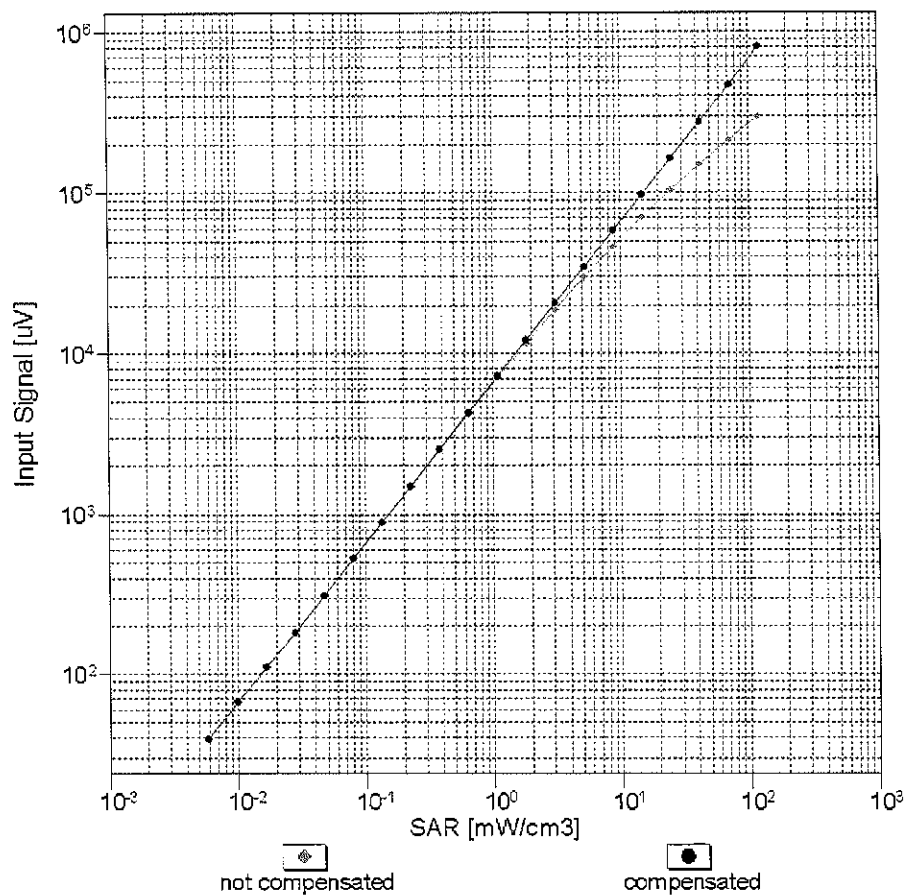


$f=1800$  MHz, R22



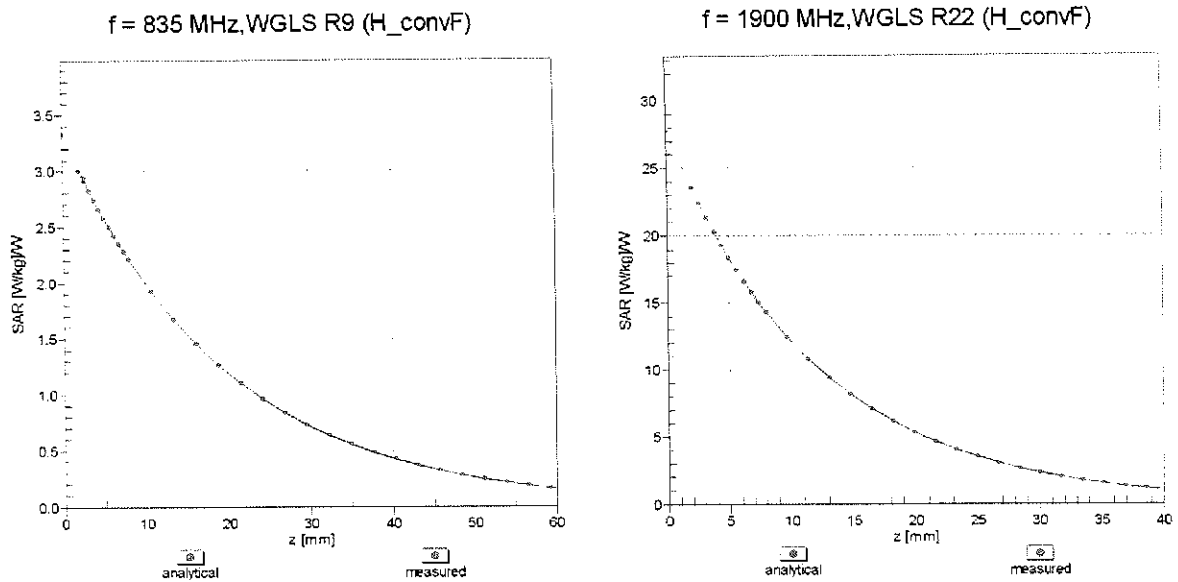
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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



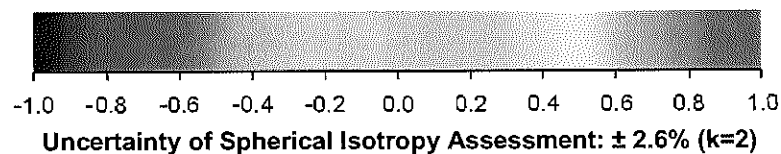
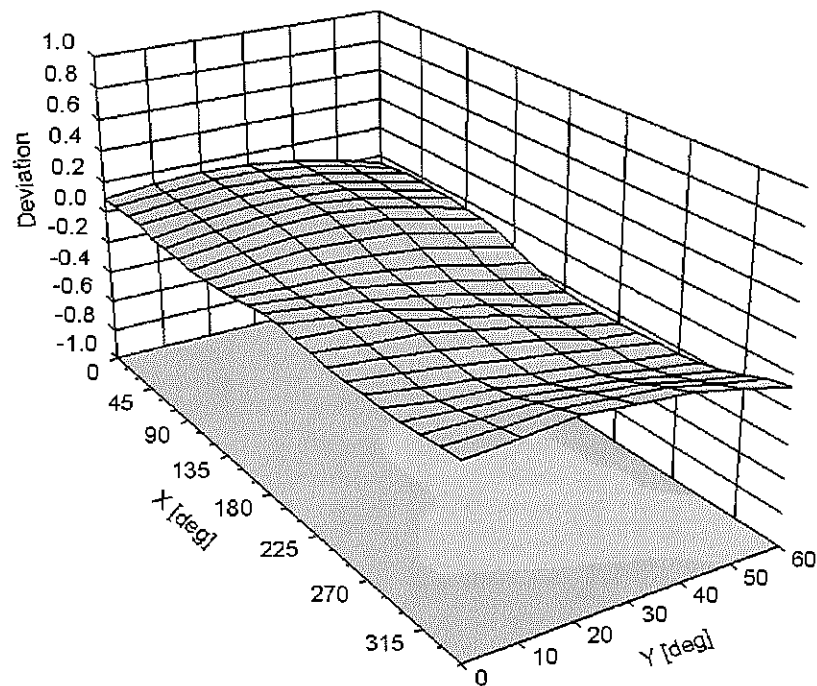
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3288

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -110       |
| 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: **ES3-3318\_Jan15**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3318**

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

CC  
 1/30/15

Calibration date: **January 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      | 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>Israe Elnaouq | Function<br>Laboratory Technician | Signature<br> |
| Approved by:   | Katja Pokovic         | Technical Manager                 |               |

Issued: January 26, 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<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:3318

Manufactured: January 10, 2012  
Calibrated: January 23, 2015

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



# DASY/EASY - Parameters of Probe: ES3DV3 - SN:3318

## Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|---------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 1.15     | 0.92     | 1.28     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                 | 106.4    | 109.2    | 103.4    |               |

## 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    | 200.6    | $\pm 3.5 \%$              |
|               |                                               | Y | 0.0     | 0.0                    | 1.0  |         | 185.3    |                           |
|               |                                               | Z | 0.0     | 0.0                    | 1.0  |         | 207.7    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 3.26    | 66.4                   | 14.0 | 10.00   | 41.4     | $\pm 1.2 \%$              |
|               |                                               | Y | 1.76    | 59.6                   | 9.8  |         | 36.1     |                           |
|               |                                               | Z | 1.82    | 57.7                   | 9.6  |         | 43.6     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.48    | 68.9                   | 19.9 | 2.91    | 120.2    | $\pm 0.5 \%$              |
|               |                                               | Y | 3.76    | 70.1                   | 19.9 |         | 146.0    |                           |
|               |                                               | Z | 3.11    | 66.0                   | 17.9 |         | 124.4    |                           |
| 10012-<br>CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.71    | 74.2                   | 21.7 | 1.87    | 121.7    | $\pm 0.7 \%$              |
|               |                                               | Y | 3.65    | 73.3                   | 20.7 |         | 147.5    |                           |
|               |                                               | Z | 2.77    | 67.4                   | 17.8 |         | 126.6    |                           |
| 10013-<br>CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.68   | 69.5                   | 22.7 | 9.46    | 114.7    | $\pm 2.5 \%$              |
|               |                                               | Y | 10.82   | 70.4                   | 23.0 |         | 139.8    |                           |
|               |                                               | Z | 11.22   | 71.1                   | 23.7 |         | 122.2    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 16.13   | 95.0                   | 26.6 | 9.39    | 122.7    | $\pm 2.2 \%$              |
|               |                                               | Y | 4.61    | 73.1                   | 17.2 |         | 130.8    |                           |
|               |                                               | Z | 15.10   | 92.0                   | 25.4 |         | 135.9    |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 17.03   | 96.8                   | 27.5 | 9.57    | 113.0    | $\pm 1.9 \%$              |
|               |                                               | Y | 4.15    | 71.7                   | 16.8 |         | 119.9    |                           |
|               |                                               | Z | 21.50   | 98.0                   | 27.5 |         | 130.9    |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 35.51   | 99.5                   | 24.5 | 6.56    | 147.6    | $\pm 2.7 \%$              |
|               |                                               | Y | 6.12    | 77.2                   | 17.1 |         | 118.1    |                           |
|               |                                               | Z | 38.50   | 99.7                   | 24.7 |         | 114.0    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 45.57   | 99.9                   | 23.2 | 4.80    | 113.3    | $\pm 1.7 \%$              |
|               |                                               | Y | 2.73    | 68.4                   | 12.6 |         | 133.3    |                           |
|               |                                               | Z | 54.59   | 99.9                   | 22.9 |         | 131.0    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 53.68   | 99.5                   | 21.9 | 3.55    | 123.0    | $\pm 3.0 \%$              |
|               |                                               | Y | 60.05   | 99.8                   | 21.1 |         | 144.9    |                           |
|               |                                               | Z | 66.60   | 99.6                   | 21.6 |         | 140.7    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 20.92   | 99.4                   | 21.8 | 1.16    | 136.6    | $\pm 2.2 \%$              |
|               |                                               | Y | 95.40   | 88.3                   | 13.8 |         | 117.6    |                           |
|               |                                               | Z | 100.00  | 99.5                   | 18.7 |         | 110.1    |                           |
| 10100-<br>CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.50    | 68.1                   | 20.2 | 5.67    | 130.5    | $\pm 1.2 \%$              |
|               |                                               | Y | 6.11    | 66.7                   | 19.2 |         | 107.2    |                           |
|               |                                               | Z | 6.55    | 68.2                   | 20.1 |         | 142.7    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 9.76  | 74.8 | 25.9 | 9.29 | 116.0 | ±2.5 % |
|           |                                          | Y | 8.85  | 72.2 | 24.1 |      | 134.9 |        |
|           |                                          | Z | 10.83 | 77.4 | 27.2 |      | 131.5 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.36  | 67.7 | 20.1 | 5.80 | 128.7 | ±1.2 % |
|           |                                          | Y | 5.92  | 66.1 | 19.0 |      | 106.6 |        |
|           |                                          | Z | 6.42  | 67.7 | 20.0 |      | 140.4 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.20 | 69.1 | 21.6 | 8.07 | 118.1 | ±2.5 % |
|           |                                          | Y | 10.27 | 69.3 | 21.4 |      | 143.9 |        |
|           |                                          | Z | 10.43 | 69.7 | 21.8 |      | 131.0 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 9.09  | 73.7 | 25.5 | 9.28 | 112.0 | ±2.7 % |
|           |                                          | Y | 8.35  | 71.5 | 23.9 |      | 131.1 |        |
|           |                                          | Z | 9.58  | 74.4 | 25.6 |      | 126.8 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 6.01  | 67.0 | 19.8 | 5.75 | 126.4 | ±1.2 % |
|           |                                          | Y | 6.17  | 67.7 | 19.9 |      | 148.9 |        |
|           |                                          | Z | 6.07  | 67.1 | 19.7 |      | 137.2 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.41  | 67.4 | 19.9 | 5.82 | 130.9 | ±0.9 % |
|           |                                          | Y | 6.06  | 66.2 | 19.0 |      | 109.1 |        |
|           |                                          | Z | 6.54  | 67.7 | 20.0 |      | 142.6 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 4.79  | 66.5 | 19.8 | 5.73 | 109.4 | ±0.9 % |
|           |                                          | Y | 4.82  | 67.1 | 19.8 |      | 128.8 |        |
|           |                                          | Z | 4.85  | 66.4 | 19.5 |      | 119.0 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 8.44  | 79.3 | 28.7 | 9.21 | 125.1 | ±2.5 % |
|           |                                          | Y | 7.15  | 75.0 | 26.0 |      | 144.0 |        |
|           |                                          | Z | 10.13 | 83.8 | 30.8 |      | 141.9 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 5.13  | 68.2 | 20.8 | 5.72 | 146.5 | ±0.9 % |
|           |                                          | Y | 4.77  | 66.8 | 19.6 |      | 125.2 |        |
|           |                                          | Z | 4.81  | 66.2 | 19.4 |      | 118.5 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 5.11  | 68.1 | 20.7 | 5.72 | 146.4 | ±0.9 % |
|           |                                          | Y | 4.79  | 67.0 | 19.7 |      | 126.0 |        |
|           |                                          | Z | 4.88  | 66.6 | 19.7 |      | 118.9 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.63  | 68.3 | 21.2 | 8.10 | 108.2 | ±2.5 % |
|           |                                          | Y | 9.84  | 68.9 | 21.3 |      | 135.5 |        |
|           |                                          | Z | 9.99  | 69.2 | 21.7 |      | 124.0 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 6.99  | 67.3 | 19.7 | 5.97 | 134.8 | ±0.9 % |
|           |                                          | Y | 6.73  | 66.8 | 19.2 |      | 115.9 |        |
|           |                                          | Z | 6.71  | 66.2 | 19.0 |      | 106.3 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 7.79  | 76.4 | 27.0 | 9.21 | 126.4 | ±2.5 % |
|           |                                          | Y | 7.19  | 75.1 | 26.1 |      | 144.7 |        |
|           |                                          | Z | 10.12 | 83.9 | 30.9 |      | 142.0 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 8.19  | 71.9 | 24.7 | 9.24 | 103.3 | ±2.2 % |
|           |                                          | Y | 7.76  | 70.8 | 23.6 |      | 122.0 |        |
|           |                                          | Z | 9.31  | 75.2 | 26.4 |      | 119.1 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 8.90  | 73.0 | 25.1 | 9.30 | 108.7 | ±2.2 % |
|           |                                          | Y | 8.38  | 71.6 | 24.0 |      | 129.7 |        |
|           |                                          | Z | 10.15 | 76.5 | 26.9 |      | 126.1 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.42  | 67.2 | 19.2 | 3.96 | 119.1 | ±0.7 % |
|           |                                                               | Y | 4.71  | 68.5 | 19.5 |      | 143.8 |        |
|           |                                                               | Z | 4.39  | 66.7 | 18.6 |      | 131.7 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.65  | 67.5 | 19.3 | 3.46 | 111.3 | ±0.5 % |
|           |                                                               | Y | 3.89  | 69.0 | 19.6 |      | 130.9 |        |
|           |                                                               | Z | 3.49  | 66.1 | 18.2 |      | 122.4 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.60  | 67.6 | 19.3 | 3.39 | 114.4 | ±0.5 % |
|           |                                                               | Y | 3.85  | 69.1 | 19.7 |      | 133.4 |        |
|           |                                                               | Z | 3.45  | 66.2 | 18.2 |      | 123.7 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.36  | 67.6 | 20.1 | 5.81 | 128.7 | ±1.2 % |
|           |                                                               | Y | 5.95  | 66.1 | 19.0 |      | 106.5 |        |
|           |                                                               | Z | 6.39  | 67.6 | 19.9 |      | 140.7 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.98  | 68.4 | 20.6 | 6.06 | 134.9 | ±1.2 % |
|           |                                                               | Y | 6.52  | 66.7 | 19.3 |      | 111.3 |        |
|           |                                                               | Z | 7.06  | 68.6 | 20.5 |      | 146.2 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.97  | 69.7 | 19.7 | 3.76 | 122.2 | ±0.5 % |
|           |                                                               | Y | 5.31  | 71.6 | 20.2 |      | 143.6 |        |
|           |                                                               | Z | 4.54  | 67.3 | 18.2 |      | 133.0 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.77  | 69.4 | 19.6 | 3.77 | 120.8 | ±0.5 % |
|           |                                                               | Y | 5.40  | 72.4 | 20.6 |      | 141.3 |        |
|           |                                                               | Z | 4.71  | 68.5 | 18.9 |      | 131.5 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 3.07  | 71.7 | 20.7 | 1.54 | 120.5 | ±0.7 % |
|           |                                                               | Y | 3.52  | 73.8 | 21.0 |      | 142.0 |        |
|           |                                                               | Z | 2.38  | 66.1 | 17.4 |      | 129.6 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.73  | 68.3 | 21.2 | 8.23 | 114.7 | ±2.5 % |
|           |                                                               | Y | 9.99  | 69.2 | 21.5 |      | 138.0 |        |
|           |                                                               | Z | 10.10 | 69.4 | 21.9 |      | 125.3 |        |

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 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:3318

### 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                            | 6.58    | 6.58    | 6.58    | 0.36               | 1.73                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.39    | 6.39    | 6.39    | 0.80               | 1.14                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.27    | 5.27    | 5.27    | 0.76               | 1.19                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.05    | 5.05    | 5.05    | 0.44               | 1.55                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 4.78    | 4.78    | 4.78    | 0.80               | 1.23                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.50    | 4.50    | 4.50    | 0.55               | 1.49                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.34    | 4.34    | 4.34    | 0.76               | 1.32                    | ± 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:3318

### 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                            | 6.22    | 6.22    | 6.22    | 0.67               | 1.28                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.23    | 6.23    | 6.23    | 0.80               | 1.19                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.95    | 4.95    | 4.95    | 0.40               | 1.77                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.76    | 4.76    | 4.76    | 0.60               | 1.48                    | ± 12.0 %    |
| 2300                 | 52.9                               | 1.81                            | 4.52    | 4.52    | 4.52    | 0.80               | 1.19                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.37    | 4.37    | 4.37    | 0.72               | 1.23                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 4.17    | 4.17    | 4.17    | 0.80               | 1.00                    | ± 12.0 %    |

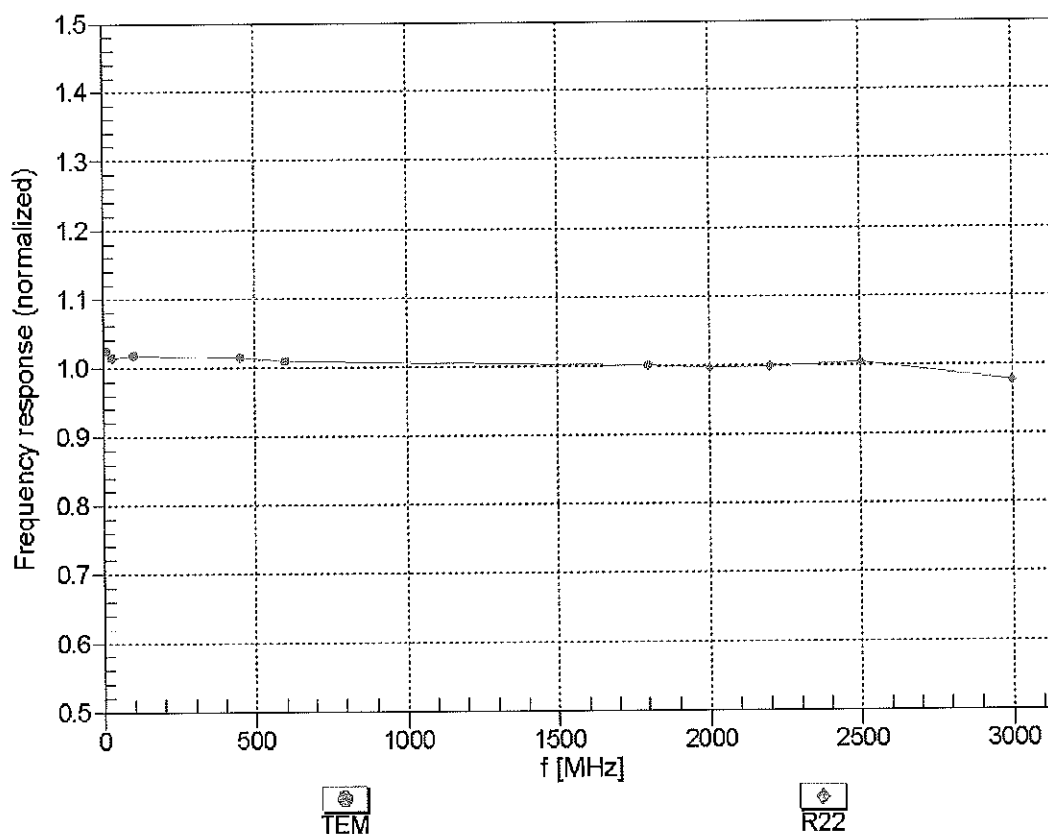
<sup>C</sup> Frequency validity above 300 MHz of  $\pm 100$  MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to  $\pm 50$  MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is  $\pm 10$ , 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  $\pm 110$  MHz.

<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to  $\pm 10\%$  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  $\pm 5\%$ . 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  $\pm 1\%$  for frequencies below 3 GHz and below  $\pm 2\%$  for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

## Frequency Response of E-Field

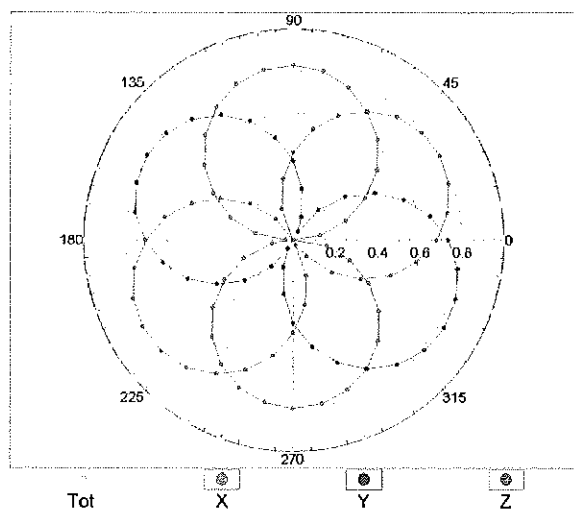
(TEM-Cell:ifi110 EXX, Waveguide: R22)



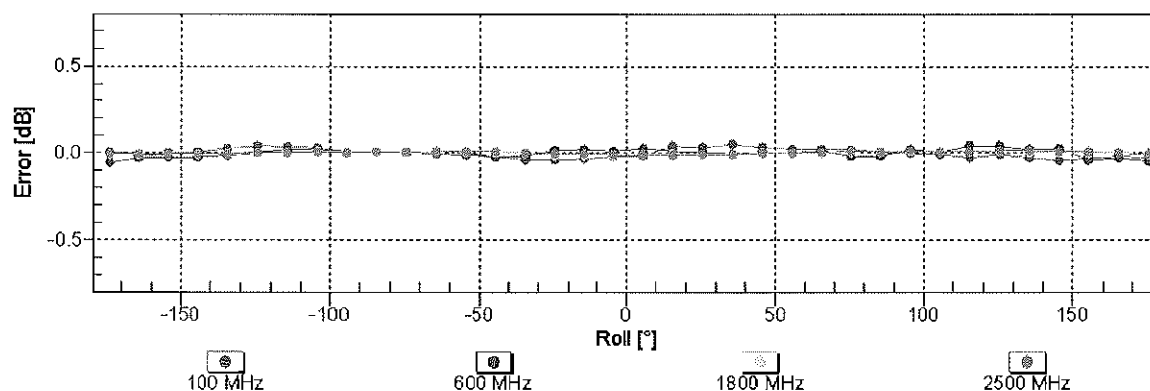
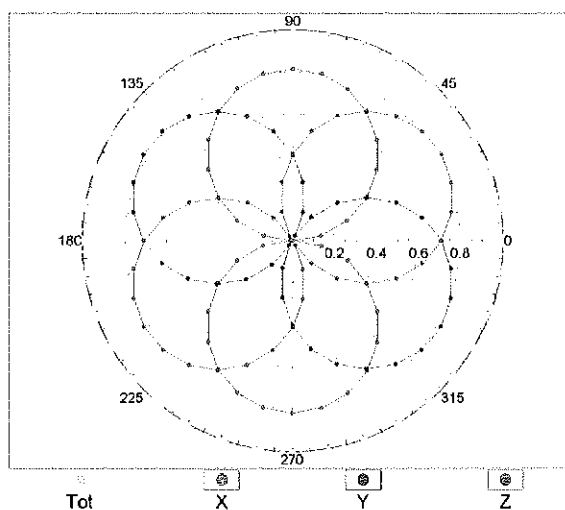
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM



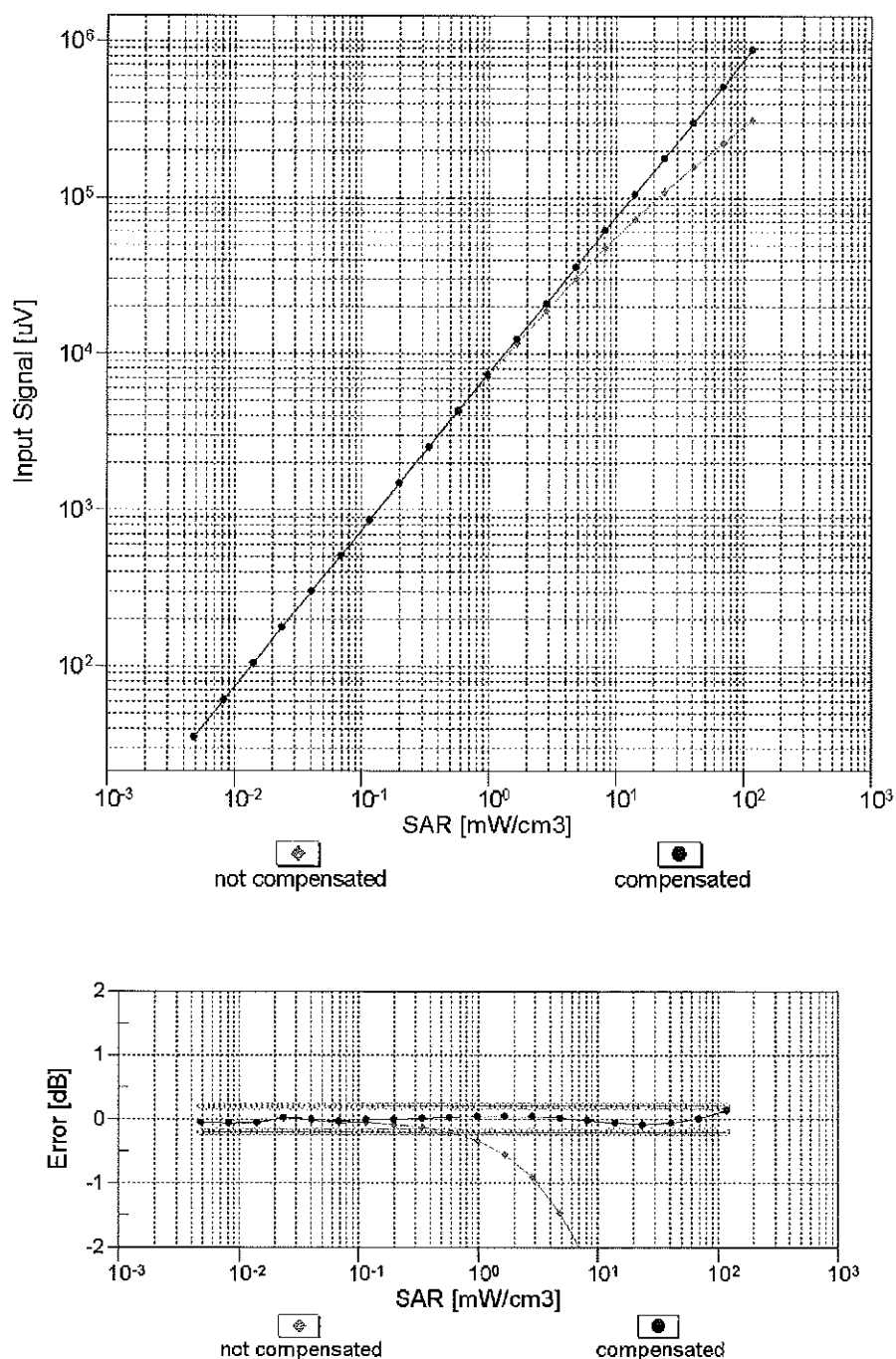
f=1800 MHz,R22



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

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

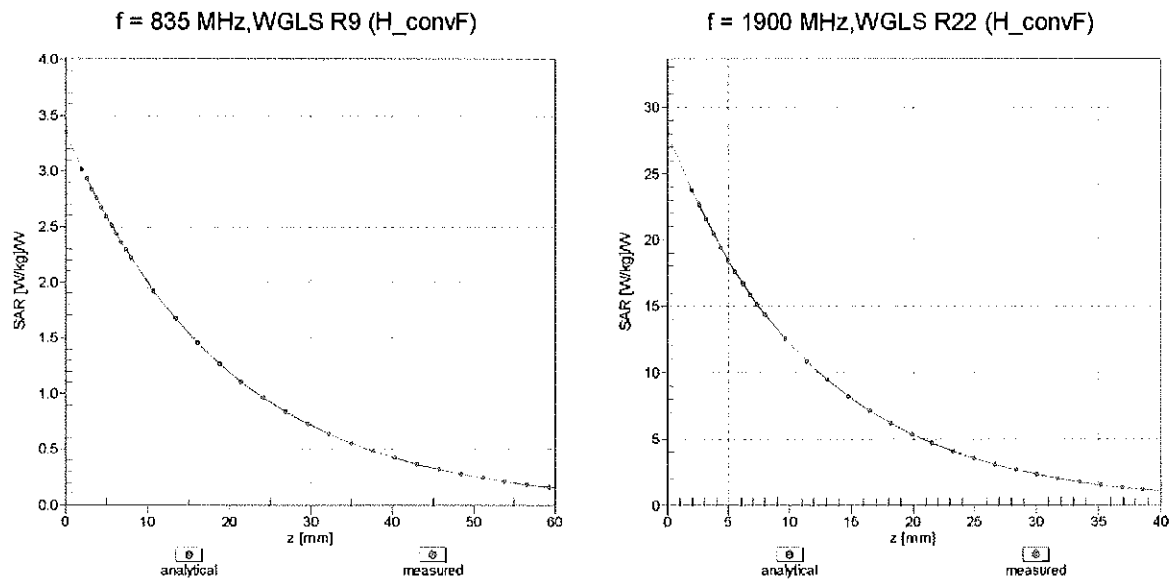
(TEM cell , f<sub>eval</sub>= 1900 MHz)



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

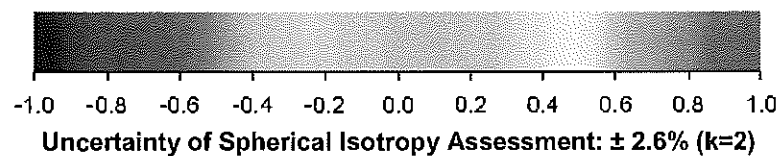
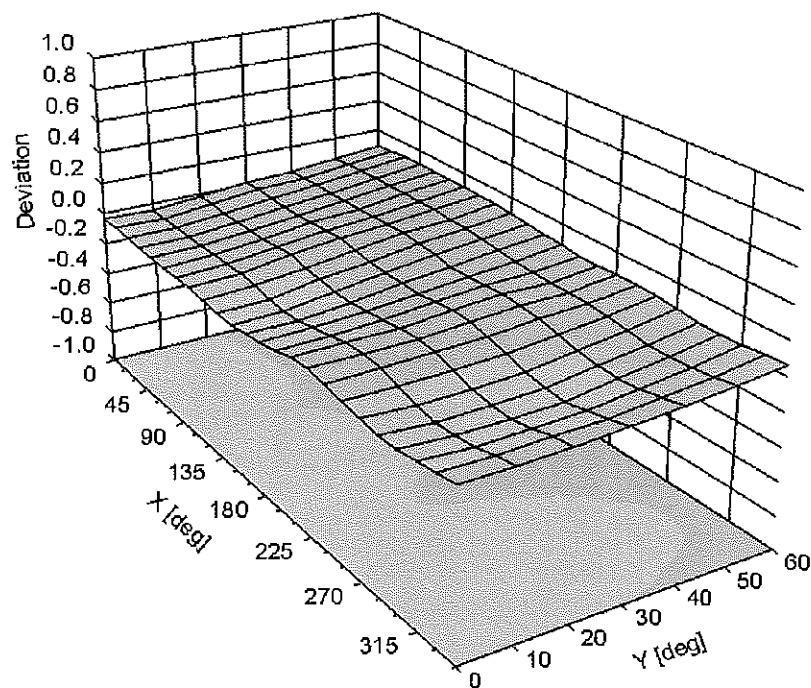


## Conversion Factor Assessment



## 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:3318

### Other Probe Parameters

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -104.4     |
| 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       |

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



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

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

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **ES3-3332\_Sep14/2**

## CALIBRATION CERTIFICATE (Replacement of No: ES3-3332\_Sep14)

Object **ES3DV3 - SN:3332**

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

CC  
12/14/14

Calibration date: **September 18, 2014**

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      | 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-13 (No. ES3-3013_Dec13)    | Dec-14                 |
| DAE4                       | SN: 660         | 13-Dec-13 (No. DAE4-660_Dec13)    | Dec-14                 |
| 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-13) | In house check: Oct-14 |

|                                                                                                                 | Name           | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|----------------|-----------------------|-----------|
| Calibrated by:                                                                                                  | Israe El-Naouq | Laboratory Technician |           |
| Approved by:                                                                                                    | Katja Pokovic  | Technical Manager     |           |
| Issued: November 3, 2014                                                                                        |                |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                |                       |           |



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

Accreditation No.: **SCS 108**

### 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:3332

Manufactured: January 24, 2012  
Calibrated: September 18, 2014

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

## DASY/EASY - Parameters of Probe: ES3DV3 - SN:3332

### Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.94     | 1.15     | 0.98     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 105.8    | 103.8    | 112.4    |               |

### 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    | 178.7    | $\pm 3.0 \%$              |
|           |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 199.5    |                           |
|           |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 186.5    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)          | X | 55.60   | 92.4                         | 20.6 | 10.00   | 35.7     | $\pm 1.7 \%$              |
|           |                                               | Y | 2.80    | 61.2                         | 11.6 |         | 42.9     |                           |
|           |                                               | Z | 10.49   | 80.1                         | 18.0 |         | 36.1     |                           |
| 10011-CAB | UMTS-FDD (WCDMA)                              | X | 3.47    | 67.9                         | 18.8 | 2.91    | 141.3    | $\pm 0.7 \%$              |
|           |                                               | Y | 3.29    | 67.0                         | 18.4 |         | 138.2    |                           |
|           |                                               | Z | 3.78    | 70.4                         | 20.1 |         | 147.9    |                           |
| 10012-CAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 3.53    | 72.0                         | 20.1 | 1.87    | 141.7    | $\pm 0.7 \%$              |
|           |                                               | Y | 3.03    | 69.1                         | 18.8 |         | 141.1    |                           |
|           |                                               | Z | 4.06    | 75.5                         | 21.6 |         | 148.2    |                           |
| 10013-CAA | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.87   | 69.8                         | 22.6 | 9.46    | 137.3    | $\pm 3.5 \%$              |
|           |                                               | Y | 11.63   | 71.7                         | 23.9 |         | 141.9    |                           |
|           |                                               | Z | 10.51   | 69.6                         | 22.5 |         | 139.2    |                           |
| 10021-DAB | GSM-FDD (TDMA, GMSK)                          | X | 6.92    | 78.4                         | 20.1 | 9.39    | 137.0    | $\pm 2.5 \%$              |
|           |                                               | Y | 26.20   | 99.6                         | 27.8 |         | 141.5    |                           |
|           |                                               | Z | 5.13    | 78.3                         | 21.1 |         | 144.7    |                           |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 9.10    | 83.6                         | 22.5 | 9.57    | 144.0    | $\pm 2.5 \%$              |
|           |                                               | Y | 26.31   | 100.0                        | 28.1 |         | 136.7    |                           |
|           |                                               | Z | 6.15    | 81.6                         | 22.5 |         | 139.9    |                           |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 10.54   | 84.1                         | 20.4 | 6.56    | 141.8    | $\pm 2.5 \%$              |
|           |                                               | Y | 40.55   | 99.6                         | 24.9 |         | 142.2    |                           |
|           |                                               | Z | 6.45    | 81.5                         | 20.2 |         | 145.7    |                           |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 28.34   | 94.6                         | 21.9 | 4.80    | 131.4    | $\pm 2.5 \%$              |
|           |                                               | Y | 52.22   | 99.6                         | 23.3 |         | 126.8    |                           |
|           |                                               | Z | 28.33   | 99.5                         | 23.9 |         | 140.7    |                           |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 52.17   | 100.0                        | 22.2 | 3.55    | 147.0    | $\pm 1.7 \%$              |
|           |                                               | Y | 57.29   | 99.6                         | 22.4 |         | 133.0    |                           |
|           |                                               | Z | 25.84   | 99.5                         | 23.3 |         | 126.2    |                           |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 59.05   | 100.0                        | 19.9 | 1.16    | 135.5    | $\pm 1.9 \%$              |
|           |                                               | Y | 100.00  | 99.7                         | 19.2 |         | 143.5    |                           |
|           |                                               | Z | 34.97   | 100.0                        | 20.4 |         | 143.1    |                           |

|           |                                               |   |       |      |      |      |       |        |
|-----------|-----------------------------------------------|---|-------|------|------|------|-------|--------|
| 10039-CAB | CDMA2000 (1xRTT, RC1)                         | X | 4.78  | 66.9 | 18.9 | 4.57 | 134.6 | ±0.9 % |
|           |                                               | Y | 4.85  | 67.1 | 19.1 |      | 141.0 |        |
|           |                                               | Z | 4.76  | 67.8 | 19.4 |      | 140.7 |        |
| 10081-CAB | CDMA2000 (1xRTT, RC3)                         | X | 3.98  | 66.4 | 18.6 | 3.97 | 130.4 | ±0.7 % |
|           |                                               | Y | 3.98  | 66.5 | 18.7 |      | 136.2 |        |
|           |                                               | Z | 4.04  | 67.7 | 19.2 |      | 137.4 |        |
| 10098-CAB | UMTS-FDD (HSUPA, Subtest 2)                   | X | 4.75  | 67.3 | 18.8 | 3.98 | 144.4 | ±0.7 % |
|           |                                               | Y | 4.55  | 66.5 | 18.5 |      | 126.5 |        |
|           |                                               | Z | 4.72  | 67.9 | 19.0 |      | 128.1 |        |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.26  | 66.9 | 19.2 | 5.67 | 124.5 | ±1.2 % |
|           |                                               | Y | 6.38  | 67.4 | 19.7 |      | 131.7 |        |
|           |                                               | Z | 6.36  | 67.7 | 19.7 |      | 132.3 |        |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)      | X | 6.44  | 67.5 | 19.7 | 5.80 | 147.4 | ±1.4 % |
|           |                                               | Y | 6.31  | 67.2 | 19.7 |      | 130.2 |        |
|           |                                               | Z | 6.17  | 67.2 | 19.6 |      | 130.1 |        |
| 10110-CAB | LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)       | X | 6.08  | 66.9 | 19.5 | 5.75 | 142.7 | ±1.4 % |
|           |                                               | Y | 5.97  | 66.6 | 19.4 |      | 127.3 |        |
|           |                                               | Z | 5.84  | 66.7 | 19.3 |      | 126.2 |        |
| 10114-CAA | IEEE 802.11n (HT Greenfield, 13.5 Mbps, BPSK) | X | 10.13 | 68.7 | 21.0 | 8.10 | 136.9 | ±2.5 % |
|           |                                               | Y | 10.57 | 69.9 | 21.9 |      | 146.3 |        |
|           |                                               | Z | 10.06 | 69.0 | 21.1 |      | 143.6 |        |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)      | X | 10.12 | 68.6 | 21.0 | 8.07 | 138.2 | ±2.5 % |
|           |                                               | Y | 10.60 | 69.9 | 21.9 |      | 148.0 |        |
|           |                                               | Z | 10.07 | 69.0 | 21.1 |      | 146.6 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)       | X | 8.76  | 71.7 | 23.8 | 9.28 | 130.7 | ±3.0 % |
|           |                                               | Y | 10.03 | 75.2 | 25.9 |      | 121.5 |        |
|           |                                               | Z | 8.15  | 70.7 | 23.5 |      | 134.1 |        |
| 10164-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)       | X | 6.10  | 67.0 | 19.5 | 5.75 | 144.4 | ±1.4 % |
|           |                                               | Y | 5.98  | 66.6 | 19.4 |      | 127.8 |        |
|           |                                               | Z | 5.84  | 66.6 | 19.3 |      | 127.2 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)       | X | 6.56  | 67.5 | 19.7 | 5.82 | 149.5 | ±1.7 % |
|           |                                               | Y | 6.41  | 67.1 | 19.6 |      | 132.5 |        |
|           |                                               | Z | 6.17  | 66.8 | 19.4 |      | 130.4 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)         | X | 5.01  | 67.0 | 19.7 | 5.73 | 147.8 | ±1.2 % |
|           |                                               | Y | 5.01  | 66.9 | 19.8 |      | 132.1 |        |
|           |                                               | Z | 4.75  | 66.9 | 19.7 |      | 130.3 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)         | X | 7.65  | 75.0 | 25.8 | 9.21 | 144.9 | ±2.7 % |
|           |                                               | Y | 10.17 | 82.4 | 29.7 |      | 136.4 |        |
|           |                                               | Z | 6.53  | 72.3 | 24.6 |      | 145.6 |        |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)         | X | 4.98  | 66.9 | 19.6 | 5.72 | 141.0 | ±1.2 % |
|           |                                               | Y | 4.98  | 66.7 | 19.7 |      | 130.5 |        |
|           |                                               | Z | 4.71  | 66.7 | 19.5 |      | 128.1 |        |

|           |                                              |   |       |      |      |      |       |        |
|-----------|----------------------------------------------|---|-------|------|------|------|-------|--------|
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)        | X | 4.95  | 66.7 | 19.5 | 5.72 | 139.8 | ±1.2 % |
|           |                                              | Y | 4.97  | 66.7 | 19.7 |      | 129.5 |        |
|           |                                              | Z | 4.72  | 66.8 | 19.6 |      | 128.0 |        |
| 10193-CAA | IEEE 802.11n (HT Greenfield, 6.5 Mbps, BPSK) | X | 9.75  | 68.2 | 20.9 | 8.09 | 131.8 | ±2.5 % |
|           |                                              | Y | 10.16 | 69.4 | 21.7 |      | 139.2 |        |
|           |                                              | Z | 9.62  | 68.6 | 21.0 |      | 137.3 |        |
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)      | X | 9.77  | 68.3 | 20.9 | 8.10 | 133.6 | ±2.5 % |
|           |                                              | Y | 10.17 | 69.4 | 21.8 |      | 140.1 |        |
|           |                                              | Z | 9.61  | 68.5 | 21.0 |      | 140.1 |        |
| 10219-CAA | IEEE 802.11n (HT Mixed, 7.2 Mbps, BPSK)      | X | 9.69  | 68.3 | 20.9 | 8.03 | 133.6 | ±2.5 % |
|           |                                              | Y | 10.05 | 69.3 | 21.7 |      | 139.2 |        |
|           |                                              | Z | 9.58  | 68.7 | 21.1 |      | 139.4 |        |
| 10222-CAA | IEEE 802.11n (HT Mixed, 15 Mbps, BPSK)       | X | 10.13 | 68.7 | 21.0 | 8.06 | 140.7 | ±2.5 % |
|           |                                              | Y | 10.61 | 69.8 | 21.8 |      | 145.1 |        |
|           |                                              | Z | 10.11 | 69.1 | 21.2 |      | 148.4 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                             | X | 7.03  | 67.2 | 19.4 | 5.97 | 138.0 | ±1.4 % |
|           |                                              | Y | 7.07  | 67.2 | 19.6 |      | 140.2 |        |
|           |                                              | Z | 6.97  | 67.8 | 19.7 |      | 144.6 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)        | X | 7.11  | 72.9 | 24.7 | 9.21 | 124.6 | ±2.7 % |
|           |                                              | Y | 10.04 | 82.0 | 29.5 |      | 135.7 |        |
|           |                                              | Z | 6.29  | 71.2 | 24.0 |      | 126.2 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)      | X | 8.61  | 72.5 | 24.3 | 9.24 | 145.2 | ±3.3 % |
|           |                                              | Y | 10.53 | 77.8 | 27.4 |      | 136.7 |        |
|           |                                              | Z | 7.56  | 70.0 | 23.1 |      | 126.7 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK)     | X | 8.74  | 71.6 | 23.8 | 9.30 | 128.7 | ±3.3 % |
|           |                                              | Y | 11.51 | 79.1 | 28.0 |      | 147.2 |        |
|           |                                              | Z | 8.07  | 70.4 | 23.2 |      | 134.1 |        |
| 10274-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.10)    | X | 5.90  | 66.7 | 18.7 | 4.87 | 128.0 | ±0.9 % |
|           |                                              | Y | 5.93  | 66.8 | 18.9 |      | 134.5 |        |
|           |                                              | Z | 5.92  | 67.6 | 19.1 |      | 138.2 |        |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)     | X | 4.53  | 67.1 | 18.8 | 3.96 | 133.8 | ±0.7 % |
|           |                                              | Y | 4.48  | 67.0 | 18.8 |      | 139.6 |        |
|           |                                              | Z | 4.62  | 68.3 | 19.3 |      | 145.0 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate               | X | 3.82  | 67.8 | 19.0 | 3.46 | 147.6 | ±0.7 % |
|           |                                              | Y | 3.66  | 67.0 | 18.8 |      | 131.7 |        |
|           |                                              | Z | 3.97  | 69.6 | 20.0 |      | 135.9 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate               | X | 3.70  | 67.5 | 18.8 | 3.39 | 128.1 | ±0.7 % |
|           |                                              | Y | 3.60  | 66.9 | 18.7 |      | 132.5 |        |
|           |                                              | Z | 3.80  | 68.9 | 19.5 |      | 139.8 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)      | X | 6.47  | 67.6 | 19.8 | 5.81 | 149.7 | ±1.7 % |
|           |                                              | Y | 6.24  | 66.9 | 19.5 |      | 126.3 |        |
|           |                                              | Z | 6.20  | 67.3 | 19.6 |      | 130.9 |        |



|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.72  | 67.1 | 19.5 | 6.06 | 128.8 | ±1.4 % |
|           |                                                               | Y | 6.85  | 67.7 | 20.0 |      | 132.4 |        |
|           |                                                               | Z | 6.75  | 67.7 | 19.8 |      | 136.6 |        |
| 10315-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 96pc duty cycle)     | X | 3.27  | 71.1 | 19.8 | 1.71 | 140.1 | ±0.7 % |
|           |                                                               | Y | 2.95  | 69.4 | 19.1 |      | 139.8 |        |
|           |                                                               | Z | 3.75  | 74.4 | 21.2 |      | 146.9 |        |
| 10316-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 96pc duty cycle) | X | 10.04 | 68.7 | 21.3 | 8.36 | 136.3 | ±2.5 % |
|           |                                                               | Y | 10.42 | 69.8 | 22.1 |      | 138.1 |        |
|           |                                                               | Z | 9.84  | 68.9 | 21.3 |      | 139.7 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 5.01  | 69.3 | 19.2 | 3.76 | 144.3 | ±0.7 % |
|           |                                                               | Y | 4.79  | 68.1 | 18.7 |      | 146.3 |        |
|           |                                                               | Z | 5.40  | 72.5 | 20.8 |      | 146.7 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.97  | 69.5 | 19.3 | 3.77 | 141.3 | ±0.7 % |
|           |                                                               | Y | 4.72  | 68.2 | 18.8 |      | 143.1 |        |
|           |                                                               | Z | 5.12  | 71.8 | 20.5 |      | 144.4 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 3.05  | 70.5 | 19.5 | 1.54 | 139.7 | ±0.7 % |
|           |                                                               | Y | 2.71  | 68.7 | 18.9 |      | 140.2 |        |
|           |                                                               | Z | 4.22  | 77.3 | 22.5 |      | 145.9 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.92  | 68.6 | 21.1 | 8.23 | 136.3 | ±2.5 % |
|           |                                                               | Y | 10.20 | 69.4 | 21.8 |      | 138.3 |        |
|           |                                                               | Z | 9.76  | 68.8 | 21.3 |      | 138.9 |        |

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 8 and 9).

<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:3332

### 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                            | 6.56    | 6.56    | 6.56    | 0.50               | 1.43                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.31    | 6.31    | 6.31    | 0.61               | 1.31                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.17    | 5.17    | 5.17    | 0.62               | 1.33                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.04    | 5.04    | 5.04    | 0.80               | 1.17                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.49    | 4.49    | 4.49    | 0.77               | 1.24                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.35    | 4.35    | 4.35    | 0.73               | 1.38                    | ± 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:3332

### 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                            | 6.24    | 6.24    | 6.24    | 0.50               | 1.50                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.21    | 6.21    | 6.21    | 0.45               | 1.59                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.88    | 4.88    | 4.88    | 0.39               | 1.78                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.64    | 4.64    | 4.64    | 0.61               | 1.47                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.31    | 4.31    | 4.31    | 0.80               | 1.18                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 4.11    | 4.11    | 4.11    | 0.68               | 0.99                    | ± 12.0 %    |

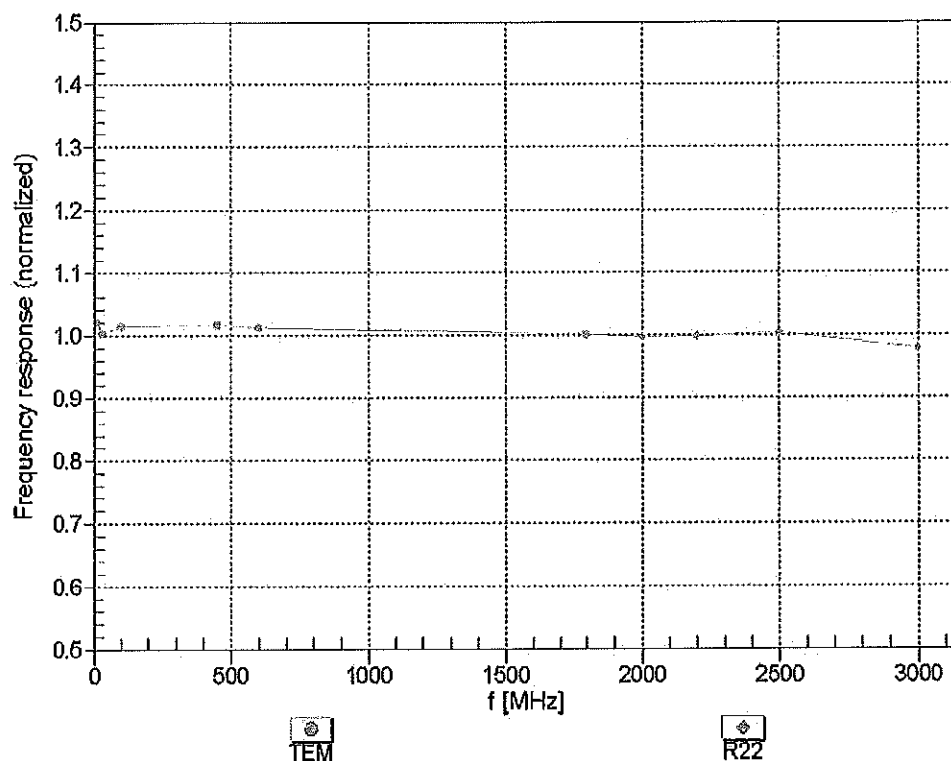
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 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)

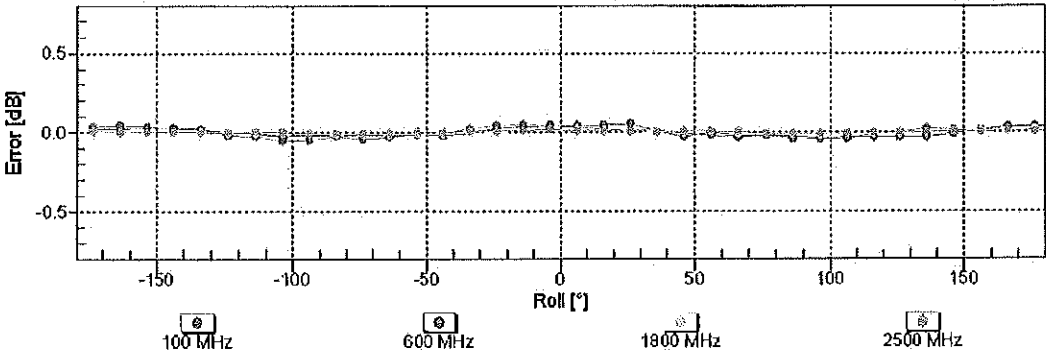
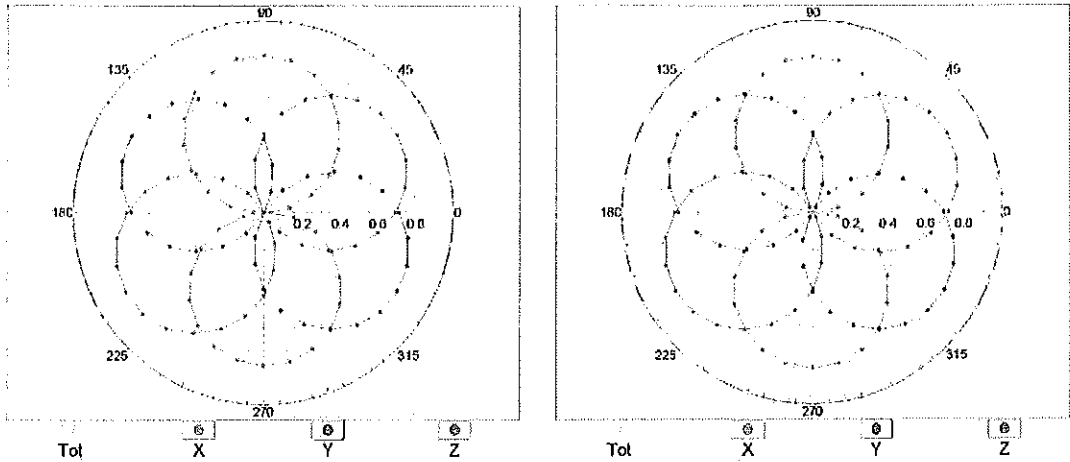


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

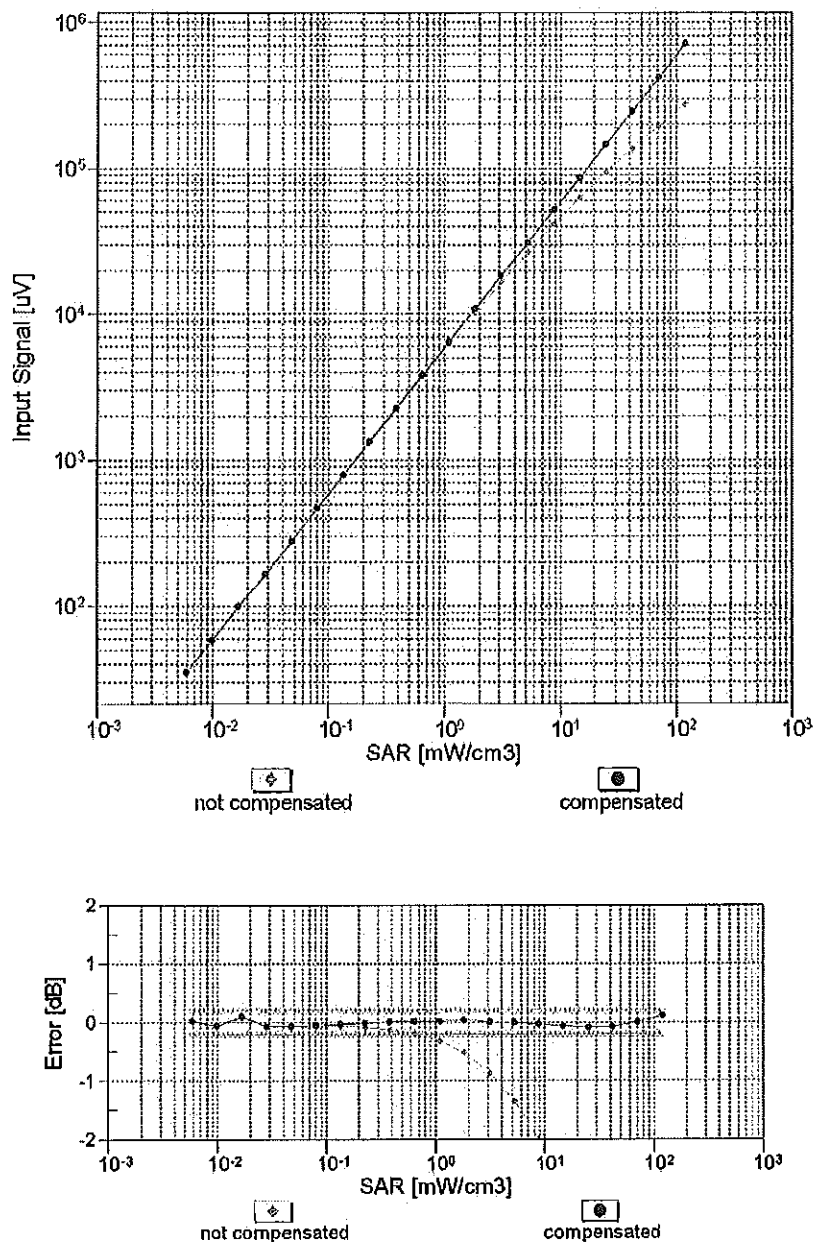
f=600 MHz,TEM

f=1800 MHz,R22



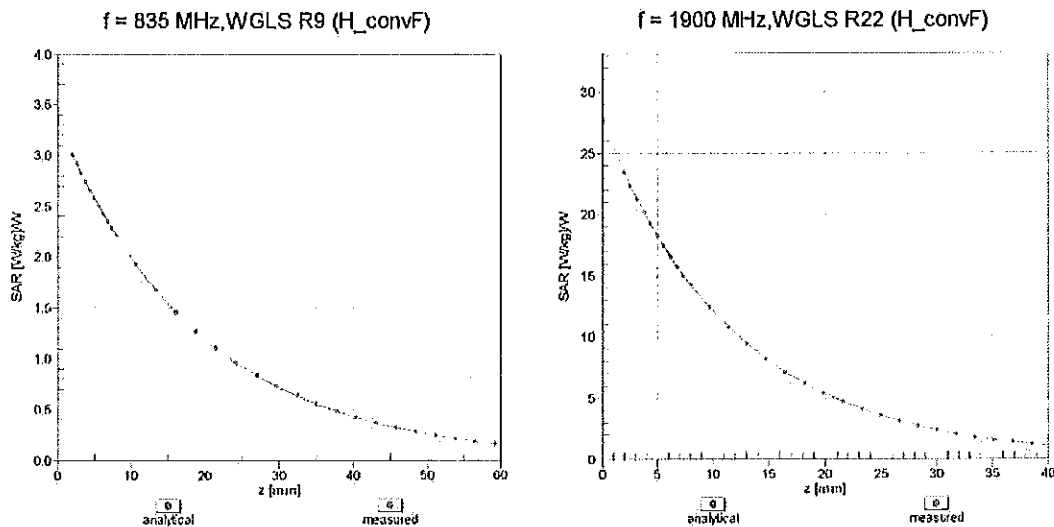
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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



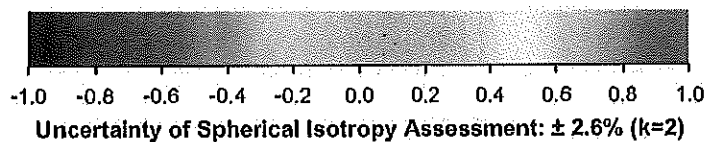
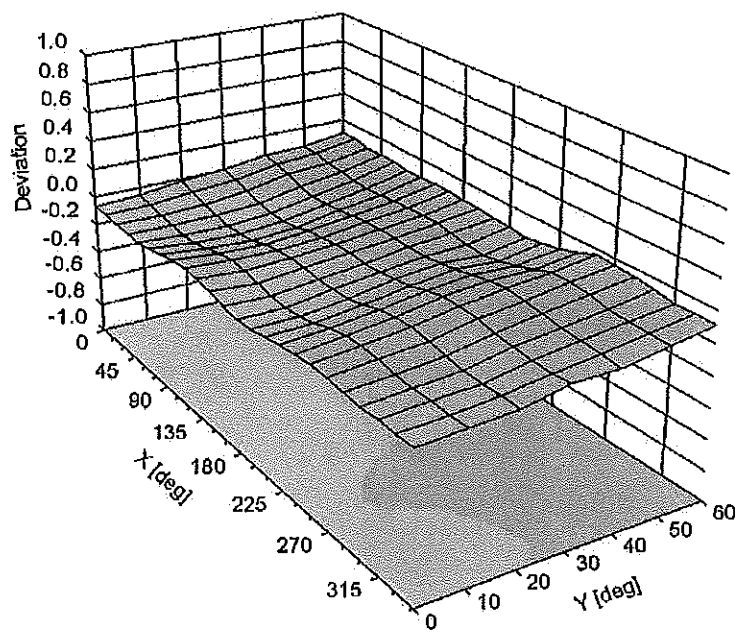
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



**DASY/EASY - Parameters of Probe: ES3DV3 - SN:3332****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -3.7       |
| 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       |



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



**S** Schweizerischer Kalibrierdienst  
**C** Service suisse d'étalonnage  
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 The Swiss Accreditation Service is one of the signatories to the EA  
 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **ES3-3333\_Oct14**

## 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**

CC  
10/31/14

Calibration date: **October 24, 2014**

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      | 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-13 (No. ES3-3013_Dec13)    | Dec-14                 |
| DAE4                       | SN: 660         | 13-Dec-13 (No. DAE4-660_Dec13)    | Dec-14                 |
| 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>Laboratory Technician | Signature<br> |
| Approved by:             | Name<br><b>Kalja Pokovic</b> | Technical Manager                 |               |
| Issued: October 24, 2014 |                              |                                   |               |

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

### 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:3333

Manufactured: January 24, 2012  
Calibrated: October 24, 2014

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 ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 1.08     | 0.90     | 0.88     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                 | 102.7    | 107.7    | 106.3    |           |

### 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    | 190.7    | ±2.5 %                    |
|           |                                               | Y | 0.0     | 0.0                    | 1.0  |         | 183.3    |                           |
|           |                                               | Z | 0.0     | 0.0                    | 1.0  |         | 197.9    |                           |
| 10010-CAA | SAR Validation (Square, 100ms, 10ms)          | X | 3.17    | 61.7                   | 12.2 | 10.00   | 42.4     | ±1.9 %                    |
|           |                                               | Y | 3.16    | 63.7                   | 12.4 |         | 38.0     |                           |
|           |                                               | Z | 1.84    | 59.2                   | 10.5 |         | 39.9     |                           |
| 10011-CAB | UMTS-FDD (WCDMA)                              | X | 3.22    | 65.9                   | 17.6 | 2.91    | 128.5    | ±0.5 %                    |
|           |                                               | Y | 3.60    | 69.3                   | 19.8 |         | 146.7    |                           |
|           |                                               | Z | 3.51    | 68.1                   | 18.8 |         | 133.7    |                           |
| 10012-CAA | IEEE 802.11b WIFI 2.4 GHz (DSSS, 1 Mbps)      | X | 3.14    | 68.6                   | 18.2 | 1.87    | 132.6    | ±0.7 %                    |
|           |                                               | Y | 3.64    | 73.3                   | 21.1 |         | 127.5    |                           |
|           |                                               | Z | 3.50    | 71.4                   | 19.6 |         | 136.4    |                           |
| 10013-CAA | IEEE 802.11g WIFI 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.56   | 70.8                   | 23.0 | 9.46    | 135.8    | ±3.5 %                    |
|           |                                               | Y | 10.93   | 70.2                   | 23.0 |         | 122.3    |                           |
|           |                                               | Z | 10.93   | 70.0                   | 22.6 |         | 132.8    |                           |
| 10021-DAB | GSM-FDD (TDMA, GMSK)                          | X | 24.80   | 96.9                   | 27.6 | 9.39    | 147.6    | ±1.9 %                    |
|           |                                               | Y | 19.44   | 94.3                   | 26.1 |         | 148.6    |                           |
|           |                                               | Z | 9.58    | 82.7                   | 21.9 |         | 138.2    |                           |
| 10023-DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 20.09   | 93.0                   | 26.4 | 9.57    | 141.7    | ±2.7 %                    |
|           |                                               | Y | 24.86   | 99.0                   | 27.9 |         | 143.5    |                           |
|           |                                               | Z | 11.74   | 86.4                   | 23.4 |         | 134.4    |                           |
| 10024-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 23.76   | 91.2                   | 23.1 | 6.56    | 147.8    | ±2.5 %                    |
|           |                                               | Y | 37.10   | 99.8                   | 25.3 |         | 149.9    |                           |
|           |                                               | Z | 16.01   | 88.1                   | 21.6 |         | 128.0    |                           |
| 10027-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 36.24   | 94.5                   | 22.6 | 4.80    | 128.6    | ±2.5 %                    |
|           |                                               | Y | 47.57   | 99.9                   | 23.7 |         | 133.5    |                           |
|           |                                               | Z | 44.37   | 99.7                   | 23.6 |         | 140.1    |                           |
| 10028-DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 65.86   | 99.7                   | 22.7 | 3.55    | 133.1    | ±2.7 %                    |
|           |                                               | Y | 55.92   | 100.0                  | 22.6 |         | 142.0    |                           |
|           |                                               | Z | 59.41   | 100.0                  | 22.2 |         | 125.1    |                           |
| 10032-CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 85.87   | 100.0                  | 20.1 | 1.16    | 138.3    | ±2.2 %                    |
|           |                                               | Y | 14.41   | 99.2                   | 23.3 |         | 130.5    |                           |
|           |                                               | Z | 85.82   | 99.8                   | 19.3 |         | 135.9    |                           |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.49    | 67.4                   | 19.4 | 5.67    | 144.6    | ±1.7 %                    |
|           |                                               | Y | 6.49    | 68.0                   | 20.1 |         | 139.9    |                           |
|           |                                               | Z | 6.54    | 67.9                   | 19.7 |         | 147.3    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 10.81 | 74.7 | 24.9 | 9.29 | 122.0 | ±3.0 % |
|           |                                          | Y | 10.50 | 75.9 | 26.1 |      | 131.6 |        |
|           |                                          | Z | 9.76  | 73.5 | 24.5 |      | 138.6 |        |
| 10108-CAB | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.43  | 67.2 | 19.4 | 5.80 | 143.3 | ±1.7 % |
|           |                                          | Y | 6.37  | 67.7 | 20.0 |      | 138.0 |        |
|           |                                          | Z | 6.43  | 67.5 | 19.7 |      | 146.7 |        |
| 10117-CAA | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.19 | 68.6 | 20.9 | 8.07 | 136.2 | ±2.5 % |
|           |                                          | Y | 10.15 | 68.9 | 21.4 |      | 128.3 |        |
|           |                                          | Z | 10.12 | 68.7 | 21.0 |      | 137.9 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 11.48 | 77.0 | 26.1 | 9.28 | 147.5 | ±3.3 % |
|           |                                          | Y | 9.81  | 74.9 | 25.8 |      | 125.7 |        |
|           |                                          | Z | 9.22  | 72.8 | 24.3 |      | 133.2 |        |
| 10154-CAB | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 6.10  | 66.5 | 19.1 | 5.75 | 140.0 | ±1.7 % |
|           |                                          | Y | 6.04  | 67.1 | 19.8 |      | 134.8 |        |
|           |                                          | Z | 6.12  | 67.1 | 19.5 |      | 143.2 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.57  | 67.2 | 19.4 | 5.82 | 146.3 | ±1.7 % |
|           |                                          | Y | 6.47  | 67.6 | 20.0 |      | 139.6 |        |
|           |                                          | Z | 6.56  | 67.6 | 19.7 |      | 148.5 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 5.16  | 66.7 | 19.4 | 5.73 | 145.8 | ±1.4 % |
|           |                                          | Y | 5.02  | 67.5 | 20.2 |      | 137.5 |        |
|           |                                          | Z | 5.07  | 67.2 | 19.7 |      | 147.1 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 10.07 | 79.2 | 27.3 | 9.21 | 136.5 | ±3.0 % |
|           |                                          | Y | 9.70  | 81.5 | 29.3 |      | 142.5 |        |
|           |                                          | Z | 7.63  | 74.3 | 25.3 |      | 125.0 |        |
| 10175-CAB | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 5.13  | 66.6 | 19.3 | 5.72 | 145.9 | ±1.4 % |
|           |                                          | Y | 5.01  | 67.4 | 20.1 |      | 137.5 |        |
|           |                                          | Z | 5.04  | 67.1 | 19.7 |      | 146.3 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 5.14  | 66.6 | 19.3 | 5.72 | 145.7 | ±1.4 % |
|           |                                          | Y | 5.03  | 67.5 | 20.3 |      | 137.4 |        |
|           |                                          | Z | 5.06  | 67.2 | 19.7 |      | 146.6 |        |
| 10196-CAA | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.88  | 68.3 | 20.8 | 8.10 | 130.9 | ±2.5 % |
|           |                                          | Y | 10.13 | 69.6 | 21.8 |      | 149.0 |        |
|           |                                          | Z | 9.77  | 68.4 | 20.9 |      | 131.6 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 6.98  | 66.5 | 19.0 | 5.97 | 132.9 | ±1.7 % |
|           |                                          | Y | 7.14  | 67.8 | 20.0 |      | 149.7 |        |
|           |                                          | Z | 7.02  | 67.2 | 19.4 |      | 134.3 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 10.13 | 79.4 | 27.4 | 9.21 | 137.5 | ±3.0 % |
|           |                                          | Y | 9.73  | 81.6 | 29.3 |      | 143.3 |        |
|           |                                          | Z | 7.59  | 74.1 | 25.1 |      | 125.6 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 10.80 | 76.4 | 25.9 | 9.24 | 140.0 | ±3.3 % |
|           |                                          | Y | 10.19 | 77.2 | 27.1 |      | 147.2 |        |
|           |                                          | Z | 8.55  | 71.8 | 23.9 |      | 124.9 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 11.59 | 77.3 | 26.3 | 9.30 | 148.4 | ±3.5 % |
|           |                                          | Y | 9.87  | 75.1 | 25.9 |      | 126.0 |        |
|           |                                          | Z | 9.21  | 72.7 | 24.2 |      | 133.6 |        |

|           |                                                               |   |      |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.40 | 66.1 | 18.1 | 3.96 | 134.1 | ±0.7 % |
|           |                                                               | Y | 4.48 | 67.4 | 19.2 |      | 129.7 |        |
|           |                                                               | Z | 4.54 | 67.2 | 18.7 |      | 137.4 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.59 | 65.7 | 17.7 | 3.46 | 127.5 | ±0.7 % |
|           |                                                               | Y | 3.85 | 68.4 | 19.7 |      | 143.4 |        |
|           |                                                               | Z | 3.78 | 67.6 | 18.8 |      | 129.7 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.56 | 65.9 | 17.8 | 3.39 | 127.9 | ±0.7 % |
|           |                                                               | Y | 3.81 | 68.6 | 19.8 |      | 144.2 |        |
|           |                                                               | Z | 3.71 | 67.5 | 18.8 |      | 130.7 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.44 | 67.1 | 19.4 | 5.81 | 143.0 | ±1.7 % |
|           |                                                               | Y | 6.37 | 67.6 | 20.0 |      | 137.9 |        |
|           |                                                               | Z | 6.43 | 67.5 | 19.7 |      | 146.5 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 7.02 | 67.8 | 19.8 | 6.06 | 148.7 | ±1.9 % |
|           |                                                               | Y | 6.96 | 68.2 | 20.4 |      | 143.6 |        |
|           |                                                               | Z | 6.72 | 67.1 | 19.5 |      | 126.9 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 4.73 | 67.0 | 17.9 | 3.76 | 140.2 | ±0.7 % |
|           |                                                               | Y | 4.96 | 69.4 | 19.5 |      | 130.7 |        |
|           |                                                               | Z | 5.05 | 69.3 | 19.1 |      | 140.9 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 4.70 | 67.2 | 18.1 | 3.77 | 138.1 | ±0.7 % |
|           |                                                               | Y | 4.85 | 69.5 | 19.6 |      | 129.6 |        |
|           |                                                               | Z | 5.14 | 70.1 | 19.5 |      | 139.3 |        |
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 2.47 | 66.1 | 17.1 | 1.54 | 133.2 | ±0.7 % |
|           |                                                               | Y | 3.15 | 72.2 | 20.9 |      | 127.9 |        |
|           |                                                               | Z | 3.32 | 72.0 | 20.1 |      | 137.2 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 9.99 | 68.4 | 21.0 | 8.23 | 131.6 | ±2.5 % |
|           |                                                               | Y | 9.84 | 68.6 | 21.4 |      | 123.3 |        |
|           |                                                               | Z | 9.89 | 68.6 | 21.1 |      | 133.4 |        |

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: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) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 41.9                               | 0.89                            | 6.55    | 6.55    | 6.55    | 0.34               | 1.74                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.33    | 6.33    | 6.33    | 0.44               | 1.48                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.26    | 5.26    | 5.26    | 0.73               | 1.21                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.11    | 5.11    | 5.11    | 0.66               | 1.32                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.53    | 4.53    | 4.53    | 0.62               | 1.40                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.40    | 4.40    | 4.40    | 0.68               | 1.38                    | ± 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 <sup>G</sup> (mm) | Uct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|------------|
| 750                  | 55.5                               | 0.96                            | 6.14    | 6.14    | 6.14    | 0.35               | 1.76                    | ± 12.0 %   |
| 835                  | 55.2                               | 0.97                            | 6.12    | 6.12    | 6.12    | 0.57               | 1.37                    | ± 12.0 %   |
| 1750                 | 53.4                               | 1.49                            | 4.89    | 4.89    | 4.89    | 0.80               | 1.24                    | ± 12.0 %   |
| 1900                 | 53.3                               | 1.52                            | 4.67    | 4.67    | 4.67    | 0.75               | 1.29                    | ± 12.0 %   |
| 2450                 | 52.7                               | 1.95                            | 4.26    | 4.26    | 4.26    | 0.80               | 1.01                    | ± 12.0 %   |
| 2600                 | 52.5                               | 2.16                            | 4.13    | 4.13    | 4.13    | 0.80               | 0.99                    | ± 12.0 %   |

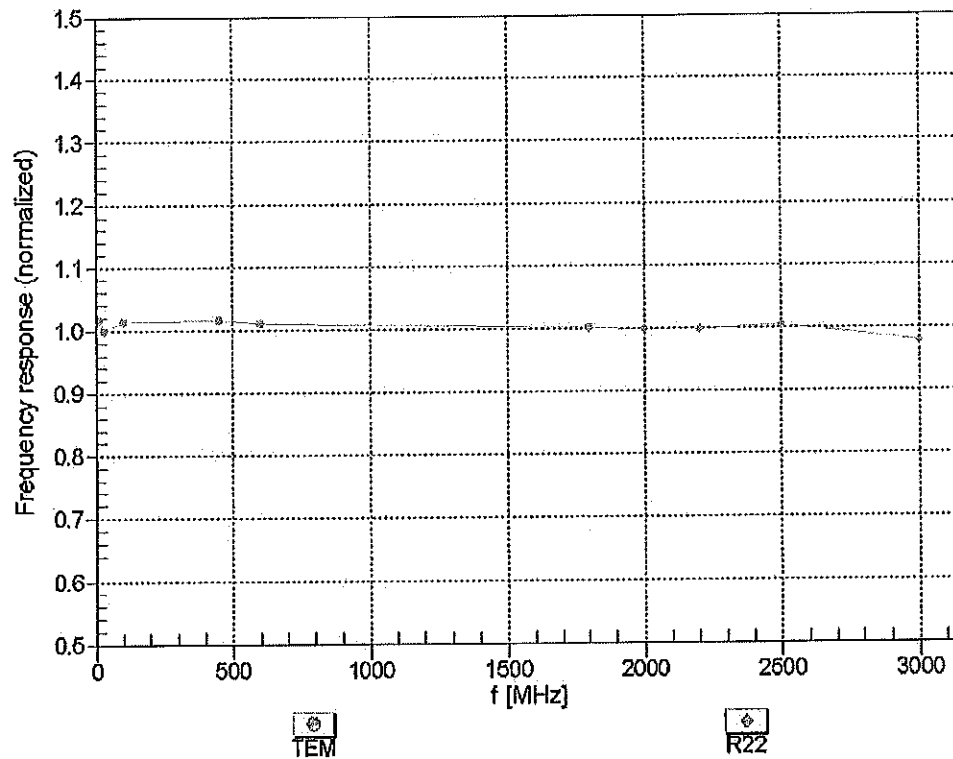
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 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.



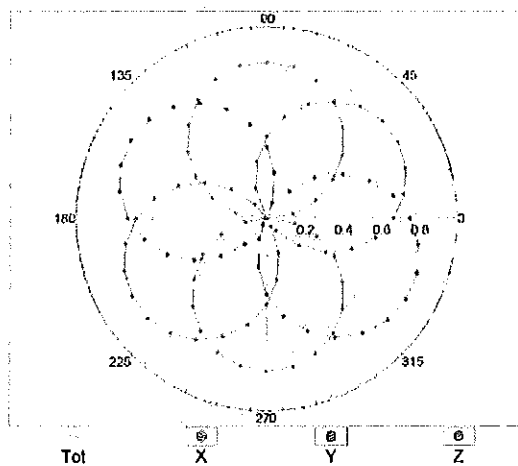
## Frequency Response of E-Field (TEM-Cell: Ifi110 EXX, Waveguide: R22)



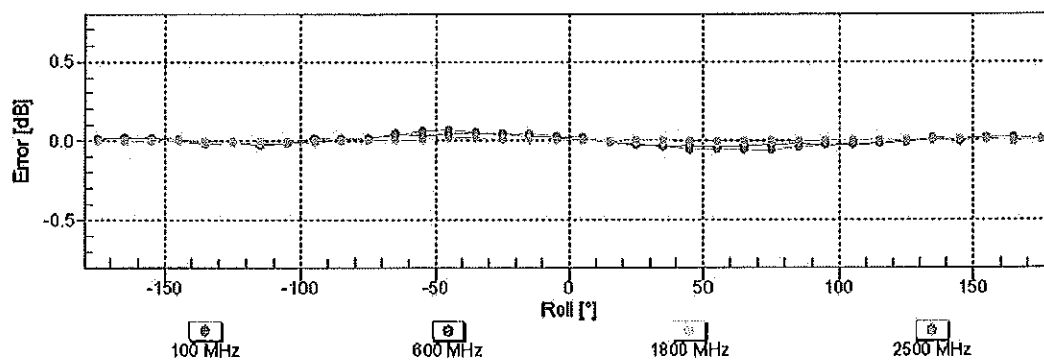
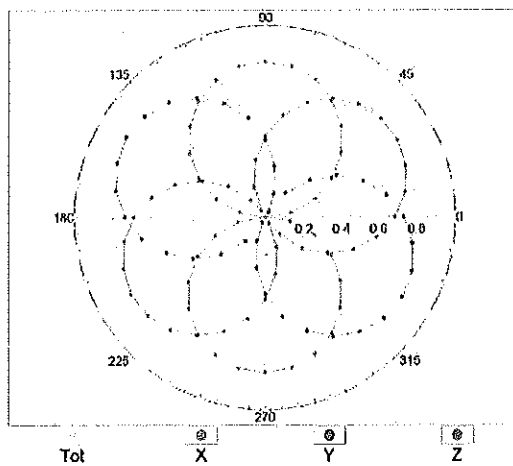
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

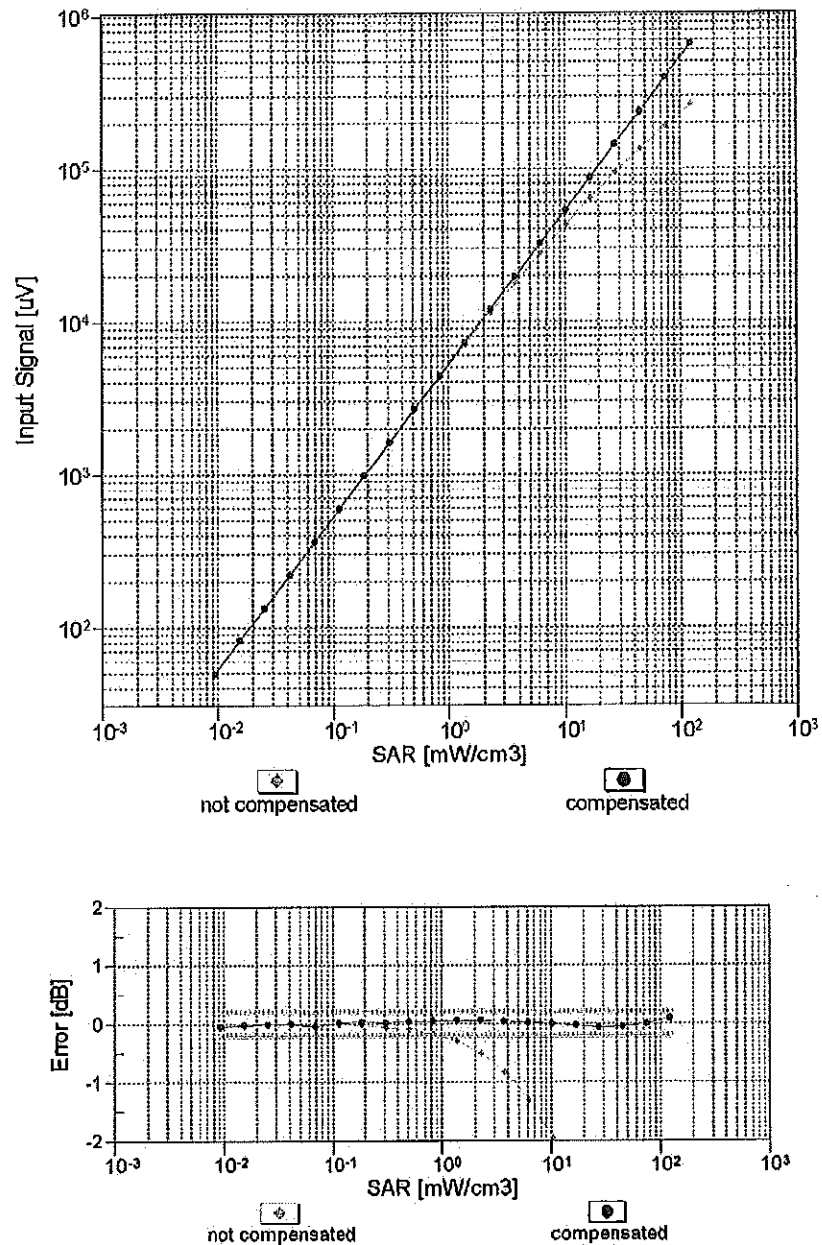
f=600 MHz,TEM



f=1800 MHz,R22

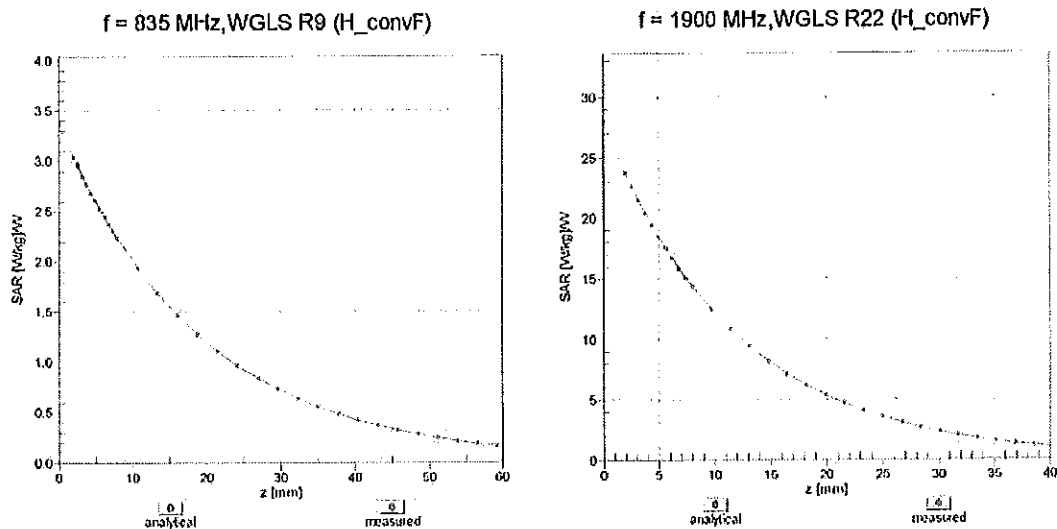
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

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



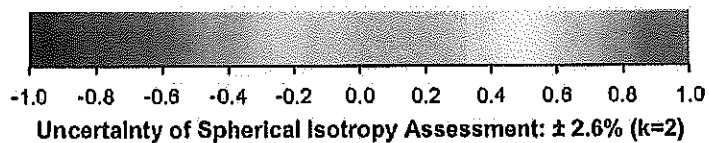
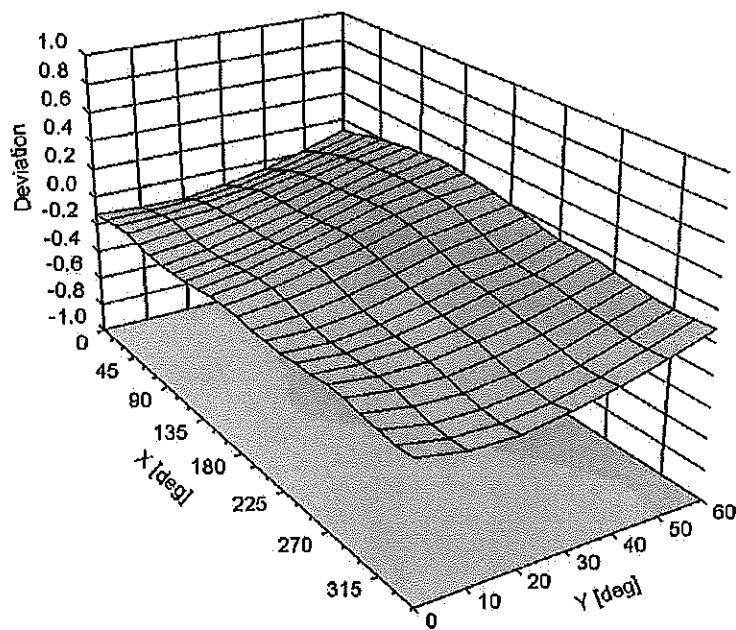
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



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

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

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -34.9      |
| 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       |

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



**S** Schweizerischer Kalibrierdienst  
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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **ES3-3334\_Dec14**

## CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3334**

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

CC  
 12/31/14

Calibration date: **December 16, 2014**

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      | 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-13 (No. ES3-3013_Dec13)    | Dec-14                 |
| DAE4                       | SN: 789         | 30-Apr-14 (No. DAE4-789_Apr14)    | Apr-15                 |
| 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>Lelf Klysnar | Function<br>Laboratory Technician | Signature<br>             |
| Approved by:   | Katja Pokovic        | Technical Manager                 |                           |
|                |                      |                                   | Issued: December 16, 2014 |

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



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Accreditation No.: **SCS 108**

### 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:3334

|               |                   |
|---------------|-------------------|
| Manufactured: | January 24, 2012  |
| Repaired:     | December 9, 2014  |
| Calibrated:   | December 16, 2014 |

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> | 1.04     | 1.05     | 1.01     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 106.5    | 105.0    | 105.6    |               |

### 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>E</sup><br>(k=2) |
|---------------|-----------------------------------------------|---|---------|------------------------------|------|---------|----------|---------------------------|
| 0             | CW                                            | X | 0.0     | 0.0                          | 1.0  | 0.00    | 188.0    | $\pm 3.0 \%$              |
|               |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 183.2    |                           |
|               |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 181.8    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 4.61    | 67.2                         | 13.7 | 10.00   | 38.4     | $\pm 1.4 \%$              |
|               |                                               | Y | 20.36   | 82.7                         | 18.7 |         | 38.0     |                           |
|               |                                               | Z | 17.55   | 80.3                         | 17.6 |         | 37.0     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.56    | 68.4                         | 19.1 | 2.91    | 148.4    | $\pm 0.7 \%$              |
|               |                                               | Y | 3.44    | 68.1                         | 19.2 |         | 146.9    |                           |
|               |                                               | Z | 3.52    | 68.3                         | 19.1 |         | 144.7    |                           |
| 10012-<br>CAB | IEEE 802.11b WIFI 2.4 GHz (DSSS, 1 Mbps)      | X | 3.54    | 71.9                         | 20.0 | 1.87    | 148.0    | $\pm 0.7 \%$              |
|               |                                               | Y | 3.51    | 72.2                         | 20.5 |         | 148.9    |                           |
|               |                                               | Z | 3.80    | 73.3                         | 20.6 |         | 144.6    |                           |
| 10013-<br>CAB | IEEE 802.11g WIFI 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 11.39   | 71.1                         | 23.3 | 9.46    | 149.8    | $\pm 3.8 \%$              |
|               |                                               | Y | 11.54   | 71.8                         | 24.0 |         | 149.5    |                           |
|               |                                               | Z | 11.11   | 70.5                         | 23.0 |         | 141.6    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 15.29   | 91.3                         | 25.0 | 9.39    | 131.9    | $\pm 1.7 \%$              |
|               |                                               | Y | 24.16   | 100.0                        | 28.4 |         | 142.8    |                           |
|               |                                               | Z | 13.05   | 89.2                         | 24.5 |         | 126.5    |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 16.07   | 91.7                         | 25.1 | 9.57    | 144.0    | $\pm 2.2 \%$              |
|               |                                               | Y | 19.00   | 95.3                         | 26.8 |         | 136.4    |                           |
|               |                                               | Z | 13.93   | 89.8                         | 24.6 |         | 141.0    |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 19.98   | 91.0                         | 22.4 | 6.56    | 134.2    | $\pm 1.9 \%$              |
|               |                                               | Y | 34.78   | 99.7                         | 25.5 |         | 145.0    |                           |
|               |                                               | Z | 29.89   | 96.8                         | 24.1 |         | 129.8    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 56.30   | 99.7                         | 22.8 | 4.80    | 125.2    | $\pm 1.9 \%$              |
|               |                                               | Y | 41.16   | 99.6                         | 23.9 |         | 131.2    |                           |
|               |                                               | Z | 50.78   | 99.8                         | 23.1 |         | 147.6    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 49.35   | 99.7                         | 22.5 | 3.55    | 133.2    | $\pm 2.2 \%$              |
|               |                                               | Y | 46.49   | 99.6                         | 22.9 |         | 139.2    |                           |
|               |                                               | Z | 58.21   | 99.7                         | 22.0 |         | 129.4    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 56.54   | 100.0                        | 20.2 | 1.16    | 128.0    | $\pm 1.7 \%$              |
|               |                                               | Y | 20.03   | 99.3                         | 22.4 |         | 130.3    |                           |
|               |                                               | Z | 84.01   | 100.0                        | 19.4 |         | 141.0    |                           |
| 10100-<br>CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)      | X | 6.44    | 67.6                         | 19.6 | 5.67    | 138.5    | $\pm 1.4 \%$              |
|               |                                               | Y | 6.50    | 67.9                         | 20.0 |         | 142.1    |                           |
|               |                                               | Z | 6.31    | 67.2                         | 19.4 |         | 129.4    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 9.77  | 73.6 | 24.6 | 9.29 | 129.6 | ±3.3 % |
|           |                                          | Y | 10.52 | 76.0 | 26.3 |      | 132.1 |        |
|           |                                          | Z | 10.21 | 75.0 | 25.4 |      | 147.7 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.36  | 67.2 | 19.6 | 5.80 | 136.8 | ±1.4 % |
|           |                                          | Y | 6.31  | 67.3 | 19.8 |      | 137.2 |        |
|           |                                          | Z | 6.20  | 66.7 | 19.3 |      | 128.8 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 9.96  | 68.3 | 20.8 | 8.07 | 126.5 | ±2.5 % |
|           |                                          | Y | 10.12 | 68.8 | 21.3 |      | 126.6 |        |
|           |                                          | Z | 10.22 | 69.0 | 21.2 |      | 143.7 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 9.29  | 73.0 | 24.4 | 9.28 | 125.3 | ±3.3 % |
|           |                                          | Y | 9.65  | 74.5 | 25.6 |      | 124.4 |        |
|           |                                          | Z | 9.65  | 74.3 | 25.2 |      | 141.1 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 6.03  | 66.7 | 19.3 | 5.75 | 132.7 | ±1.4 % |
|           |                                          | Y | 5.97  | 66.7 | 19.5 |      | 132.7 |        |
|           |                                          | Z | 6.17  | 67.3 | 19.7 |      | 148.3 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.47  | 67.2 | 19.5 | 5.82 | 138.1 | ±1.4 % |
|           |                                          | Y | 6.44  | 67.3 | 19.8 |      | 138.2 |        |
|           |                                          | Z | 6.27  | 66.6 | 19.2 |      | 126.8 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 5.03  | 66.9 | 19.6 | 5.73 | 137.2 | ±1.2 % |
|           |                                          | Y | 4.97  | 67.0 | 19.9 |      | 135.7 |        |
|           |                                          | Z | 4.91  | 66.5 | 19.5 |      | 127.1 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 8.53  | 77.4 | 26.9 | 9.21 | 142.4 | ±2.7 % |
|           |                                          | Y | 9.59  | 81.3 | 29.3 |      | 142.3 |        |
|           |                                          | Z | 7.78  | 75.0 | 25.7 |      | 126.7 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 5.02  | 67.0 | 19.7 | 5.72 | 131.8 | ±1.2 % |
|           |                                          | Y | 4.98  | 67.0 | 19.9 |      | 136.1 |        |
|           |                                          | Z | 4.95  | 66.8 | 19.6 |      | 128.1 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.99  | 66.8 | 19.6 | 5.72 | 131.2 | ±1.2 % |
|           |                                          | Y | 4.99  | 67.1 | 20.0 |      | 136.2 |        |
|           |                                          | Z | 4.92  | 66.6 | 19.5 |      | 127.9 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.98  | 68.8 | 21.2 | 8.10 | 141.7 | ±2.5 % |
|           |                                          | Y | 10.14 | 69.5 | 21.8 |      | 147.2 |        |
|           |                                          | Z | 9.85  | 68.6 | 21.1 |      | 137.5 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 7.17  | 67.5 | 19.6 | 5.97 | 146.0 | ±1.4 % |
|           |                                          | Y | 7.13  | 67.7 | 19.9 |      | 149.9 |        |
|           |                                          | Z | 7.12  | 67.5 | 19.6 |      | 142.9 |        |
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 8.29  | 76.6 | 26.5 | 9.21 | 136.1 | ±2.7 % |
|           |                                          | Y | 9.60  | 81.4 | 29.3 |      | 142.3 |        |
|           |                                          | Z | 7.98  | 75.8 | 26.1 |      | 132.9 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 9.27  | 74.1 | 25.1 | 9.24 | 139.1 | ±3.3 % |
|           |                                          | Y | 10.25 | 77.5 | 27.4 |      | 146.3 |        |
|           |                                          | Z | 9.07  | 73.7 | 25.0 |      | 135.8 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 9.95  | 74.9 | 25.4 | 9.30 | 147.0 | ±3.3 % |
|           |                                          | Y | 9.80  | 75.0 | 25.9 |      | 125.9 |        |
|           |                                          | Z | 9.74  | 74.6 | 25.4 |      | 143.8 |        |

|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                      | X | 4.63  | 67.6 | 19.0 | 3.96 | 147.5 | ±0.7 % |
|           |                                                               | Y | 4.41  | 66.9 | 18.9 |      | 129.5 |        |
|           |                                                               | Z | 4.61  | 67.6 | 19.1 |      | 148.1 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                                | X | 3.83  | 67.7 | 19.0 | 3.46 | 133.7 | ±0.7 % |
|           |                                                               | Y | 3.71  | 67.4 | 19.0 |      | 139.0 |        |
|           |                                                               | Z | 3.86  | 68.1 | 19.2 |      | 133.7 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                                | X | 3.85  | 68.2 | 19.2 | 3.39 | 136.7 | ±0.5 % |
|           |                                                               | Y | 3.67  | 67.5 | 19.1 |      | 141.3 |        |
|           |                                                               | Z | 3.75  | 67.8 | 19.0 |      | 136.2 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                       | X | 6.31  | 67.1 | 19.5 | 5.81 | 130.6 | ±1.4 % |
|           |                                                               | Y | 6.32  | 67.3 | 19.8 |      | 135.1 |        |
|           |                                                               | Z | 6.24  | 66.9 | 19.4 |      | 129.2 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                      | X | 6.85  | 67.5 | 19.8 | 6.06 | 135.1 | ±1.4 % |
|           |                                                               | Y | 6.90  | 67.9 | 20.2 |      | 141.5 |        |
|           |                                                               | Z | 6.82  | 67.5 | 19.8 |      | 135.1 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                                    | X | 5.04  | 69.1 | 19.1 | 3.76 | 126.0 | ±0.5 % |
|           |                                                               | Y | 4.90  | 69.0 | 19.3 |      | 129.6 |        |
|           |                                                               | Z | 5.11  | 69.7 | 19.4 |      | 125.8 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                                    | X | 5.05  | 69.6 | 19.4 | 3.77 | 147.1 | ±0.7 % |
|           |                                                               | Y | 4.84  | 69.2 | 19.5 |      | 127.8 |        |
|           |                                                               | Z | 5.15  | 70.1 | 19.6 |      | 143.3 |        |
| 10415-AAA | IEEE 802.11b WIFI 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 3.13  | 71.2 | 19.9 | 1.54 | 144.5 | ±0.5 % |
|           |                                                               | Y | 2.93  | 70.4 | 19.9 |      | 149.8 |        |
|           |                                                               | Z | 3.18  | 71.6 | 20.1 |      | 141.4 |        |
| 10416-AAA | IEEE 802.11g WIFI 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.11 | 69.0 | 21.4 | 8.23 | 144.3 | ±2.5 % |
|           |                                                               | Y | 10.21 | 69.6 | 21.9 |      | 148.3 |        |
|           |                                                               | Z | 9.99  | 68.9 | 21.3 |      | 141.1 |        |

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:3334

### 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                            | 6.51    | 6.51    | 6.51    | 0.80               | 1.17                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 6.25    | 6.25    | 6.25    | 0.38               | 1.58                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 5.21    | 5.21    | 5.21    | 0.43               | 1.63                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 5.03    | 5.03    | 5.03    | 0.53               | 1.45                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 4.51    | 4.51    | 4.51    | 0.80               | 1.26                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 4.31    | 4.31    | 4.31    | 0.79               | 1.27                    | ± 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: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>d</sup> (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 750                  | 55.5                               | 0.96                            | 6.09    | 6.09    | 6.09    | 0.49               | 1.47                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 6.14    | 6.14    | 6.14    | 0.69               | 1.27                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 4.94    | 4.94    | 4.94    | 0.80               | 1.24                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 4.73    | 4.73    | 4.73    | 0.62               | 1.44                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 4.28    | 4.28    | 4.28    | 0.80               | 1.13                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 4.16    | 4.16    | 4.16    | 0.75               | 1.25                    | ± 12.0 %    |

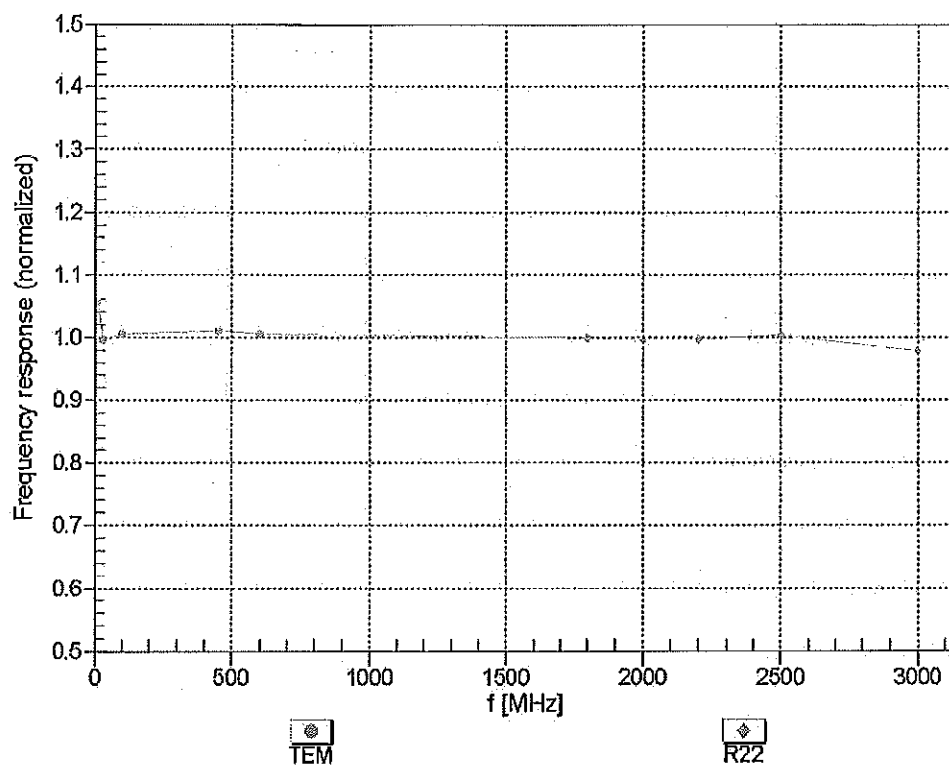
<sup>c</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 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.

## Frequency Response of E-Field

(TEM-Cell: Ifi110 EXX, Waveguide: R22)

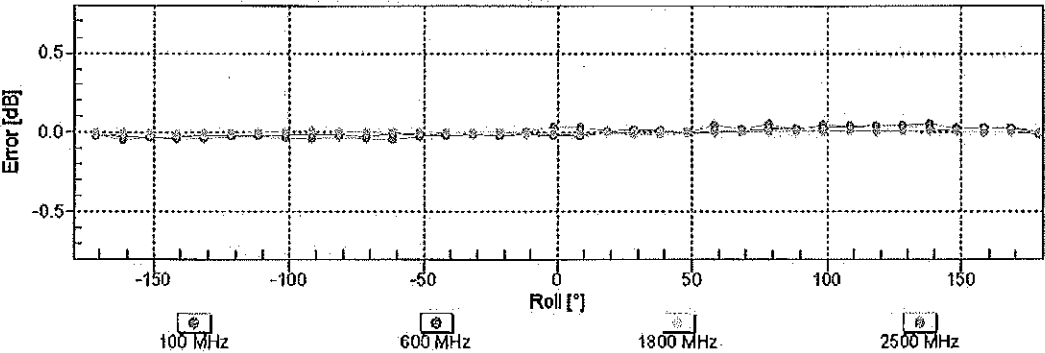
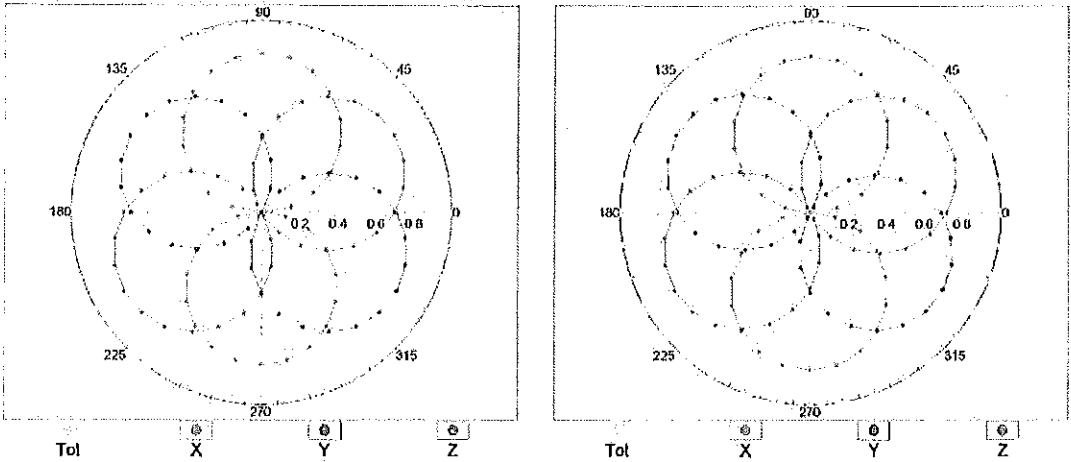


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

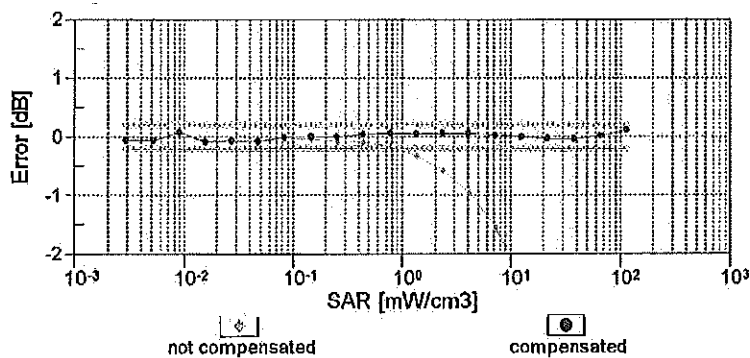
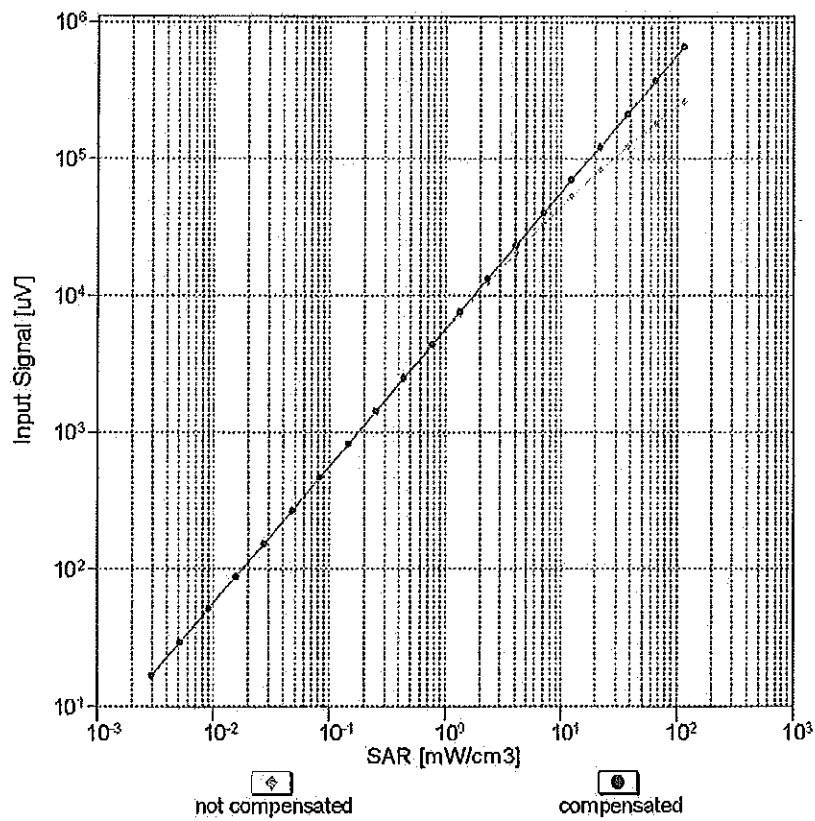
f=600 MHz,TEM

f=1800 MHz,R22



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

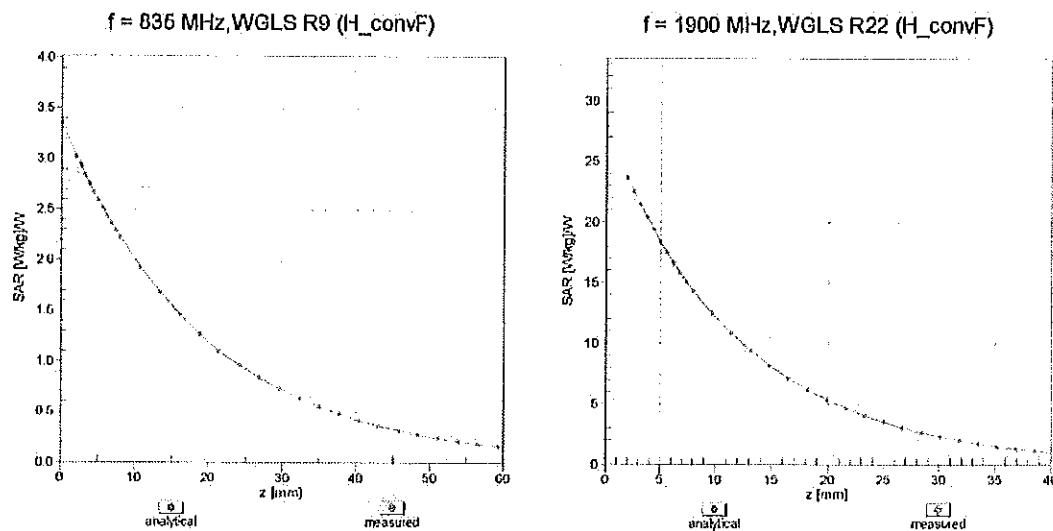
# Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f_{\text{eval}} = 1900 \text{ MHz}$ )



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

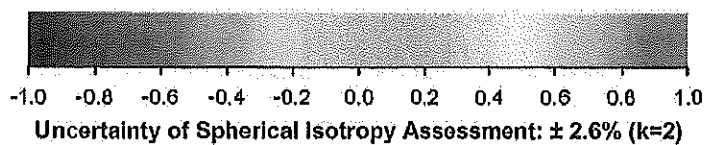
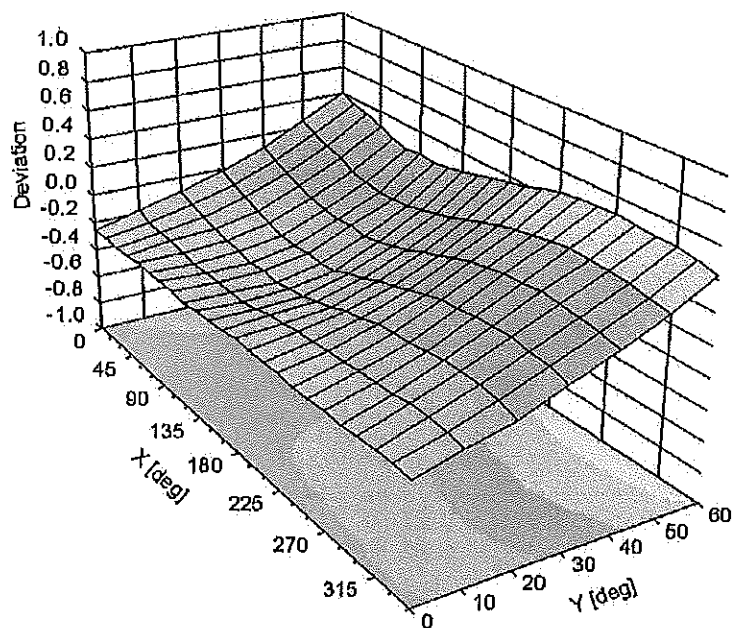


## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



**DASY/EASY - Parameters of Probe: ES3DV3 - SN:3334****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 18.5       |
| 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: **EX3-3914\_Feb15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3914**

CCV  
3/6/15

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: **February 10, 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      | 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>Claudio Leubler</b> | Function<br><b>Laboratory Technician</b> | Signature<br>             |
| Approved by:                                                                                                    | <b>Katja Pokovic</b>           | <b>Technical Manager</b>                 |                           |
|                                                                                                                 |                                |                                          | Issued: February 10, 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  $E^2$ -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:3914

|               |                   |
|---------------|-------------------|
| Manufactured: | December 18, 2012 |
| Repaired:     | January 23, 2015  |
| Calibrated:   | February 10, 2015 |

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

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3914

### Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|-----------------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.48     | 0.42     | 0.45     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                                     | 102.7    | 103.2    | 101.3    |               |

### 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    | 137.3    | $\pm 2.7 \%$              |
|               |                                               | Y | 0.0     | 0.0                          | 1.0  |         | 140.8    |                           |
|               |                                               | Z | 0.0     | 0.0                          | 1.0  |         | 134.6    |                           |
| 10010-<br>CAA | SAR Validation (Square, 100ms, 10ms)          | X | 1.33    | 60.3                         | 9.9  | 10.00   | 40.4     | $\pm 1.2 \%$              |
|               |                                               | Y | 1.02    | 57.7                         | 9.2  |         | 42.2     |                           |
|               |                                               | Z | 1.41    | 61.3                         | 11.0 |         | 39.9     |                           |
| 10011-<br>CAB | UMTS-FDD (WCDMA)                              | X | 3.39    | 67.3                         | 18.6 | 2.91    | 148.9    | $\pm 0.5 \%$              |
|               |                                               | Y | 3.47    | 67.6                         | 18.6 |         | 130.1    |                           |
|               |                                               | Z | 3.30    | 66.5                         | 17.9 |         | 145.8    |                           |
| 10012-<br>CAB | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)      | X | 2.92    | 68.9                         | 18.9 | 1.87    | 149.0    | $\pm 0.7 \%$              |
|               |                                               | Y | 3.17    | 70.1                         | 19.2 |         | 131.4    |                           |
|               |                                               | Z | 2.72    | 67.0                         | 17.6 |         | 146.9    |                           |
| 10013-<br>CAB | IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps) | X | 10.52   | 69.1                         | 22.1 | 9.46    | 140.7    | $\pm 3.3 \%$              |
|               |                                               | Y | 10.67   | 69.8                         | 22.6 |         | 146.8    |                           |
|               |                                               | Z | 10.44   | 68.9                         | 22.0 |         | 136.8    |                           |
| 10021-<br>DAB | GSM-FDD (TDMA, GMSK)                          | X | 1.64    | 63.4                         | 11.8 | 9.39    | 86.2     | $\pm 1.7 \%$              |
|               |                                               | Y | 2.03    | 65.7                         | 13.6 |         | 105.2    |                           |
|               |                                               | Z | 1.78    | 63.6                         | 12.4 |         | 85.9     |                           |
| 10023-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0)                   | X | 1.78    | 65.0                         | 13.2 | 9.57    | 84.0     | $\pm 2.2 \%$              |
|               |                                               | Y | 1.84    | 63.8                         | 12.5 |         | 101.1    |                           |
|               |                                               | Z | 1.92    | 64.9                         | 13.4 |         | 83.0     |                           |
| 10024-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1)                 | X | 2.04    | 68.8                         | 13.2 | 6.56    | 141.3    | $\pm 1.9 \%$              |
|               |                                               | Y | 2.32    | 70.4                         | 14.4 |         | 134.7    |                           |
|               |                                               | Z | 1.59    | 65.5                         | 12.3 |         | 139.3    |                           |
| 10027-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2)               | X | 1.51    | 67.3                         | 11.9 | 4.80    | 148.8    | $\pm 1.9 \%$              |
|               |                                               | Y | 1.27    | 63.7                         | 10.0 |         | 136.2    |                           |
|               |                                               | Z | 3.26    | 75.5                         | 15.4 |         | 148.7    |                           |
| 10028-<br>DAB | GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)             | X | 52.54   | 99.9                         | 20.2 | 3.55    | 143.3    | $\pm 1.7 \%$              |
|               |                                               | Y | 2.95    | 74.0                         | 13.7 |         | 149.7    |                           |
|               |                                               | Z | 32.98   | 99.9                         | 21.5 |         | 141.9    |                           |
| 10032-<br>CAA | IEEE 802.15.1 Bluetooth (GFSK, DH5)           | X | 96.97   | 99.5                         | 17.5 | 1.16    | 145.3    | $\pm 1.2 \%$              |
|               |                                               | Y | 83.69   | 99.7                         | 18.1 |         | 128.6    |                           |
|               |                                               | Z | 0.69    | 65.4                         | 9.0  |         | 143.2    |                           |

|           |                                          |   |       |      |      |      |       |        |
|-----------|------------------------------------------|---|-------|------|------|------|-------|--------|
| 10062-CAB | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps) | X | 10.27 | 68.9 | 21.5 | 8.68 | 145.1 | ±2.7 % |
|           |                                          | Y | 9.95  | 68.4 | 21.3 |      | 123.8 |        |
|           |                                          | Z | 10.18 | 68.8 | 21.4 |      | 140.9 |        |
| 10100-CAB | LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 6.38  | 67.0 | 19.3 | 5.67 | 140.1 | ±1.4 % |
|           |                                          | Y | 6.54  | 67.7 | 19.6 |      | 147.0 |        |
|           |                                          | Z | 6.34  | 66.8 | 19.1 |      | 137.4 |        |
| 10103-CAB | LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK) | X | 7.44  | 67.6 | 21.6 | 9.29 | 132.4 | ±1.7 % |
|           |                                          | Y | 7.78  | 69.0 | 22.4 |      | 140.2 |        |
|           |                                          | Z | 7.40  | 67.4 | 21.4 |      | 129.5 |        |
| 10108-CAC | LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK) | X | 6.25  | 66.7 | 19.2 | 5.80 | 137.9 | ±1.4 % |
|           |                                          | Y | 6.36  | 67.2 | 19.5 |      | 143.3 |        |
|           |                                          | Z | 6.20  | 66.4 | 19.0 |      | 135.0 |        |
| 10117-CAB | IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK) | X | 10.03 | 68.2 | 20.7 | 8.07 | 128.5 | ±2.5 % |
|           |                                          | Y | 10.17 | 68.7 | 21.0 |      | 134.9 |        |
|           |                                          | Z | 9.94  | 68.0 | 20.5 |      | 125.2 |        |
| 10151-CAB | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)  | X | 7.21  | 67.6 | 21.8 | 9.28 | 149.5 | ±1.9 % |
|           |                                          | Y | 7.39  | 68.5 | 22.3 |      | 135.1 |        |
|           |                                          | Z | 7.19  | 67.5 | 21.7 |      | 147.3 |        |
| 10154-CAC | LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)  | X | 5.91  | 66.2 | 19.1 | 5.75 | 133.8 | ±1.2 % |
|           |                                          | Y | 6.04  | 66.8 | 19.4 |      | 139.4 |        |
|           |                                          | Z | 5.88  | 66.0 | 18.9 |      | 131.1 |        |
| 10160-CAB | LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)  | X | 6.36  | 66.7 | 19.3 | 5.82 | 139.0 | ±1.4 % |
|           |                                          | Y | 6.51  | 67.4 | 19.7 |      | 145.5 |        |
|           |                                          | Z | 6.31  | 66.4 | 19.0 |      | 136.5 |        |
| 10169-CAB | LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 4.79  | 66.3 | 19.4 | 5.73 | 136.1 | ±1.2 % |
|           |                                          | Y | 4.90  | 67.0 | 19.8 |      | 141.5 |        |
|           |                                          | Z | 4.76  | 66.0 | 19.1 |      | 133.8 |        |
| 10172-CAB | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)    | X | 5.66  | 68.8 | 22.7 | 9.21 | 138.2 | ±2.5 % |
|           |                                          | Y | 5.93  | 70.3 | 23.7 |      | 147.0 |        |
|           |                                          | Z | 5.68  | 68.6 | 22.6 |      | 136.7 |        |
| 10175-CAC | LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)    | X | 4.77  | 66.2 | 19.3 | 5.72 | 135.7 | ±1.2 % |
|           |                                          | Y | 4.92  | 67.1 | 19.8 |      | 141.2 |        |
|           |                                          | Z | 4.72  | 65.8 | 19.0 |      | 133.6 |        |
| 10181-CAB | LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)    | X | 4.77  | 66.2 | 19.3 | 5.72 | 134.8 | ±1.2 % |
|           |                                          | Y | 4.91  | 67.0 | 19.7 |      | 141.1 |        |
|           |                                          | Z | 4.76  | 66.0 | 19.1 |      | 132.8 |        |
| 10196-CAB | IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)  | X | 9.99  | 68.8 | 21.1 | 8.10 | 146.9 | ±2.5 % |
|           |                                          | Y | 9.71  | 68.4 | 21.0 |      | 127.0 |        |
|           |                                          | Z | 9.91  | 68.7 | 21.0 |      | 143.4 |        |
| 10225-CAB | UMTS-FDD (HSPA+)                         | X | 7.10  | 67.5 | 19.5 | 5.97 | 149.1 | ±1.2 % |
|           |                                          | Y | 6.98  | 67.4 | 19.5 |      | 128.9 |        |
|           |                                          | Z | 7.01  | 67.2 | 19.3 |      | 145.5 |        |

|           |                                                         |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10237-CAB | LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)                   | X | 5.68  | 68.9 | 22.8 | 9.21 | 139.9 | ±2.2 % |
|           |                                                         | Y | 5.93  | 70.3 | 23.6 |      | 148.1 |        |
|           |                                                         | Z | 5.70  | 68.8 | 22.7 |      | 137.5 |        |
| 10252-CAB | LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)                 | X | 6.81  | 67.4 | 21.7 | 9.24 | 143.4 | ±2.2 % |
|           |                                                         | Y | 6.93  | 68.0 | 22.2 |      | 129.3 |        |
|           |                                                         | Z | 6.79  | 67.2 | 21.6 |      | 140.3 |        |
| 10267-CAB | LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK)                | X | 7.23  | 67.7 | 21.9 | 9.30 | 149.4 | ±1.9 % |
|           |                                                         | Y | 7.42  | 68.6 | 22.4 |      | 135.2 |        |
|           |                                                         | Z | 7.19  | 67.4 | 21.6 |      | 146.2 |        |
| 10275-CAB | UMTS-FDD (HSUPA, Subtest 5, 3GPP Rel8.4)                | X | 4.44  | 66.7 | 18.6 | 3.96 | 129.1 | ±0.7 % |
|           |                                                         | Y | 4.57  | 67.4 | 18.9 |      | 134.5 |        |
|           |                                                         | Z | 4.35  | 66.1 | 18.1 |      | 126.6 |        |
| 10291-AAB | CDMA2000, RC3, SO55, Full Rate                          | X | 3.64  | 66.9 | 18.6 | 3.46 | 140.9 | ±0.7 % |
|           |                                                         | Y | 3.87  | 68.3 | 19.3 |      | 147.1 |        |
|           |                                                         | Z | 3.61  | 66.5 | 18.2 |      | 138.4 |        |
| 10292-AAB | CDMA2000, RC3, SO32, Full Rate                          | X | 3.64  | 67.4 | 18.8 | 3.39 | 142.3 | ±0.5 % |
|           |                                                         | Y | 3.85  | 68.5 | 19.3 |      | 148.3 |        |
|           |                                                         | Z | 3.59  | 66.7 | 18.3 |      | 139.6 |        |
| 10297-AAA | LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)                 | X | 6.23  | 66.6 | 19.2 | 5.81 | 136.3 | ±1.4 % |
|           |                                                         | Y | 6.42  | 67.4 | 19.7 |      | 142.8 |        |
|           |                                                         | Z | 6.19  | 66.3 | 19.0 |      | 133.9 |        |
| 10311-AAA | LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)                | X | 6.84  | 67.3 | 19.6 | 6.06 | 142.4 | ±1.4 % |
|           |                                                         | Y | 6.98  | 67.8 | 19.9 |      | 149.5 |        |
|           |                                                         | Z | 6.75  | 66.8 | 19.3 |      | 140.0 |        |
| 10317-AAB | IEEE 802.11a WiFi 5 GHz (OFDM, 6 Mbps, 96pc duty cycle) | X | 10.13 | 68.9 | 21.3 | 8.36 | 147.4 | ±2.7 % |
|           |                                                         | Y | 9.84  | 68.4 | 21.1 |      | 127.5 |        |
|           |                                                         | Z | 10.04 | 68.7 | 21.2 |      | 143.2 |        |
| 10400-AAB | IEEE 802.11ac WiFi (20MHz, 64-QAM, 99pc duty cycle)     | X | 10.24 | 69.0 | 21.4 | 8.37 | 148.6 | ±2.7 % |
|           |                                                         | Y | 9.92  | 68.4 | 21.2 |      | 126.6 |        |
|           |                                                         | Z | 10.14 | 68.8 | 21.3 |      | 144.6 |        |
| 10401-AAB | IEEE 802.11ac WiFi (40MHz, 64-QAM, 99pc duty cycle)     | X | 10.60 | 68.6 | 21.2 | 8.60 | 129.4 | ±3.0 % |
|           |                                                         | Y | 10.77 | 69.1 | 21.5 |      | 136.8 |        |
|           |                                                         | Z | 10.52 | 68.4 | 21.1 |      | 125.9 |        |
| 10402-AAB | IEEE 802.11ac WiFi (80MHz, 64-QAM, 99pc duty cycle)     | X | 10.60 | 68.5 | 20.9 | 8.53 | 129.7 | ±3.0 % |
|           |                                                         | Y | 11.01 | 69.5 | 21.5 |      | 139.1 |        |
|           |                                                         | Z | 10.54 | 68.3 | 20.8 |      | 126.7 |        |
| 10403-AAB | CDMA2000 (1xEV-DO, Rev. 0)                              | X | 5.07  | 70.1 | 19.4 | 3.76 | 127.5 | ±0.5 % |
|           |                                                         | Y | 5.47  | 71.9 | 20.2 |      | 133.6 |        |
|           |                                                         | Z | 4.93  | 69.5 | 19.0 |      | 124.9 |        |
| 10404-AAB | CDMA2000 (1xEV-DO, Rev. A)                              | X | 5.01  | 70.2 | 19.5 | 3.77 | 149.3 | ±0.7 % |
|           |                                                         | Y | 5.38  | 71.9 | 20.2 |      | 132.0 |        |
|           |                                                         | Z | 4.94  | 69.9 | 19.2 |      | 146.4 |        |



|           |                                                               |   |       |      |      |      |       |        |
|-----------|---------------------------------------------------------------|---|-------|------|------|------|-------|--------|
| 10415-AAA | IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps, 99pc duty cycle)     | X | 3.20  | 71.2 | 19.8 | 1.54 | 126.8 | ±0.7 % |
|           |                                                               | Y | 3.51  | 72.6 | 20.4 |      | 134.5 |        |
|           |                                                               | Z | 2.79  | 68.1 | 18.1 |      | 148.4 |        |
| 10416-AAA | IEEE 802.11g WiFi 2.4 GHz (ERP-OFDM, 6 Mbps, 99pc duty cycle) | X | 10.07 | 68.8 | 21.2 | 8.23 | 147.8 | ±2.7 % |
|           |                                                               | Y | 9.81  | 68.4 | 21.1 |      | 128.4 |        |
|           |                                                               | Z | 10.00 | 68.7 | 21.1 |      | 144.0 |        |
| 10417-AAA | IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps, 99pc duty cycle)     | X | 10.07 | 68.8 | 21.2 | 8.23 | 148.4 | ±2.7 % |
|           |                                                               | Y | 9.82  | 68.4 | 21.1 |      | 129.0 |        |
|           |                                                               | Z | 9.99  | 68.7 | 21.1 |      | 144.6 |        |

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<sup>2</sup>-field uncertainty inside TSL (see Pages 8 and 9).

<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:3914

### 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                            | 9.82    | 9.82    | 9.82    | 0.39               | 0.92                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 9.50    | 9.50    | 9.50    | 0.43               | 0.83                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 8.04    | 8.04    | 8.04    | 0.30               | 0.93                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 7.86    | 7.86    | 7.86    | 0.35               | 0.86                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 7.02    | 7.02    | 7.02    | 0.28               | 1.05                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 6.82    | 6.82    | 6.82    | 0.26               | 1.17                    | ± 12.0 %    |
| 5200                 | 36.0                               | 4.66                            | 5.26    | 5.26    | 5.26    | 0.35               | 1.80                    | ± 13.1 %    |
| 5300                 | 35.9                               | 4.76                            | 5.06    | 5.06    | 5.06    | 0.35               | 1.80                    | ± 13.1 %    |
| 5500                 | 35.6                               | 4.96                            | 4.92    | 4.92    | 4.92    | 0.40               | 1.80                    | ± 13.1 %    |
| 5600                 | 35.5                               | 5.07                            | 4.73    | 4.73    | 4.73    | 0.40               | 1.80                    | ± 13.1 %    |
| 5800                 | 35.3                               | 5.27                            | 4.67    | 4.67    | 4.67    | 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:3914

### 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                            | 9.53    | 9.53    | 9.53    | 0.33               | 1.09                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 9.49    | 9.49    | 9.49    | 0.27               | 1.25                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 7.78    | 7.78    | 7.78    | 0.51               | 0.79                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 7.49    | 7.49    | 7.49    | 0.73               | 0.64                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 7.15    | 7.15    | 7.15    | 0.69               | 0.64                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 6.84    | 6.84    | 6.84    | 0.80               | 0.57                    | ± 12.0 %    |
| 5200                 | 49.0                               | 5.30                            | 4.50    | 4.50    | 4.50    | 0.45               | 1.90                    | ± 13.1 %    |
| 5300                 | 48.9                               | 5.42                            | 4.33    | 4.33    | 4.33    | 0.45               | 1.90                    | ± 13.1 %    |
| 5500                 | 48.6                               | 5.65                            | 3.91    | 3.91    | 3.91    | 0.50               | 1.90                    | ± 13.1 %    |
| 5600                 | 48.5                               | 5.77                            | 3.89    | 3.89    | 3.89    | 0.50               | 1.90                    | ± 13.1 %    |
| 5800                 | 48.2                               | 6.00                            | 4.01    | 4.01    | 4.01    | 0.55               | 1.90                    | ± 13.1 %    |

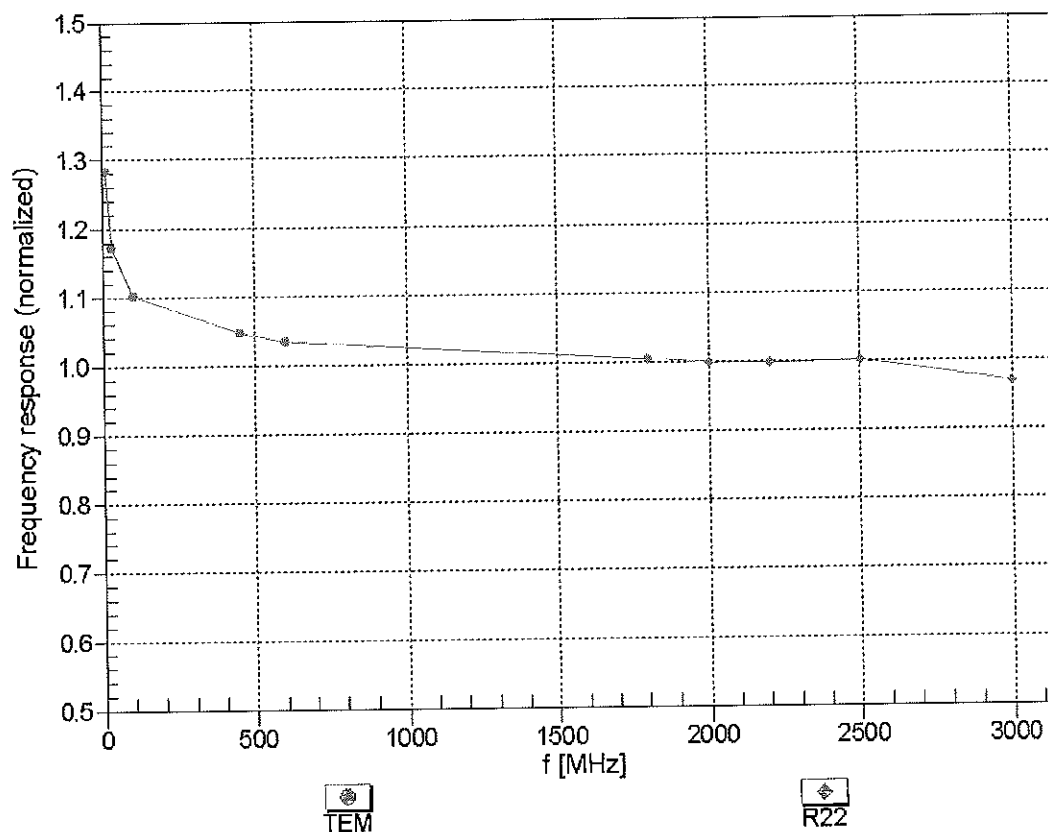
<sup>C</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 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

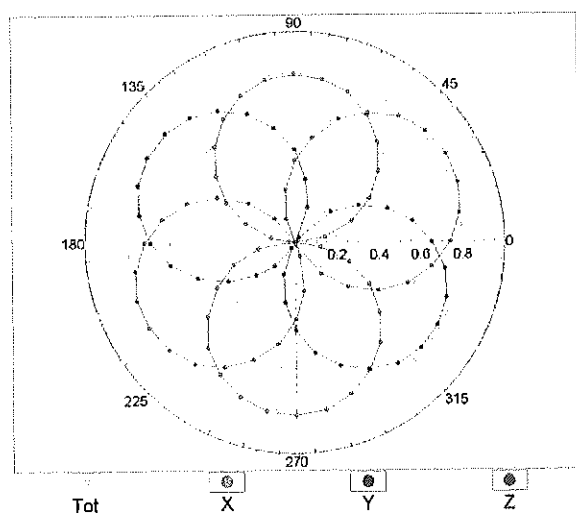
(TEM-Cell:ifi110 EXX, Waveguide: R22)



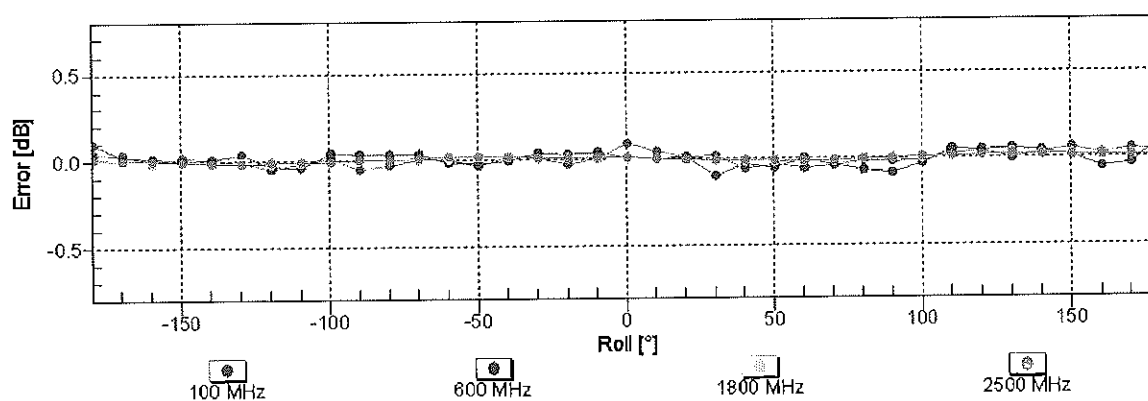
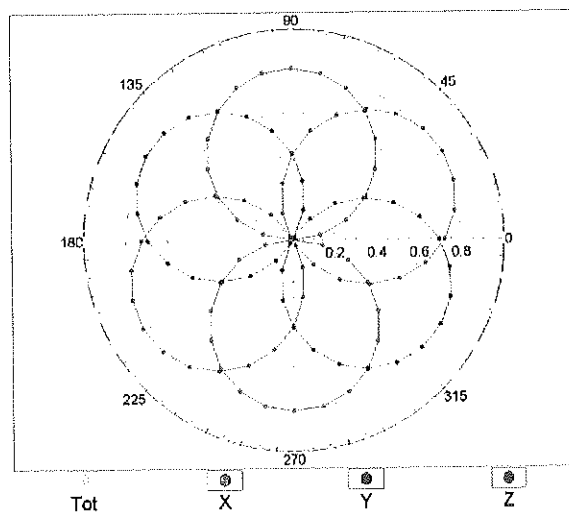
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

$f=600$  MHz, TEM

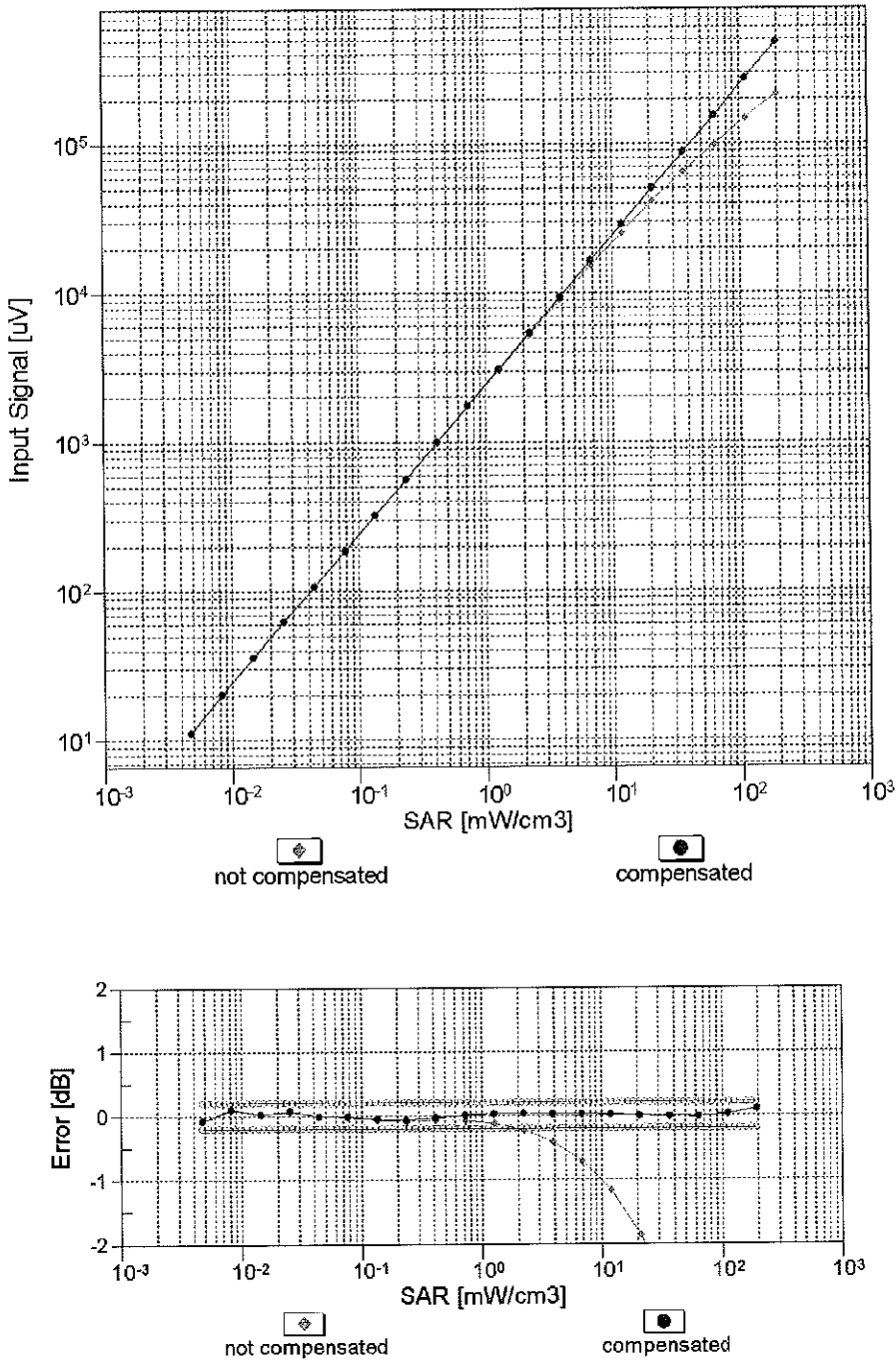


$f=1800$  MHz, R22



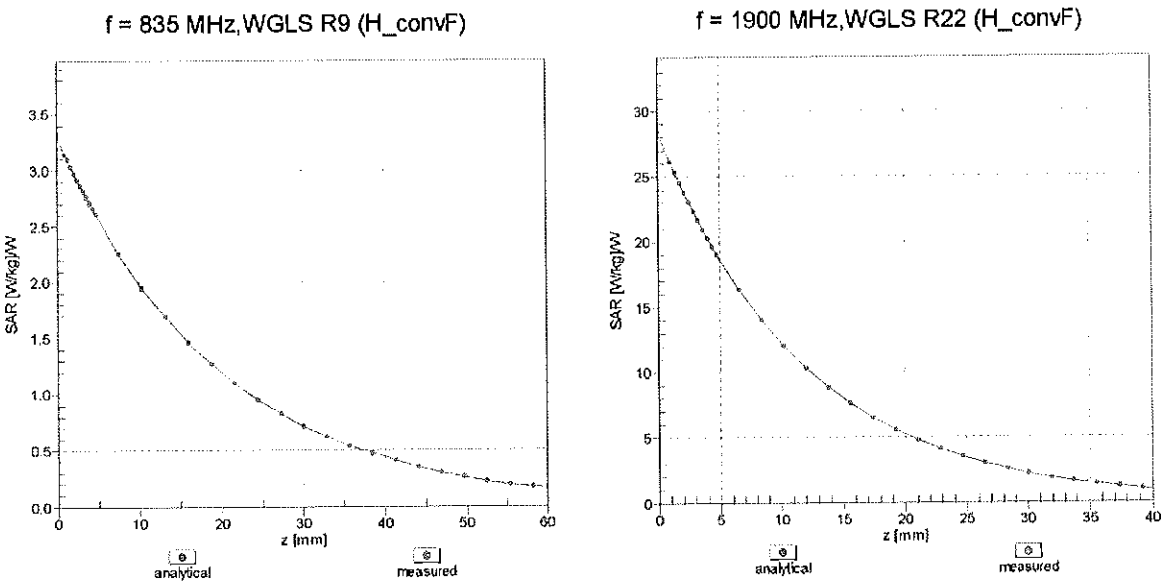
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

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



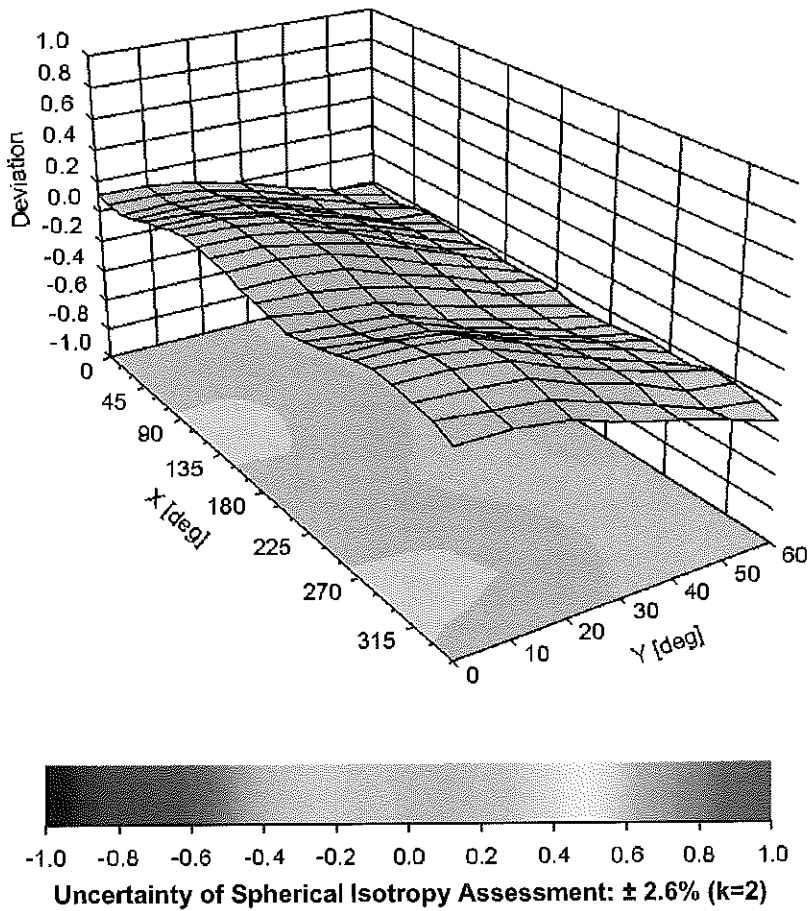
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

# Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3914****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | -49.5      |
| 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     |





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D750V3-1054\_Mar15**

## CALIBRATION CERTIFICATE

Object **D750V3 - SN:1054**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

CC v  
 3/26/15

Calibration date: **March 11, 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 EPM-442A        | GB37480704         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | US37292783         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-14 (No. 217-02021)         | Oct-15                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-14 (No. ES3-3205_Dec14)    | Dec-15                 |
| DAE4                        | SN: 601            | 18-Aug-14 (No. DAE4-601_Aug14)    | Aug-15                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

Calibrated by: **Michael Weber** **Laboratory Technician**

Signature

*M. Weber*

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

*Katja Pokovic*

Issued: March 11, 2015

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Accreditation No.: **SCS 0108**

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Multilateral Agreement for the recognition of calibration certificates

**Glossary:**

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

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

- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                                     |                        |             |
|-------------------------------------|------------------------|-------------|
| <b>DASY Version</b>                 | DASY5                  | V52.8.8     |
| <b>Extrapolation</b>                | Advanced Extrapolation |             |
| <b>Phantom</b>                      | Modular Flat Phantom   |             |
| <b>Distance Dipole Center - TSL</b> | 15 mm                  | with Spacer |
| <b>Zoom Scan Resolution</b>         | dx, dy, dz = 5 mm      |             |
| <b>Frequency</b>                    | 750 MHz $\pm$ 1 MHz    |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                                | <b>Temperature</b>  | <b>Permittivity</b> | <b>Conductivity</b>  |
|------------------------------------------------|---------------------|---------------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 41.9                | 0.89 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 40.8 $\pm$ 6 %      | 0.90 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----                | ----                 |

## SAR result with Head TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
| SAR measured                                                | 250 mW input power | 2.10 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>8.28 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
| SAR measured                                                  | 250 mW input power | 1.37 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>5.42 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

## Body TSL parameters

The following parameters and calculations were applied.

|                                                | <b>Temperature</b>  | <b>Permittivity</b> | <b>Conductivity</b>  |
|------------------------------------------------|---------------------|---------------------|----------------------|
| <b>Nominal Body TSL parameters</b>             | 22.0 °C             | 55.5                | 0.96 mho/m           |
| <b>Measured Body TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 54.7 $\pm$ 6 %      | 0.99 mho/m $\pm$ 6 % |
| <b>Body TSL temperature change during test</b> | < 0.5 °C            | ----                | ----                 |

## SAR result with Body TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b> | Condition          |                                                |
| SAR measured                                                | 250 mW input power | 2.19 W/kg                                      |
| SAR for nominal Body TSL parameters                         | normalized to 1W   | <b>8.53 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b> | condition          |                                                |
| SAR measured                                                  | 250 mW input power | 1.45 W/kg                                      |
| SAR for nominal Body TSL parameters                           | normalized to 1W   | <b>5.68 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 54.8 $\Omega$ - 0.6 j $\Omega$ |
| Return Loss                          | - 26.7 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 48.8 $\Omega$ - 2.6 j $\Omega$ |
| Return Loss                          | - 30.6 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.033 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |                   |
|-----------------|-------------------|
| Manufactured by | SPEAG             |
| Manufactured on | November 08, 2011 |

## DASY5 Validation Report for Head TSL

Date: 11.03.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1054**

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.9$  S/m;  $\epsilon_r = 40.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.44, 6.44, 6.44); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### **Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**

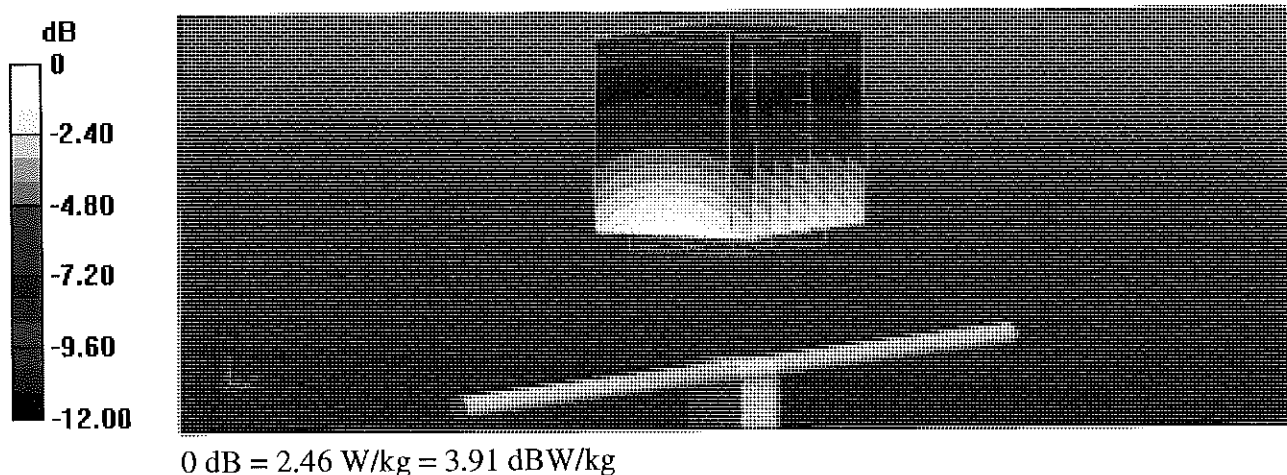
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 54.06 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.16 W/kg

**SAR(1 g) = 2.1 W/kg; SAR(10 g) = 1.37 W/kg**

Maximum value of SAR (measured) = 2.46 W/kg



# Impedance Measurement Plot for Head TSL

11 Mar 2015 12:42:05  
 CH1 S11 1 U FS 1: 54.844  $\Omega$  -552.73 m $\Omega$  383.92 pF 750.000 000 MHz

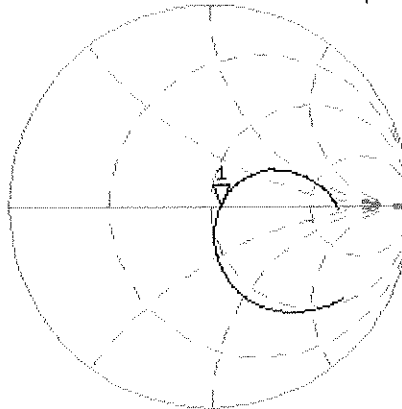
\*

Del

CA

Avg  
16

H1d



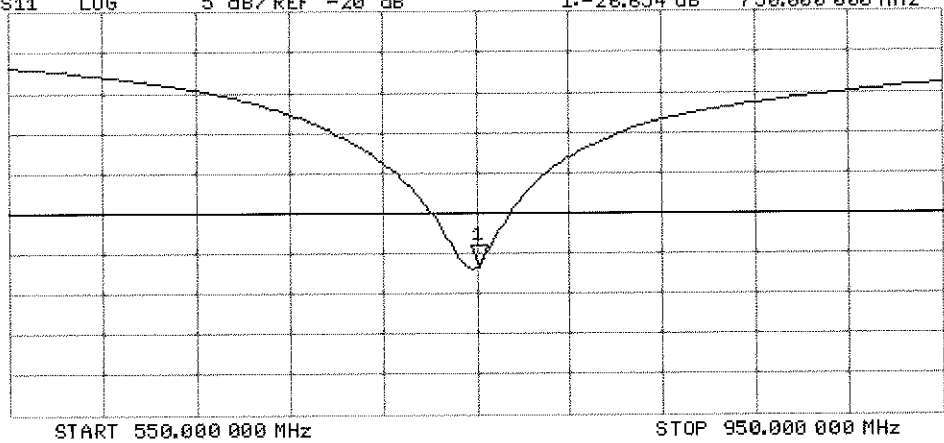
CH2 S11 LOG 5 dB/REF -20 dB 1:-26.654 dB 750.000 000 MHz

Del

CA

Avg  
16

H1d



## DASY5 Validation Report for Body TSL

Date: 11.03.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1054**

Communication System: UID 0 - CW; Frequency: 750 MHz

Medium parameters used:  $f = 750 \text{ MHz}$ ;  $\sigma = 0.99 \text{ S/m}$ ;  $\epsilon_r = 54.7$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.21, 6.21, 6.21); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### **Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**

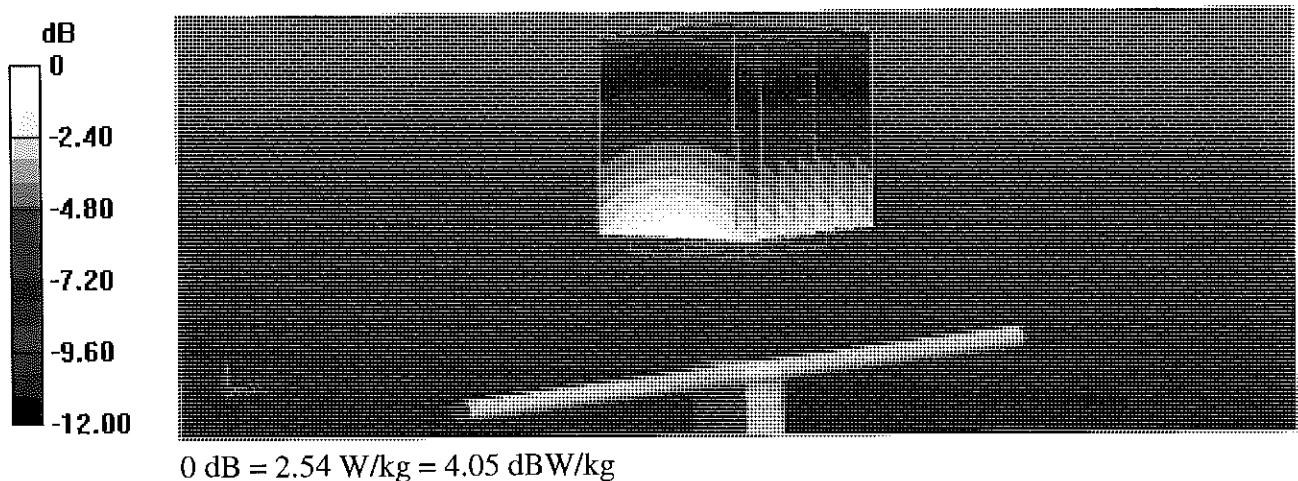
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 52.35 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 3.20 W/kg

**SAR(1 g) = 2.19 W/kg; SAR(10 g) = 1.45 W/kg**

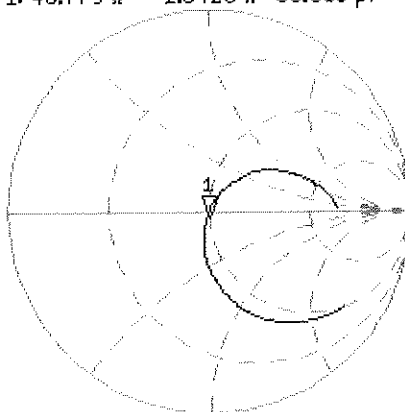
Maximum value of SAR (measured) = 2.54 W/kg



# Impedance Measurement Plot for Body TSL

CH1 S11 1 U FS 1: 48.779  $\Omega$  -2.6426  $\Omega$  80.303 pF 11 Mar 2015 11:49:08 750.000 000 MHz

\*  
De1  
CA



Avg  
16

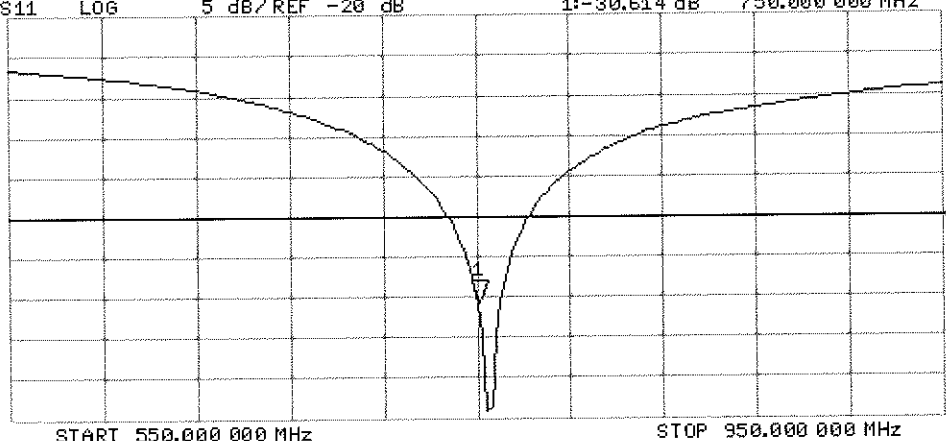
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -30.614 dB 750.000 000 MHz

De1  
CA

Avg  
16

H1d







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Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D835V2-4d132\_Jan15**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN: 4d132**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

CC  
 2/3/15

Calibration date: **January 16, 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 EPM-442A        | GB37480704         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | US37292783         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-14 (No. 217-02021)         | Oct-15                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-14 (No. ES3-3205_Dec14)    | Dec-15                 |
| DAE4                        | SN: 601            | 18-Aug-14 (No. DAE4-601_Aug14)    | Aug-15                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

Calibrated by: **Michael Weber** Function: **Laboratory Technician**

Signature

Approved by: **Katja Pokovic** Technical Manager

Issued: January 19, 2015

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Accreditation No.: **SCS 0108**

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**Glossary:**

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

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

- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                              |                        |             |
|------------------------------|------------------------|-------------|
| DASY Version                 | DASY5                  | V52.8.8     |
| Extrapolation                | Advanced Extrapolation |             |
| Phantom                      | Modular Flat Phantom   |             |
| Distance Dipole Center - TSL | 15 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm      |             |
| Frequency                    | 835 MHz $\pm$ 1 MHz    |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 41.5           | 0.90 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 41.5 $\pm$ 6 % | 0.93 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 2.37 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 9.25 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 1.54 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 6.04 W/kg $\pm$ 16.5 % (k=2) |

## Body TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Body TSL parameters             | 22.0 °C             | 55.2           | 0.97 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 55.8 $\pm$ 6 % | 1.01 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 2.35 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 9.14 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 1.53 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 5.98 W/kg $\pm$ 16.5 % (k=2) |

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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 51.8 $\Omega$ - 2.3 j $\Omega$ |
| Return Loss                          | - 30.8 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 47.5 $\Omega$ - 4.3 j $\Omega$ |
| Return Loss                          | - 25.9 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.385 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |               |
|-----------------|---------------|
| Manufactured by | SPEAG         |
| Manufactured on | July 22, 2011 |

## DASY5 Validation Report for Head TSL

Date: 16.01.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d132**

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 0.93 \text{ S/m}$ ;  $\epsilon_r = 41.5$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.2, 6.2, 6.2); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**

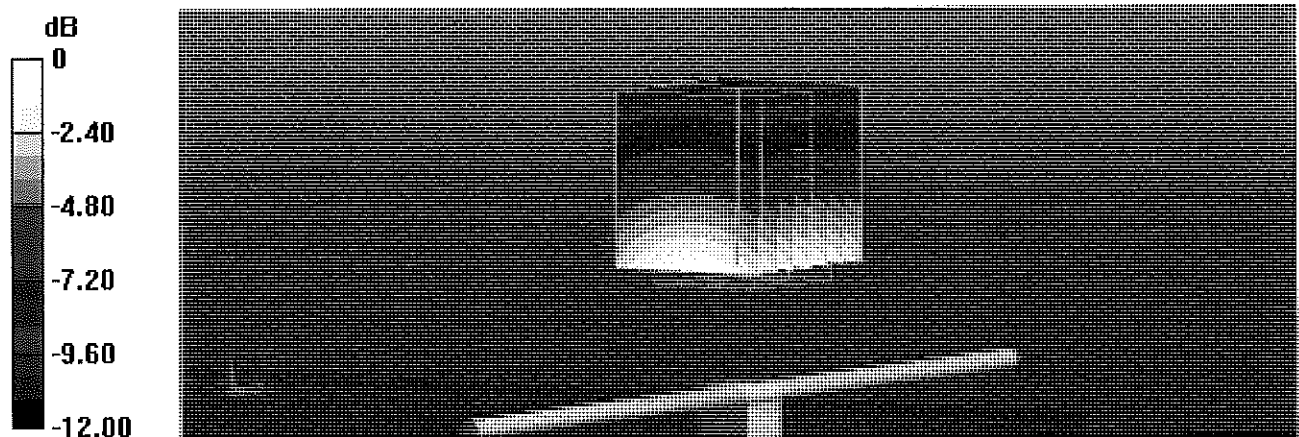
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 56.27 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 3.51 W/kg

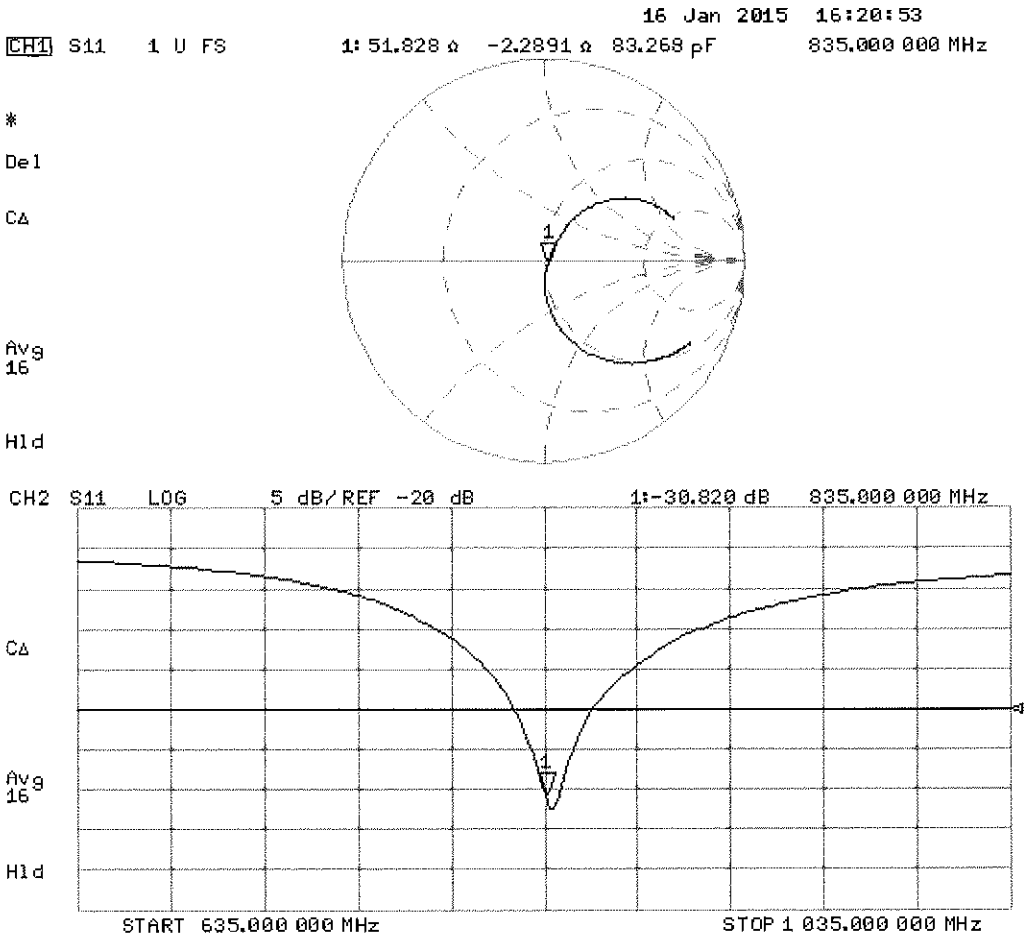
**SAR(1 g) = 2.37 W/kg; SAR(10 g) = 1.54 W/kg**

Maximum value of SAR (measured) = 2.77 W/kg



0 dB = 2.77 W/kg = 4.42 dBW/kg

Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 16.01.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d132**

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 1.01 \text{ S/m}$ ;  $\epsilon_r = 55.8$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.17, 6.17, 6.17); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### **Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**

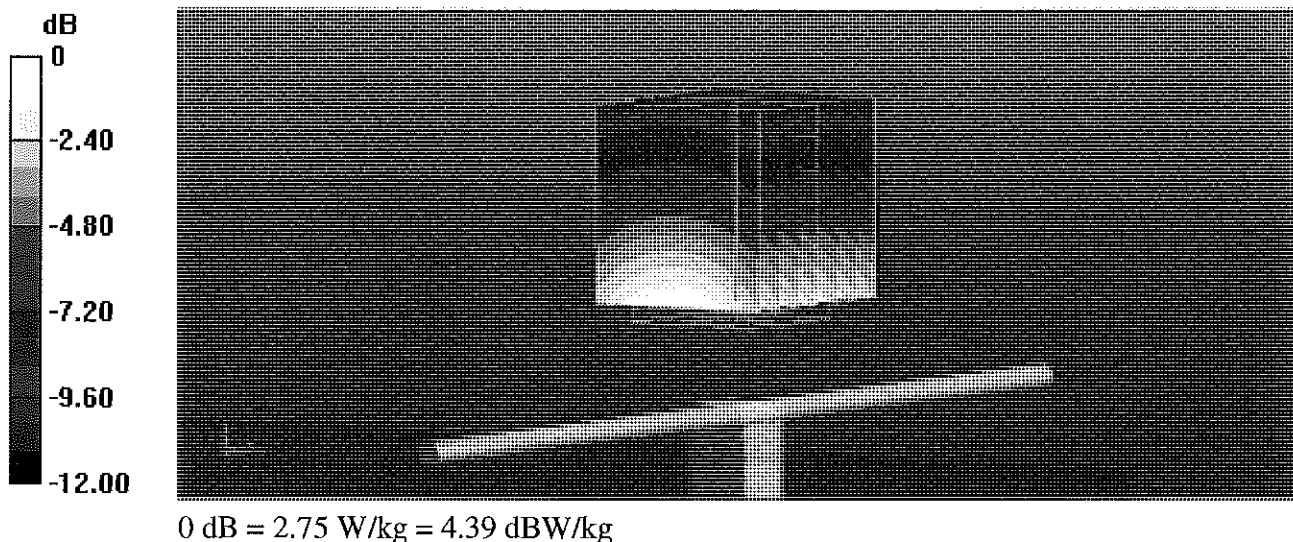
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 54.27 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 3.47 W/kg

**SAR(1 g) = 2.35 W/kg; SAR(10 g) = 1.53 W/kg**

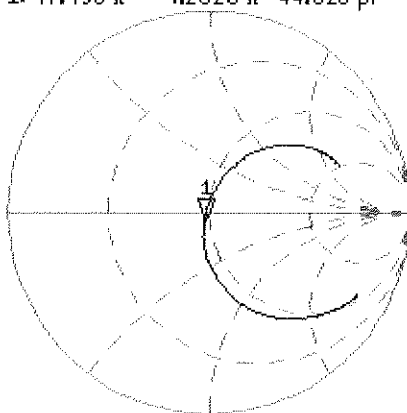
Maximum value of SAR (measured) = 2.75 W/kg



## Impedance Measurement Plot for Body TSL

16 Jan 2015 13:51:19  
CH1 S11 1 U FS 1: 47.498  $\Omega$  -4.2520  $\Omega$  44.828 pF 835.000 000 MHz

\*  
De1  
CA



Avg  
16

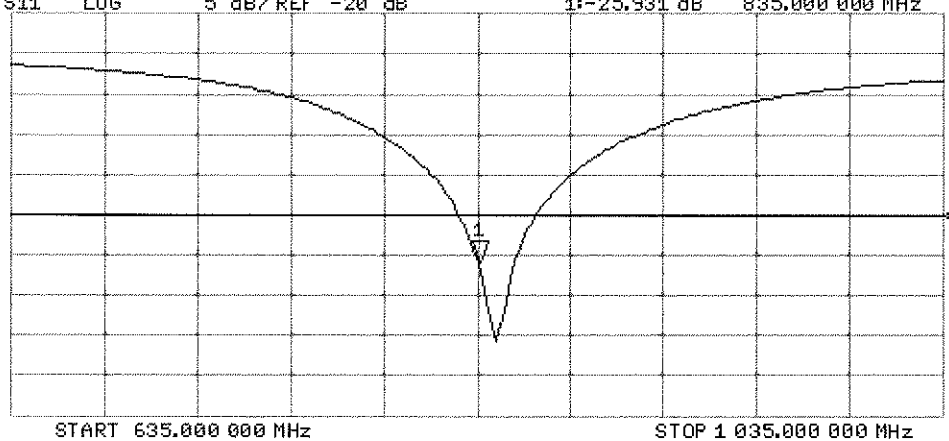
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-25.931 dB 835.000 000 MHz

CA

Avg  
16

H1d







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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D835V2-4d133\_Jul14**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN: 4d133**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

CC  
W/CM

Calibration date: **July 24, 2014**

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 EPM-442A        | GB37480704         | 09-Oct-13 (No. 217-01827)      | Oct-14                |
| Power sensor HP 8481A       | US37292783         | 09-Oct-13 (No. 217-01827)      | Oct-14                |
| Power sensor HP 8481A       | MY41092317         | 09-Oct-13 (No. 217-01828)      | Oct-14                |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)      | Apr-15                |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)      | Apr-15                |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-13 (No. ES3-3205_Dec13) | Dec-14                |
| DAE4                        | SN: 601            | 30-Apr-14 (No. DAE4-601_Apr14) | Apr-15                |

| Secondary Standards       | ID #             | Check Date (in house)             | Scheduled Check        |
|---------------------------|------------------|-----------------------------------|------------------------|
| RF generator R&S SMT-06   | 100005           | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8763E | US37390585 S4206 | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

Calibrated by: **Name** **Function**  
**Jeton Kastrali** **Laboratory Technician**

Signature

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

Issued: July 24, 2014

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

**Glossary:**

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

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

- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                              |                        |             |
|------------------------------|------------------------|-------------|
| DASY Version                 | DASY5                  | V52.8.8     |
| Extrapolation                | Advanced Extrapolation |             |
| Phantom                      | Modular Flat Phantom   |             |
| Distance Dipole Center - TSL | 15 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm      |             |
| Frequency                    | 835 MHz $\pm$ 1 MHz    |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 41.5           | 0.90 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 41.1 $\pm$ 6 % | 0.94 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 2.38 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 9.20 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 1.53 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 5.96 W/kg $\pm$ 16.5 % (k=2) |

## Body TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Body TSL parameters             | 22.0 °C             | 55.2           | 0.97 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 53.8 $\pm$ 6 % | 1.02 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 2.44 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 9.35 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 1.59 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 6.15 W/kg $\pm$ 16.5 % (k=2) |

## Appendix (Additional assessments outside the scope of SCS108)

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 51.6 $\Omega$ - 1.0 j $\Omega$ |
| Return Loss                          | - 34.7 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 47.8 $\Omega$ - 3.3 j $\Omega$ |
| Return Loss                          | - 27.8 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.395 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |               |
|-----------------|---------------|
| Manufactured by | SPEAG         |
| Manufactured on | July 22, 2011 |

## DASY5 Validation Report for Head TSL

Date: 24.07.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d133**

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 0.94 \text{ S/m}$ ;  $\epsilon_r = 41.1$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.22, 6.22, 6.22); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Head Tissue/Pin=250 mW,  $d=15\text{mm}$ /Zoom Scan (7x7x7)/Cube 0:**

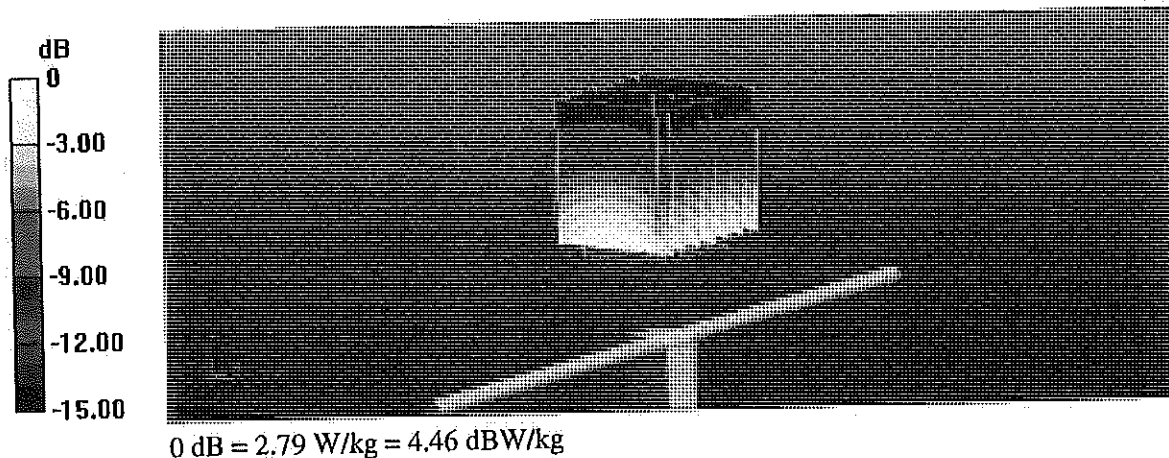
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 56.07 V/m; Power Drift = 0.03 dB

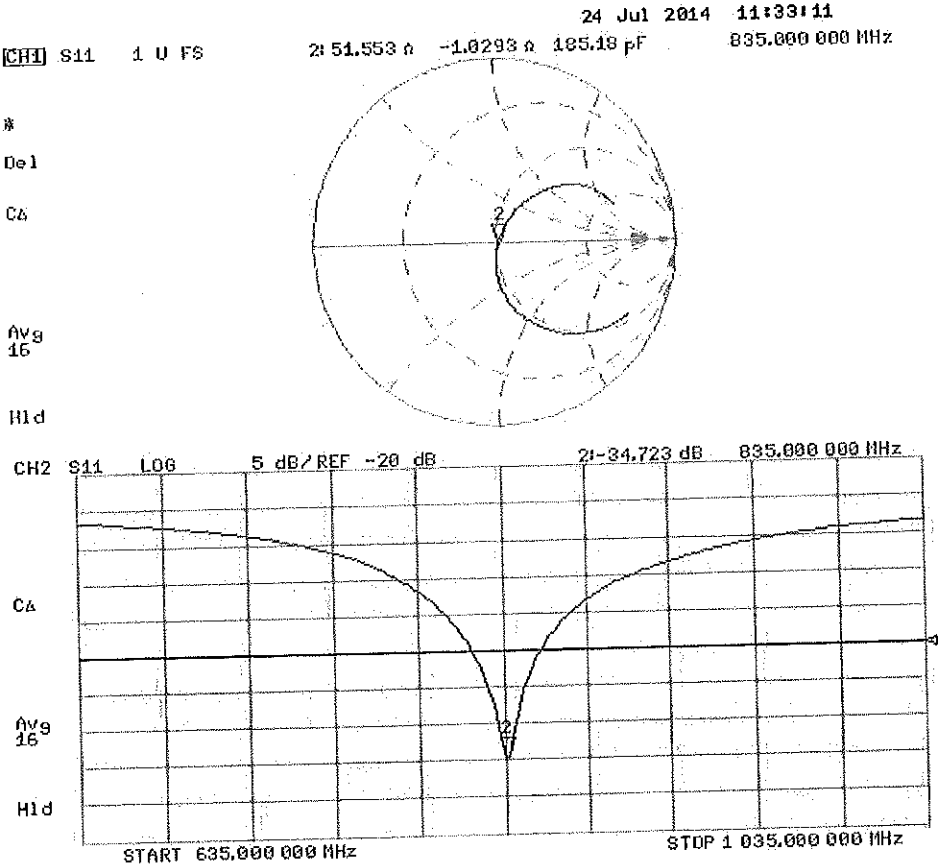
Peak SAR (extrapolated) = 3.58 W/kg

**SAR(1 g) = 2.38 W/kg; SAR(10 g) = 1.53 W/kg**

Maximum value of SAR (measured) = 2.79 W/kg



Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 17.07.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d133**

Communication System: UID 0 - CW; Frequency: 835 MHz

Medium parameters used:  $f = 835$  MHz;  $\sigma = 1.02$  S/m;  $\epsilon_r = 53.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

### DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.09, 6.09, 6.09); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### Dipole Calibration for Body Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

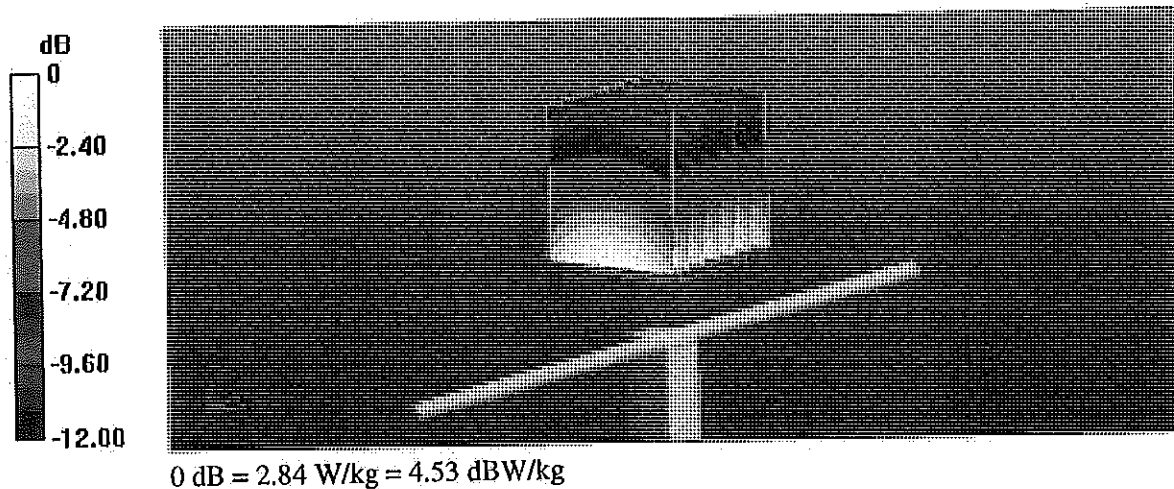
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 54.61 V/m; Power Drift = -0.01 dB

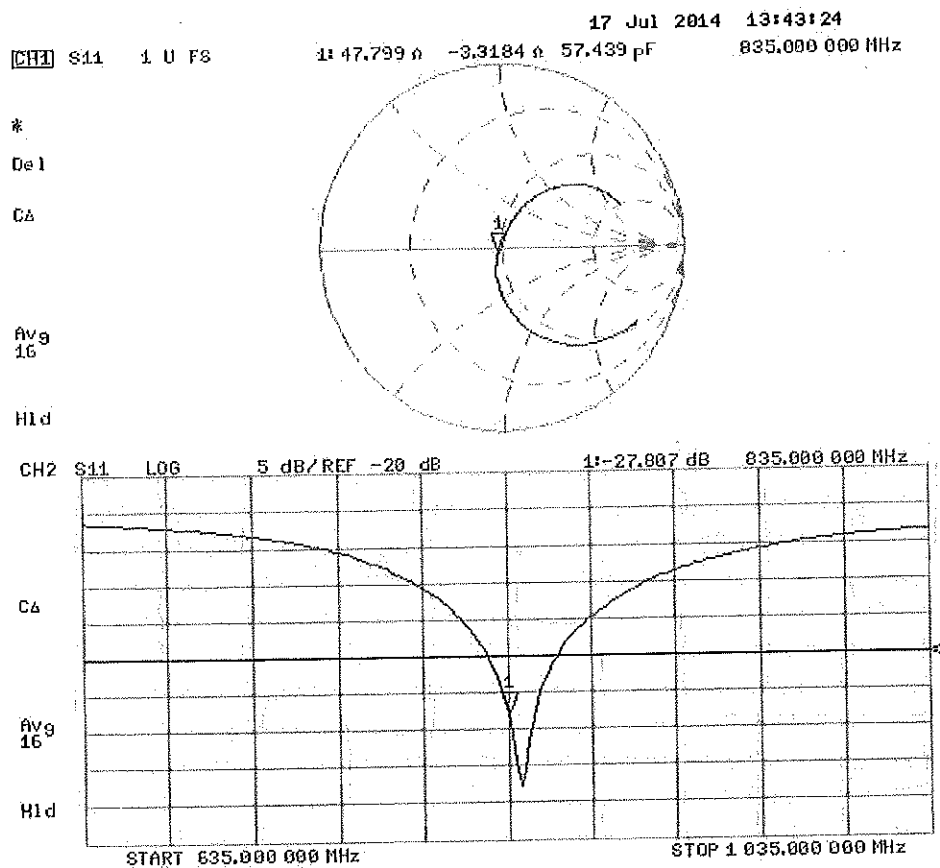
Peak SAR (extrapolated) = 3.59 W/kg

**SAR(1 g) = 2.44 W/kg; SAR(10 g) = 1.59 W/kg**

Maximum value of SAR (measured) = 2.84 W/kg



# Impedance Measurement Plot for Body TSL







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Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D1765V2-1008\_May14**

## CALIBRATION CERTIFICATE

Object **D1765V2 - SN: 1008**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

CCV  
 6/2/14

Calibration date: **May 07, 2014**

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 EPM-442A        | GB37480704         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | US37292783         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | MY41092317         | 09-Oct-13 (No. 217-01828)         | Oct-14                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-13 (No. ES3-3205_Dec13)    | Dec-14                 |
| DAE4                        | SN: 601            | 30-Apr-14 (No. DAE4-601_Apr14)    | Apr-15                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

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

Issued: May 12, 2014

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Accreditation No.: **SCS 108**

#### **Glossary:**

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

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

- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### **Additional Documentation:**

- DASY4/5 System Handbook

#### **Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                                     |                        |             |
|-------------------------------------|------------------------|-------------|
| <b>DASY Version</b>                 | DASY5                  | V52.8.8     |
| <b>Extrapolation</b>                | Advanced Extrapolation |             |
| <b>Phantom</b>                      | Modular Flat Phantom   |             |
| <b>Distance Dipole Center - TSL</b> | 10 mm                  | with Spacer |
| <b>Zoom Scan Resolution</b>         | dx, dy, dz = 5 mm      |             |
| <b>Frequency</b>                    | 1750 MHz $\pm$ 1 MHz   |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                                | <b>Temperature</b>  | <b>Permittivity</b> | <b>Conductivity</b>  |
|------------------------------------------------|---------------------|---------------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 40.1                | 1.37 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 39.0 $\pm$ 6 %      | 1.36 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----                | ----                 |

## SAR result with Head TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
| SAR measured                                                | 250 mW input power | 9.23 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>36.9 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
| SAR measured                                                  | 250 mW input power | 4.87 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>19.5 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

## Body TSL parameters

The following parameters and calculations were applied.

|                                                | <b>Temperature</b>  | <b>Permittivity</b> | <b>Conductivity</b>  |
|------------------------------------------------|---------------------|---------------------|----------------------|
| <b>Nominal Body TSL parameters</b>             | 22.0 °C             | 53.4                | 1.49 mho/m           |
| <b>Measured Body TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 52.2 $\pm$ 6 %      | 1.48 mho/m $\pm$ 6 % |
| <b>Body TSL temperature change during test</b> | < 0.5 °C            | ----                | ----                 |

## SAR result with Body TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b> | Condition          |                                                |
| SAR measured                                                | 250 mW input power | 9.41 W/kg                                      |
| SAR for nominal Body TSL parameters                         | normalized to 1W   | <b>37.6 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b> | condition          |                                                |
| SAR measured                                                  | 250 mW input power | 5.02 W/kg                                      |
| SAR for nominal Body TSL parameters                           | normalized to 1W   | <b>20.1 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

## Appendix

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 47.7 $\Omega$ - 6.1 j $\Omega$ |
| Return Loss                          | - 23.6 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 43.7 $\Omega$ - 6.4 j $\Omega$ |
| Return Loss                          | - 20.4 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.211 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |                  |
|-----------------|------------------|
| Manufactured by | SPEAG            |
| Manufactured on | October 06, 2005 |

## DASY5 Validation Report for Head TSL

Date: 07.05.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1765 MHz; Type: D1765V2; Serial: D1765V2 - SN: 1008**

Communication System: UID 0 - CW; Frequency: 1750 MHz

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.36$  S/m;  $\epsilon_r = 39$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5.23, 5.23, 5.23); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

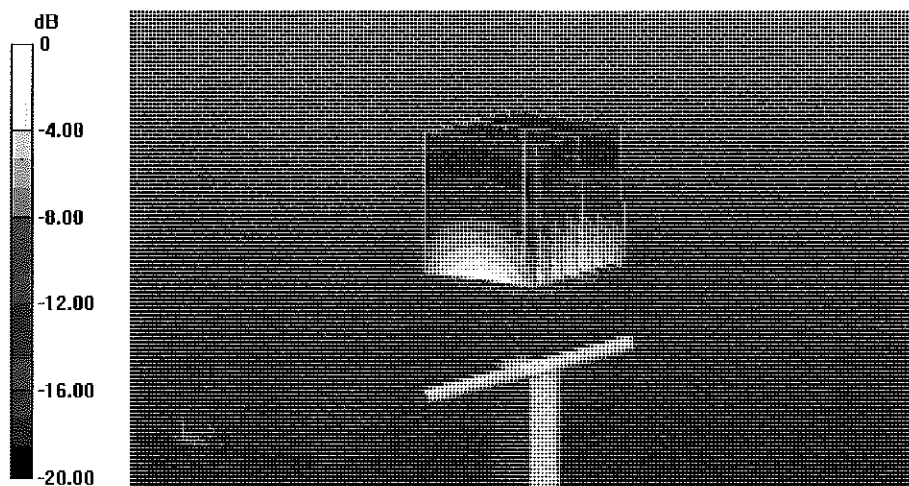
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 96.06 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 16.7 W/kg

**SAR(1 g) = 9.23 W/kg; SAR(10 g) = 4.87 W/kg**

Maximum value of SAR (measured) = 11.7 W/kg

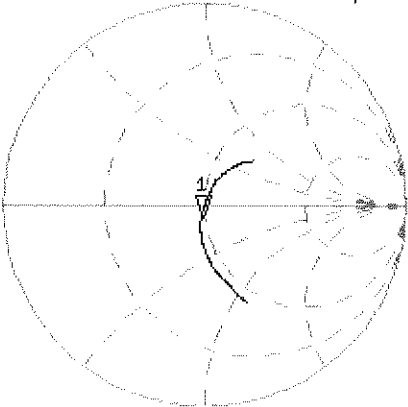


0 dB = 11.7 W/kg = 10.68 dBW/kg

Impedance Measurement Plot for Head TSL

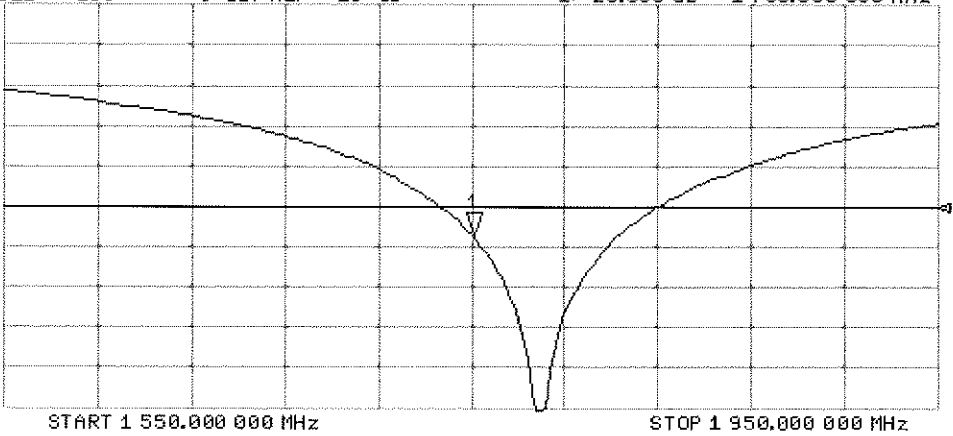
7 May 2014 09:22:36  
[CH1] S11 1 U FS 1: 47.709  $\Omega$  -6.0566  $\Omega$  15.016 pF 1 750.000 000 MHz

\*  
De1  
CA  
Avg  
16  
H1d



CH2 S11 LOG 5 dB/REF -20 dB 1:-23.588 dB 1 750.000 000 MHz

CA  
Avg  
16  
H1d



## DASY5 Validation Report for Body TSL

Date: 07.05.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1765 MHz; Type: D1765V2; Serial: D1765V2 - SN: 1008**

Communication System: UID 0 - CW; Frequency: 1750 MHz

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.48$  S/m;  $\epsilon_r = 52.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.89, 4.89, 4.89); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

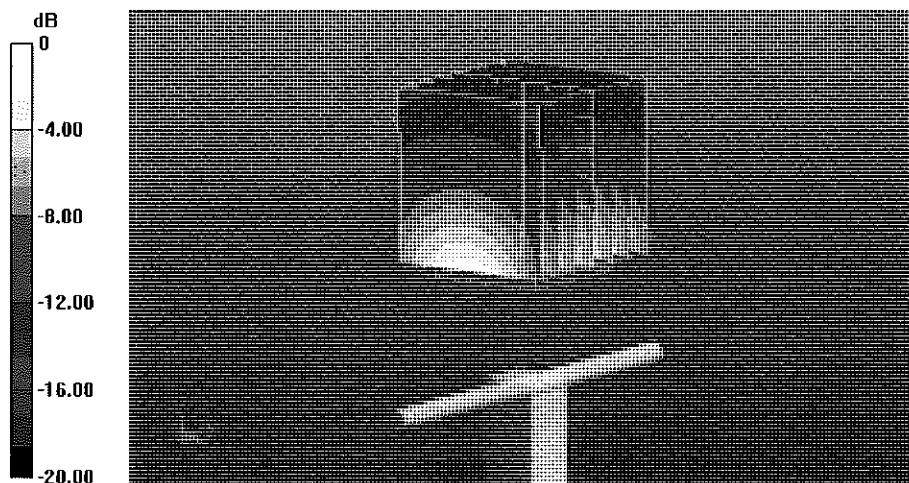
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.01 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 16.3 W/kg

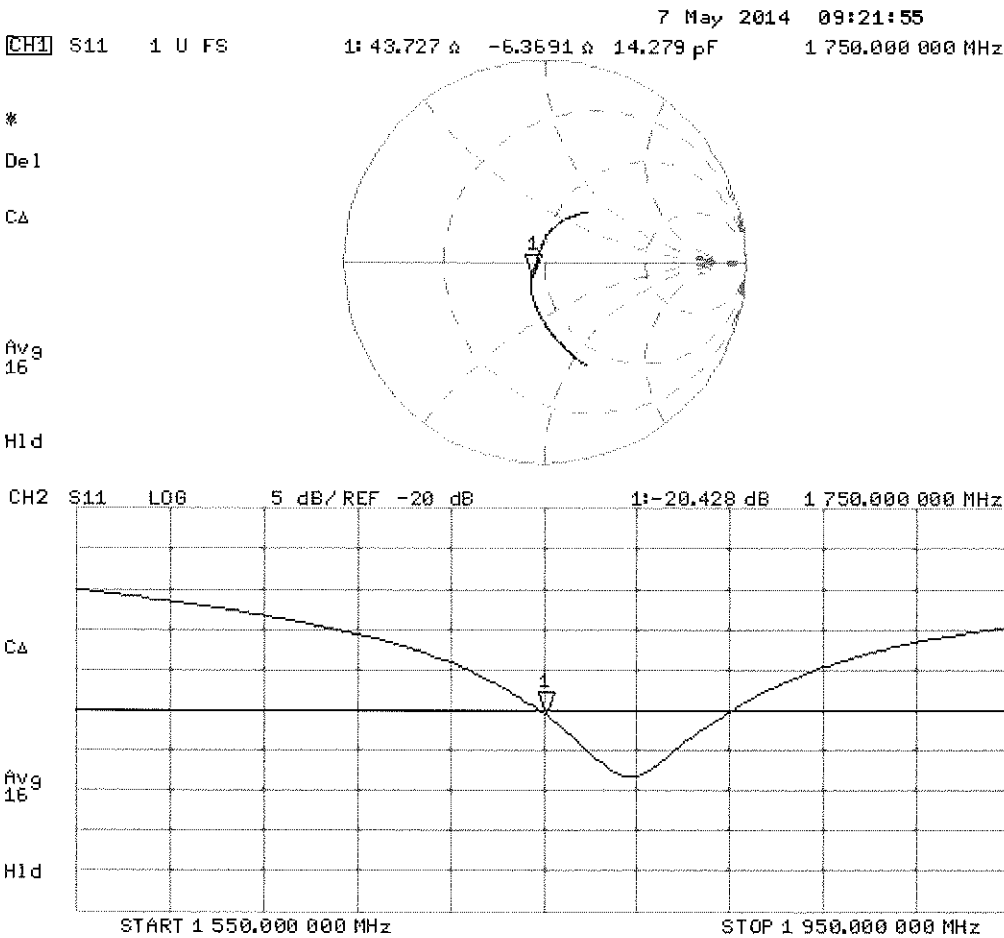
**SAR(1 g) = 9.41 W/kg; SAR(10 g) = 5.02 W/kg**

Maximum value of SAR (measured) = 11.8 W/kg



0 dB = 11.8 W/kg = 10.72 dBW/kg

Impedance Measurement Plot for Body TSL







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 108**

Client **PC Test**

Certificate No: **D1900V2-5d149\_Jul14**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN: 5d149**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

CC  
 11/5/14

Calibration date: **July 23, 2014**

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 EPM-442A        | GB37480704         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | US37292783         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | MY41092317         | 09-Oct-13 (No. 217-01828)         | Oct-14                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-13 (No. ES3-3205_Dec13)    | Dec-14                 |
| DAE4                        | SN: 601            | 30-Apr-14 (No. DAE4-601_Apr14)    | Apr-15                 |
| Secondary Standards         | ID #               | Check Date (In house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (In house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (In house check Oct-13) | In house check: Oct-14 |

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

Issued: July 23, 2014

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



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

Accreditation No.: **SCS 108**

**Glossary:**

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

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

- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                              |                        |             |
|------------------------------|------------------------|-------------|
| DASY Version                 | DASY5                  | V52.8.8     |
| Extrapolation                | Advanced Extrapolation |             |
| Phantom                      | Modular Flat Phantom   |             |
| Distance Dipole Center - TSL | 10 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm      |             |
| Frequency                    | 1900 MHz $\pm$ 1 MHz   |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 40.0           | 1.40 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 39.5 $\pm$ 6 % | 1.38 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 10.0 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 40.2 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 5.24 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 21.0 W/kg $\pm$ 16.5 % (k=2) |

## Body TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Body TSL parameters             | 22.0 °C             | 53.3           | 1.52 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 52.5 $\pm$ 6 % | 1.51 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 10.1 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 40.4 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 5.33 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 21.3 W/kg $\pm$ 16.5 % (k=2) |

## Appendix (Additional assessments outside the scope of SCS108)

### Antenna Parameters with Head TSL

|                                      |                             |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $52.6 \Omega + 5.5 j\Omega$ |
| Return Loss                          | - 24.6 dB                   |

### Antenna Parameters with Body TSL

|                                      |                             |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $48.8 \Omega + 6.1 j\Omega$ |
| Return Loss                          | - 24.0 dB                   |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.197 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |                |
|-----------------|----------------|
| Manufactured by | SPEAG          |
| Manufactured on | March 11, 2011 |

## DASY5 Validation Report for Head TSL

Date: 23.07.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d149**

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used:  $f = 1900 \text{ MHz}$ ;  $\sigma = 1.38 \text{ S/m}$ ;  $\epsilon_r = 39.5$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5.06, 5.06, 5.06); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 100I
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Head Tissue/Pin=250 mW,  $d=10\text{mm}$ /Zoom Scan (7x7x7)/Cube 0:**

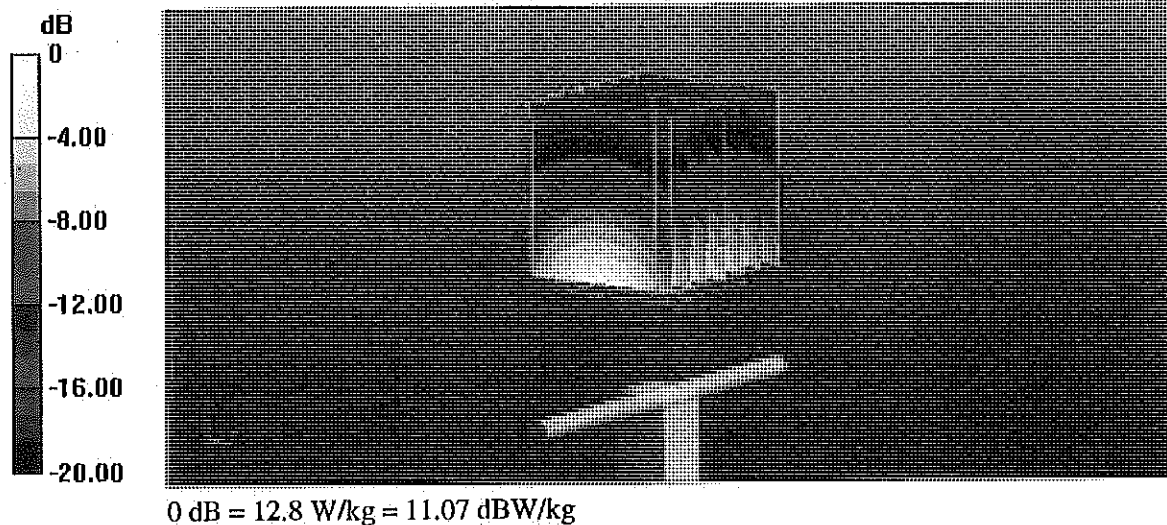
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 98.92 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 18.4 W/kg

**SAR(1 g) = 10 W/kg; SAR(10 g) = 5.24 W/kg**

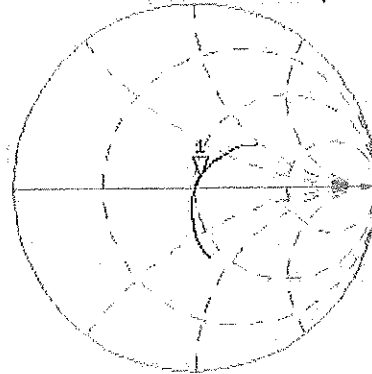
Maximum value of SAR (measured) = 12.8 W/kg



# Impedance Measurement Plot for Head TSL

23 Jul 2014 10:46:05  
 [CH1] S11 1 U FS 1: 52.600  $\Omega$  5.4570  $\Omega$  457.11 pH 1 900.000 000 MHz

\*  
 Del  
 Cor



Avg  
 16

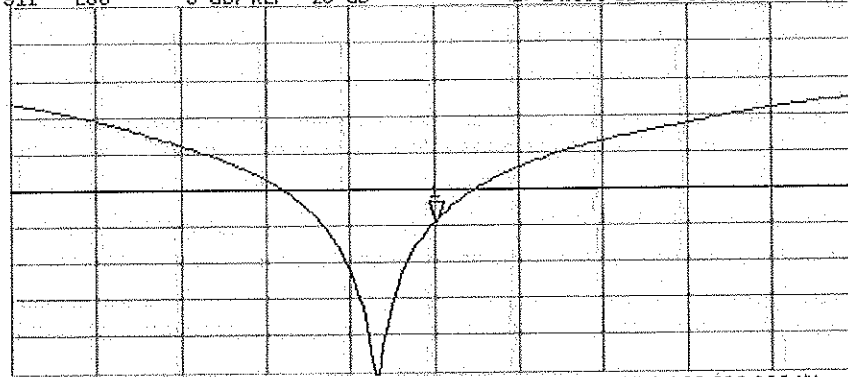
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -24.600 dB 1 900.000 000 MHz

Cor

Avg  
 16

H1d



START 1 700.000 000 MHz

STOP 2 100.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 23.07.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d149**

Communication System: UID 0 - CW; Frequency: 1900 MHz

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.51$  S/m;  $\epsilon_r = 52.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.76, 4.76, 4.76); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

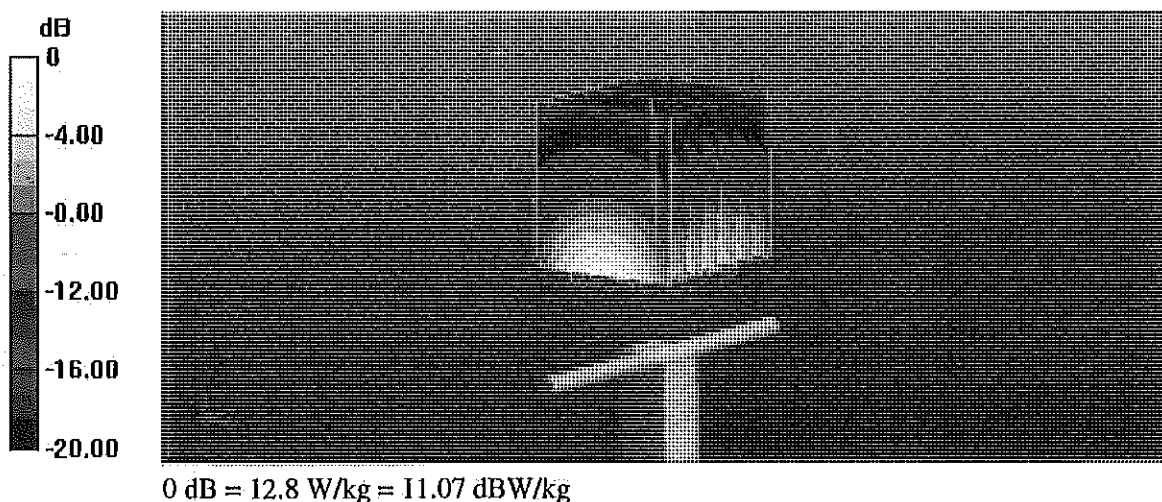
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 95.83 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 17.6 W/kg

**SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.33 W/kg**

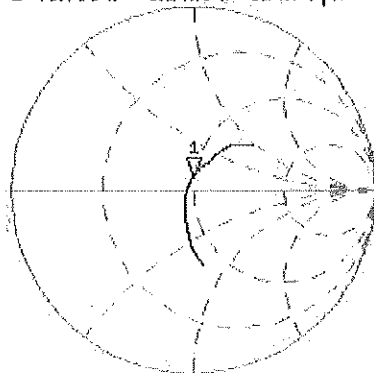
Maximum value of SAR (measured) = 12.8 W/kg



# Impedance Measurement Plot for Body TSL

23 Jul 2014 10:45:45  
 CH1 S11 1 U FS 1: 48.789  $\Omega$  6.1426  $\Omega$  514.54  $\mu\text{H}$  1 900.000 000 MHz

\*  
 Del  
 Cor



Avg  
 16

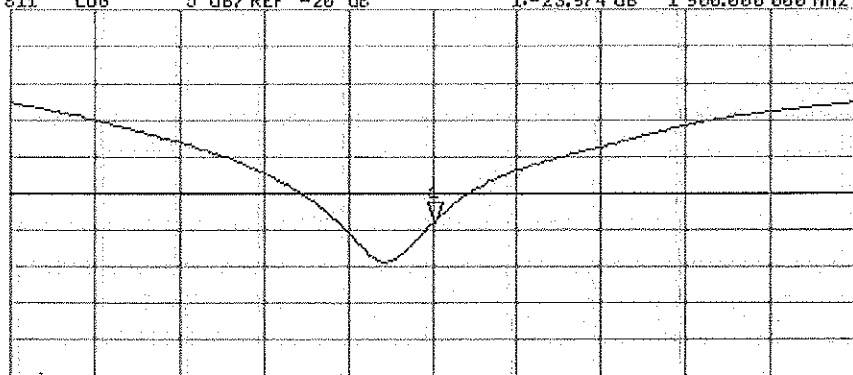
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -23.974 dB 1 900.000 000 MHz

Cor

Avg  
 16

H1d



START 1 700.000 000 MHz

STOP 2 100.000 000 MHz





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D2450V2-719\_Aug14**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 719**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **August 11, 2014**

✓ KOK  
9/8/14

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 EPM-442A        | GB37480704         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | US37292783         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | MY41092317         | 09-Oct-13 (No. 217-01828)         | Oct-14                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-13 (No. ES3-3205_Dec13)    | Dec-14                 |
| DAE4                        | SN: 601            | 30-Apr-14 (No. DAE4-601_Apr14)    | Apr-15                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

Calibrated by: **Michael Weber** Function: **Laboratory Technician**

Signature

*M. Weber*

Approved by: **Katja Pokovic** Technical Manager

*Katja Pokovic*

Issued: August 12, 2014

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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 108**

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

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

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                                     |                        |             |
|-------------------------------------|------------------------|-------------|
| <b>DASY Version</b>                 | DASY5                  | V52.8.8     |
| <b>Extrapolation</b>                | Advanced Extrapolation |             |
| <b>Phantom</b>                      | Modular Flat Phantom   |             |
| <b>Distance Dipole Center - TSL</b> | 10 mm                  | with Spacer |
| <b>Zoom Scan Resolution</b>         | dx, dy, dz = 5 mm      |             |
| <b>Frequency</b>                    | 2450 MHz $\pm$ 1 MHz   |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 39.2           | 1.80 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 38.0 $\pm$ 6 % | 1.82 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                | 250 mW input power | 13.2 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>52.1 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                  | 250 mW input power | 6.09 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>24.2 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

## Body TSL parameters

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Body TSL parameters</b>             | 22.0 °C             | 52.7           | 1.95 mho/m           |
| <b>Measured Body TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 50.5 $\pm$ 6 % | 2.02 mho/m $\pm$ 6 % |
| <b>Body TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b> | Condition          |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                | 250 mW input power | 13.3 W/kg                                      |
| SAR for nominal Body TSL parameters                         | normalized to 1W   | <b>51.8 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b> | condition          |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                  | 250 mW input power | 6.10 W/kg                                      |
| SAR for nominal Body TSL parameters                           | normalized to 1W   | <b>24.0 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

## Appendix (Additional assessments outside the scope of SCS108)

### Antenna Parameters with Head TSL

|                                      |                             |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $54.9 \Omega + 3.0 j\Omega$ |
| Return Loss                          | - 25.2 dB                   |

### Antenna Parameters with Body TSL

|                                      |                             |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $50.9 \Omega + 5.8 j\Omega$ |
| Return Loss                          | - 24.7 dB                   |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.149 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |                    |
|-----------------|--------------------|
| Manufactured by | SPEAG              |
| Manufactured on | September 10, 2002 |

## DASY5 Validation Report for Head TSL

Date: 11.08.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 719**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.82$  S/m;  $\epsilon_r = 38$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

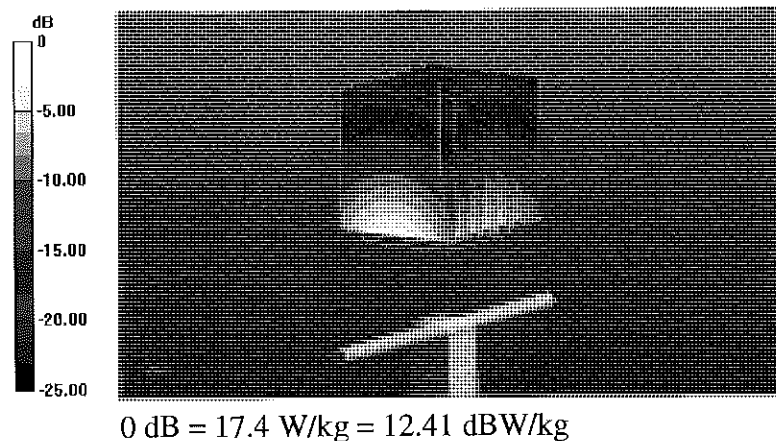
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.6 V/m; Power Drift = 0.03 dB

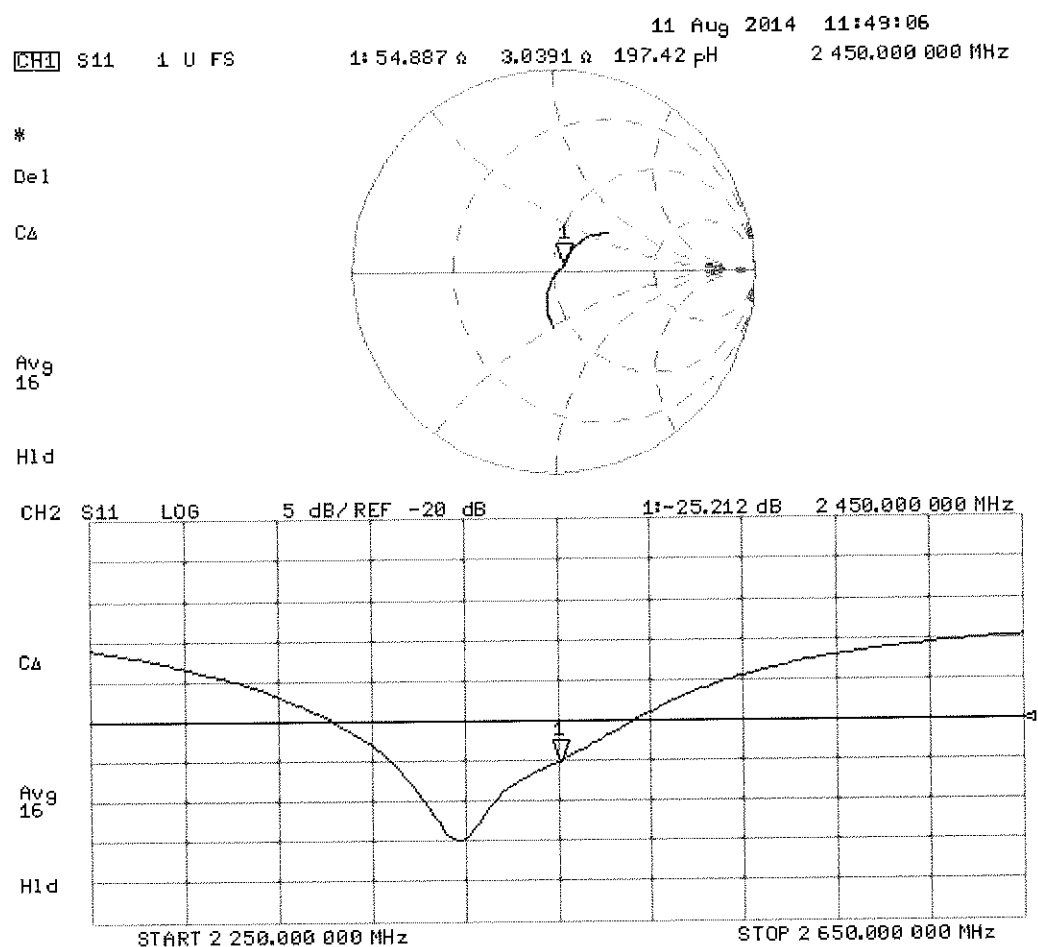
Peak SAR (extrapolated) = 27.5 W/kg

**SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.09 W/kg**

Maximum value of SAR (measured) = 17.4 W/kg



# Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 11.08.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 719**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.02$  S/m;  $\epsilon_r = 50.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

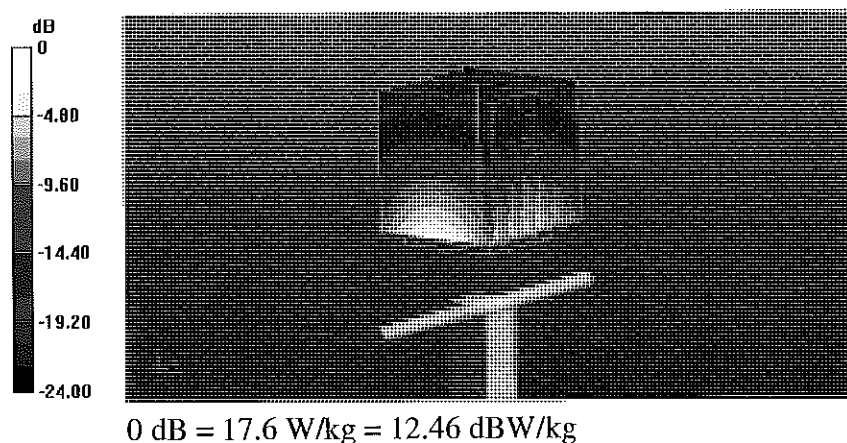
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 96.08 V/m; Power Drift = -0.01 dB

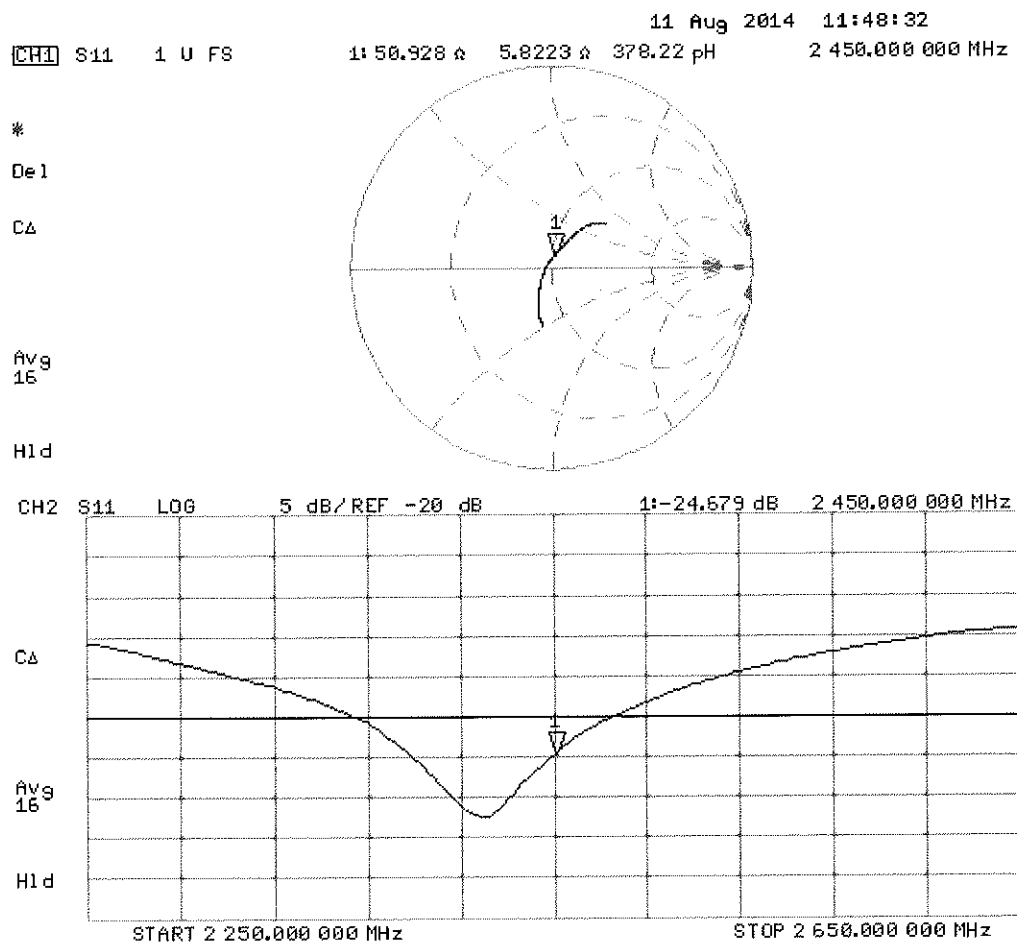
Peak SAR (extrapolated) = 27.9 W/kg

**SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.1 W/kg**

Maximum value of SAR (measured) = 17.6 W/kg



Impedance Measurement Plot for Body TSL







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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D2450V2-882\_Feb15**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN:882**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

PNV  
 3/6/15

Calibration date: **February 18, 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 EPM-442A        | GB37480704         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | US37292783         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-14 (No. 217-02021)         | Oct-15                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-14 (No. ES3-3205_Dec14)    | Dec-15                 |
| DAE4                        | SN: 601            | 18-Aug-14 (No. DAE4-601_Aug14)    | Aug-15                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician

Signature

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

Issued: February 18, 2015

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Accreditation No.: **SCS 0108**

### Glossary:

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

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

- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### Additional Documentation:

- DASY4/5 System Handbook

### Methods Applied and Interpretation of Parameters:

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

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

## Measurement Conditions

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

|                                     |                        |             |
|-------------------------------------|------------------------|-------------|
| <b>DASY Version</b>                 | DASY5                  | V52.8.8     |
| <b>Extrapolation</b>                | Advanced Extrapolation |             |
| <b>Phantom</b>                      | Modular Flat Phantom   |             |
| <b>Distance Dipole Center - TSL</b> | 10 mm                  | with Spacer |
| <b>Zoom Scan Resolution</b>         | dx, dy, dz = 5 mm      |             |
| <b>Frequency</b>                    | 2450 MHz $\pm$ 1 MHz   |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 39.2           | 1.80 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 38.2 $\pm$ 6 % | 1.87 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
| SAR measured                                                | 250 mW input power | 13.4 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>52.3 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
| SAR measured                                                  | 250 mW input power | 6.16 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>24.3 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

## Body TSL parameters

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Body TSL parameters</b>             | 22.0 °C             | 52.7           | 1.95 mho/m           |
| <b>Measured Body TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 51.7 $\pm$ 6 % | 2.04 mho/m $\pm$ 6 % |
| <b>Body TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b> | Condition          |                                                |
| SAR measured                                                | 250 mW input power | 13.0 W/kg                                      |
| SAR for nominal Body TSL parameters                         | normalized to 1W   | <b>50.7 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b> | condition          |                                                |
| SAR measured                                                  | 250 mW input power | 5.97 W/kg                                      |
| SAR for nominal Body TSL parameters                           | normalized to 1W   | <b>23.5 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 52.8 $\Omega$ - 0.2 j $\Omega$ |
| Return Loss                          | - 31.2 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 50.4 $\Omega$ + 1.9 j $\Omega$ |
| Return Loss                          | - 34.4 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.156 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |                  |
|-----------------|------------------|
| Manufactured by | SPEAG            |
| Manufactured on | October 06, 2011 |

## DASY5 Validation Report for Head TSL

Date: 18.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:882**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.87$  S/m;  $\epsilon_r = 38.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.54, 4.54, 4.54); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### Dipole Calibration for Head Tissue - ES Probe/Pin=250 mW, d=10mm/Zoom Scan

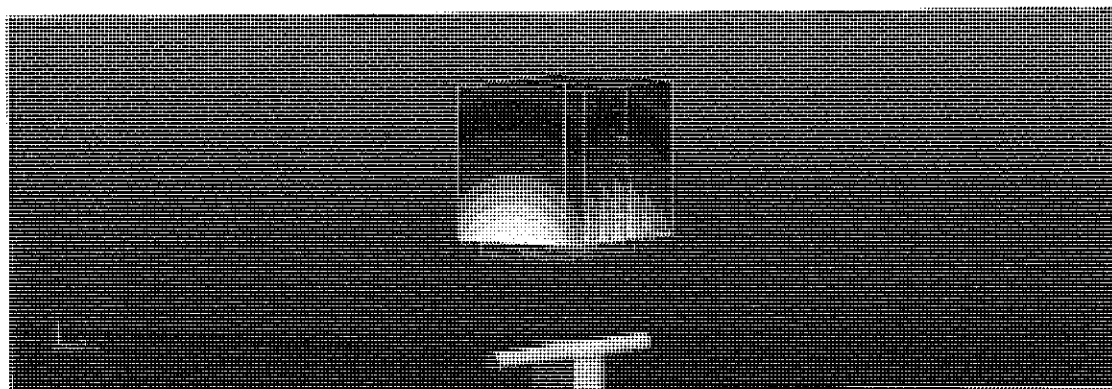
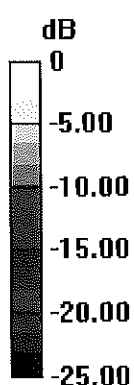
(7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 99.95 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 27.9 W/kg

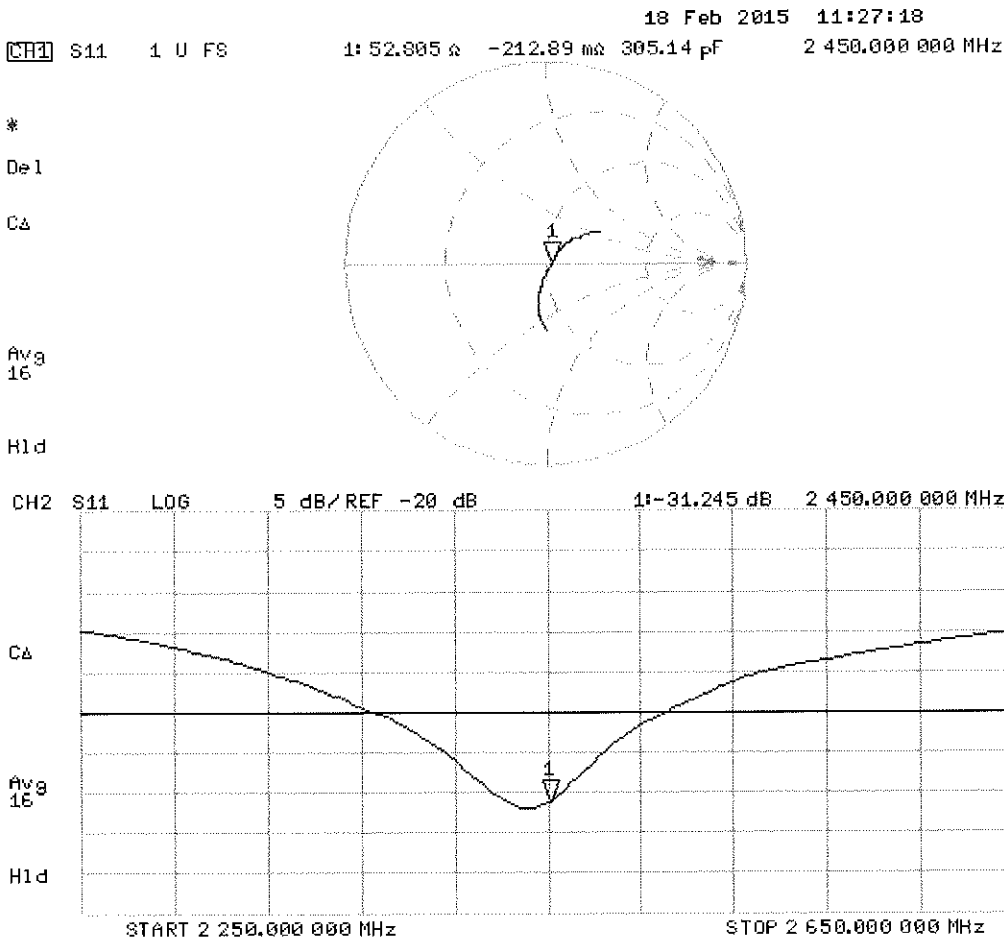
**SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.16 W/kg**

Maximum value of SAR (measured) = 17.3 W/kg



0 dB = 17.3 W/kg = 12.38 dBW/kg

Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 18.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:882**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.04$  S/m;  $\epsilon_r = 51.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

### Dipole Calibration for Body Tissue - ES Probe/Pin=250 mW, d=10mm/Zoom Scan

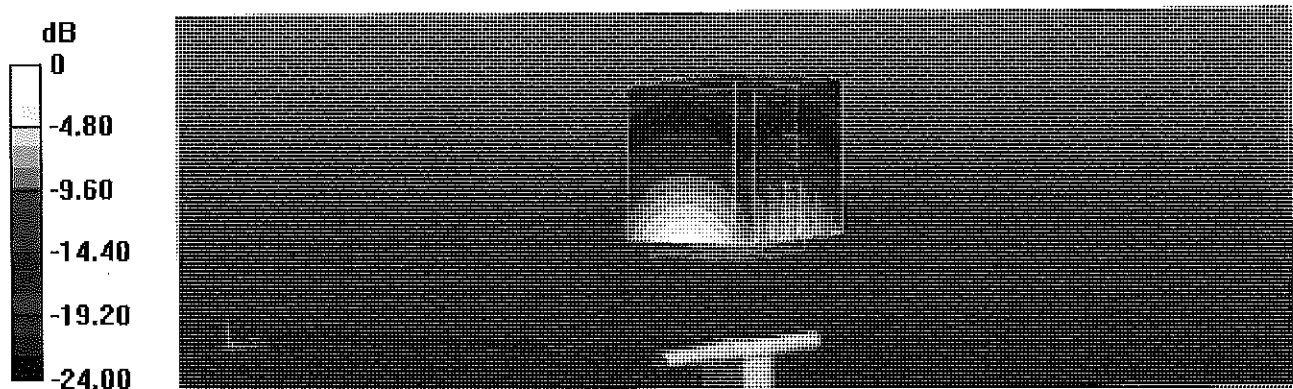
(7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.16 V/m; Power Drift = 0.02 dB

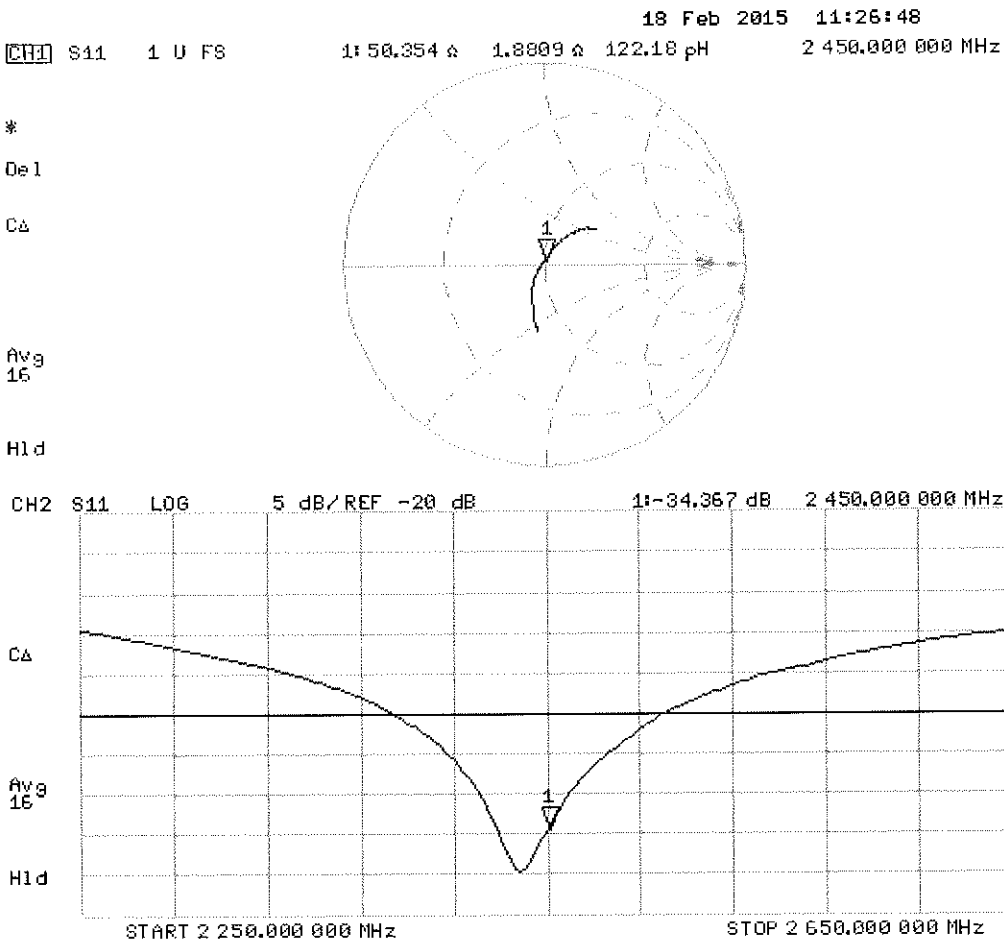
Peak SAR (extrapolated) = 27.2 W/kg

**SAR(1 g) = 13 W/kg; SAR(10 g) = 5.97 W/kg**

Maximum value of SAR (measured) = 17.0 W/kg



Impedance Measurement Plot for Body TSL







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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D2600V2-1071\_Oct14**

## CALIBRATION CERTIFICATE

Object **D2600V2 - SN: 1071**

Calibration procedure(s) **QA CAL-05.v9**  
**Calibration procedure for dipole validation kits above 700 MHz**

CC  
 W/M

Calibration date: **October 20, 2014**

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 EPM-442A        | GB37480704         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | US37292783         | 07-Oct-14 (No. 217-02020)         | Oct-15                 |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-14 (No. 217-02021)         | Oct-15                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe ES3DV3      | SN: 3205           | 30-Dec-13 (No. ES3-3205_Dec13)    | Dec-14                 |
| DAE4                        | SN: 601            | 18-Aug-14 (No. DAE4-601_Aug14)    | Aug-15                 |
| Secondary Standards         | ID #               | Check Date (In house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

Calibrated by: **Michael Weber**      Name: **Michael Weber**      Function: **Laboratory Technician**

Signature

*[Signature]*

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

*[Signature]*

Issued: October 20, 2014

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

**Glossary:**

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

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

- 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
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Additional Documentation:**

- DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                              |                        |             |
|------------------------------|------------------------|-------------|
| DASY Version                 | DASY5                  | V52.8.8     |
| Extrapolation                | Advanced Extrapolation |             |
| Phantom                      | Modular Flat Phantom   |             |
| Distance Dipole Center - TSL | 10 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm      |             |
| Frequency                    | 2600 MHz $\pm$ 1 MHz   |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         |                     |                |                      |
|-----------------------------------------|---------------------|----------------|----------------------|
|                                         | Temperature         | Permittivity   | Conductivity         |
| Nominal Head TSL parameters             | 22.0 °C             | 39.0           | 1.96 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 37.8 $\pm$ 6 % | 2.03 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 14.7 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 57.5 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW Input power | 6.57 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 25.9 W/kg $\pm$ 16.5 % (k=2) |

## Body TSL parameters

The following parameters and calculations were applied.

|                                         |                     |                |                      |
|-----------------------------------------|---------------------|----------------|----------------------|
|                                         | Temperature         | Permittivity   | Conductivity         |
| Nominal Body TSL parameters             | 22.0 °C             | 52.5           | 2.16 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 50.8 $\pm$ 6 % | 2.22 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW Input power | 14.5 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 56.9 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW Input power | 6.43 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 25.4 W/kg $\pm$ 16.5 % (k=2) |

## Appendix (Additional assessments outside the scope of SCS108)

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 48.7 $\Omega$ - 5.2 j $\Omega$ |
| Return Loss                          | - 25.3 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 45.9 $\Omega$ - 4.2 j $\Omega$ |
| Return Loss                          | - 24.2 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.153 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |               |
|-----------------|---------------|
| Manufactured by | SPEAG         |
| Manufactured on | July 17, 2013 |

## DASY5 Validation Report for Head TSL

Date: 20.10.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1071**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 37.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

### DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.46, 4.46, 4.46); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

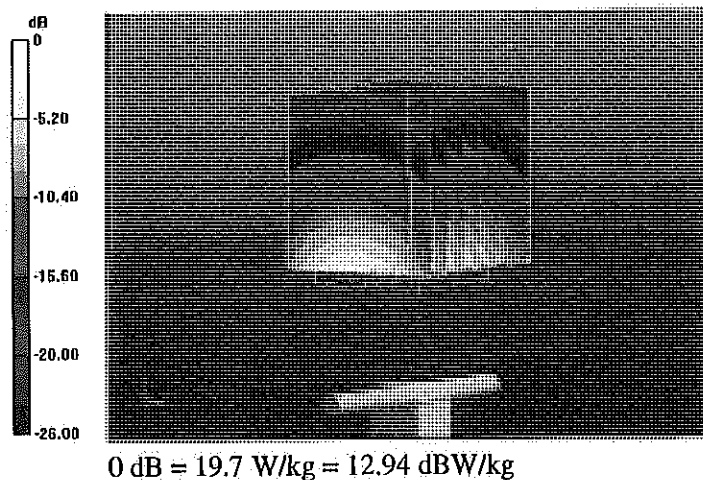
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.3 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 31.0 W/kg

**SAR(1 g) = 14.7 W/kg; SAR(10 g) = 6.57 W/kg**

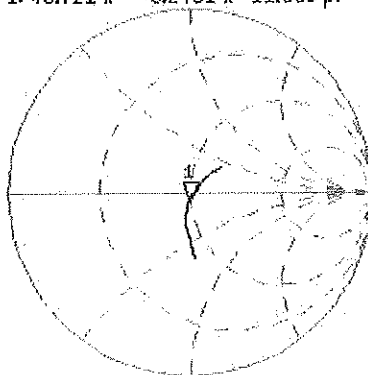
Maximum value of SAR (measured) = 19.7 W/kg



# Impedance Measurement Plot for Head TSL

20 Oct 2014 11:58:04  
 CH1 S11 1 U.FS 1: 48.721  $\Omega$  -5.2461  $\Omega$  11.668 pF 2 600.000 000 MHz

\*  
 Del  
 CA



AVG  
 16

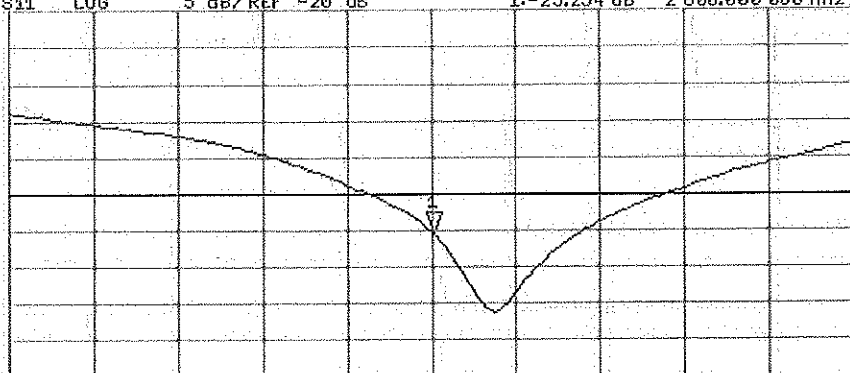
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -25.254 dB 2 600.000 000 MHz

CA

AVG  
 16

H1d



START 2 400.000 000 MHz

STOP 2 800.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 20.10.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1071**

Communication System: UID 0 - CW; Frequency: 2600 MHz

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.22$  S/m;  $\epsilon_r = 50.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.24, 4.24, 4.24); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

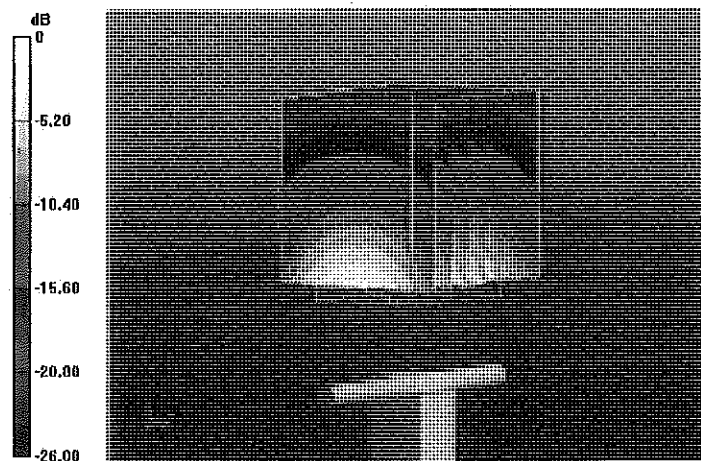
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 97.02 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 31.0 W/kg

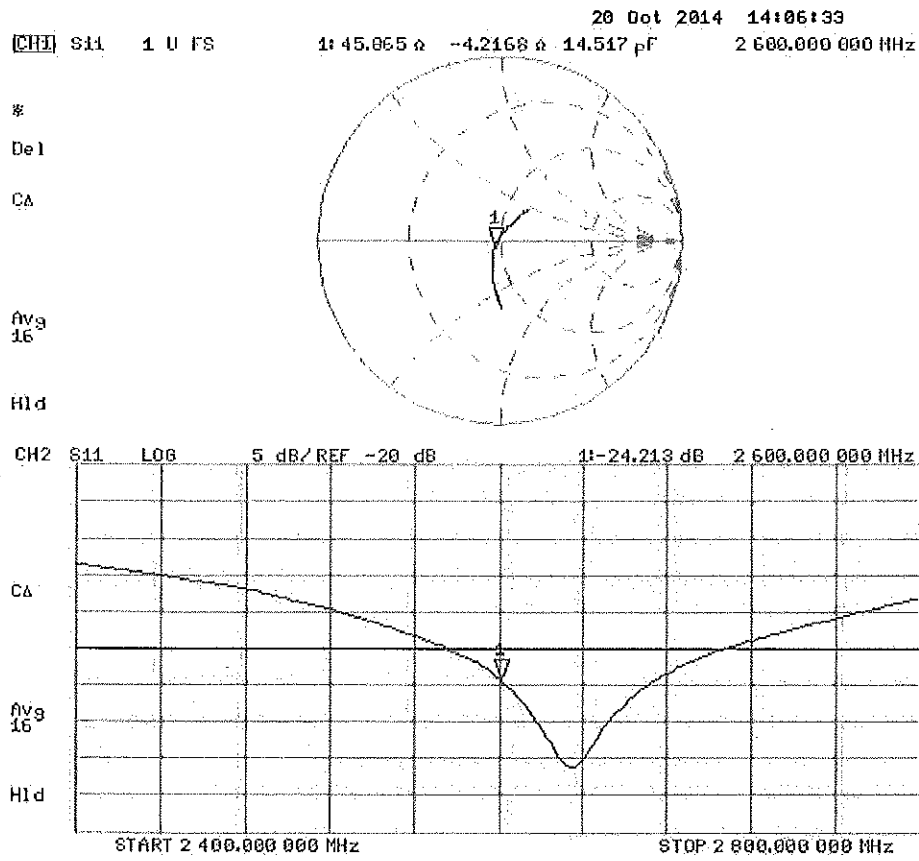
**SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.43 W/kg**

Maximum value of SAR (measured) = 19.3 W/kg



0 dB = 19.3 W/kg = 12.86 dBW/kg

# Impedance Measurement Plot for Body TSL







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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D5GHzV2-1191\_Sep14**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1191**

Calibration procedure(s) **QA CAL-22.v2**  
**Calibration procedure for dipole validation kits between 3-6 GHz**

CC  
11/14

Calibration date: **September 25, 2014**

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 EPM-442A        | GB37480704         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | US37292783         | 09-Oct-13 (No. 217-01827)         | Oct-14                 |
| Power sensor HP 8481A       | MY41092317         | 09-Oct-13 (No. 217-01828)         | Oct-14                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 03-Apr-14 (No. 217-01918)         | Apr-15                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 03-Apr-14 (No. 217-01921)         | Apr-15                 |
| Reference Probe EX3DV4      | SN: 3503           | 30-Dec-13 (No. EX3-3503_Dec13)    | Dec-14                 |
| DAE4                        | SN: 601            | 18-Aug-14 (No. DAE4-601_Aug14)    | Aug-15                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100005             | 04-Aug-99 (in house check Oct-13) | In house check: Oct-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-13) | In house check: Oct-14 |

Calibrated by: **Claudio Leubler** **Laboratory Technician**

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

Signature

Issued: September 25, 2014

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**Glossary:**

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

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

- a) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
- c) 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

**Additional Documentation:**

- d) DASY4/5 System Handbook

**Methods Applied and Interpretation of Parameters:**

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

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

## Measurement Conditions

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

|                              |                                                                                                                      |                                  |
|------------------------------|----------------------------------------------------------------------------------------------------------------------|----------------------------------|
| DASY Version                 | DASY5                                                                                                                | V52.8.8                          |
| Extrapolation                | Advanced Extrapolation                                                                                               |                                  |
| Phantom                      | Modular Flat Phantom V5.0                                                                                            |                                  |
| Distance Dipole Center - TSL | 10 mm                                                                                                                | with Spacer                      |
| Zoom Scan Resolution         | dx, dy = 4.0 mm, dz = 1.4 mm                                                                                         | Graded Ratio = 1.4 (Z direction) |
| Frequency                    | 5200 MHz $\pm$ 1 MHz<br>5300 MHz $\pm$ 1 MHz<br>5500 MHz $\pm$ 1 MHz<br>5600 MHz $\pm$ 1 MHz<br>5800 MHz $\pm$ 1 MHz |                                  |

## Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 36.0           | 4.66 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 34.9 $\pm$ 6 % | 4.54 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL at 5200 MHz

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 100 mW input power | 8.17 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 81.1 W/kg $\pm$ 19.9 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 100 mW input power | 2.33 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 23.1 W/kg $\pm$ 19.5 % (k=2) |

### Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Head TSL parameters             | 22.0 °C         | 35.9         | 4.76 mho/m       |
| Measured Head TSL parameters            | (22.0 ± 0.2) °C | 34.8 ± 6 %   | 4.64 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Head TSL at 5300 MHz

|                                                       |                    |                            |
|-------------------------------------------------------|--------------------|----------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                            |
| SAR measured                                          | 100 mW input power | 8.64 W/kg                  |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 85.8 W / kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.47 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 24.5 W/kg ± 19.5 % (k=2) |

### Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Head TSL parameters             | 22.0 °C         | 35.6         | 4.96 mho/m       |
| Measured Head TSL parameters            | (22.0 ± 0.2) °C | 34.5 ± 6 %   | 4.83 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Head TSL at 5500 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 8.93 W/kg                |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 88.6 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.54 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 25.2 W/kg ± 19.5 % (k=2) |

### Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Head TSL parameters             | 22.0 °C         | 35.5         | 5.07 mho/m       |
| Measured Head TSL parameters            | (22.0 ± 0.2) °C | 34.4 ± 6 %   | 4.93 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Head TSL at 5600 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 8.76 W/kg                |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 86.9 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.49 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 24.7 W/kg ± 19.5 % (k=2) |

### Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Head TSL parameters             | 22.0 °C         | 35.3         | 5.27 mho/m       |
| Measured Head TSL parameters            | (22.0 ± 0.2) °C | 34.1 ± 6 %   | 5.14 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Head TSL at 5800 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 8.30 W/kg                |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 82.3 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.35 W/kg                |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 23.3 W/kg ± 19.5 % (k=2) |

### Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Body TSL parameters             | 22.0 °C         | 49.0         | 5.30 mho/m       |
| Measured Body TSL parameters            | (22.0 ± 0.2) °C | 47.1 ± 6 %   | 5.40 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Body TSL at 5200 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 7.84 W/kg                |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 77.8 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.18 W/kg                |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 21.6 W/kg ± 19.5 % (k=2) |

### Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Body TSL parameters             | 22.0 °C         | 48.9         | 5.42 mho/m       |
| Measured Body TSL parameters            | (22.0 ± 0.2) °C | 46.9 ± 6 %   | 5.53 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Body TSL at 5300 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 8.05 W/kg                |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 79.9 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.25 W/kg                |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 22.3 W/kg ± 19.5 % (k=2) |

### Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Body TSL parameters             | 22.0 °C         | 48.6         | 5.65 mho/m       |
| Measured Body TSL parameters            | (22.0 ± 0.2) °C | 46.6 ± 6 %   | 5.79 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Body TSL at 5500 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 8.37 W/kg                |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 83.1 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.32 W/kg                |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 23.0 W/kg ± 19.5 % (k=2) |

### Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Body TSL parameters             | 22.0 °C         | 48.5         | 5.77 mho/m       |
| Measured Body TSL parameters            | (22.0 ± 0.2) °C | 46.4 ± 6 %   | 5.93 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Body TSL at 5600 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 8.48 W/kg                |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 84.1 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.35 W/kg                |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 23.3 W/kg ± 19.5 % (k=2) |

### Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Body TSL parameters             | 22.0 °C         | 48.2         | 6.00 mho/m       |
| Measured Body TSL parameters            | (22.0 ± 0.2) °C | 46.1 ± 6 %   | 6.21 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C        | ----         | ----             |

### SAR result with Body TSL at 5800 MHz

|                                                       |                    |                          |
|-------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                          |
| SAR measured                                          | 100 mW input power | 7.86 W/kg                |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 78.0 W/kg ± 19.9 % (k=2) |

|                                                         |                    |                          |
|---------------------------------------------------------|--------------------|--------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                          |
| SAR measured                                            | 100 mW input power | 2.17 W/kg                |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 21.5 W/kg ± 19.5 % (k=2) |



## Appendix (Additional assessments outside the scope of SCS108)

### Antenna Parameters with Head TSL at 5200 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 51.8 $\Omega$ - 9.9 j $\Omega$ |
| Return Loss                          | - 20.1 dB                      |

### Antenna Parameters with Head TSL at 5300 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 54.5 $\Omega$ - 1.5 j $\Omega$ |
| Return Loss                          | - 26.8 dB                      |

### Antenna Parameters with Head TSL at 5500 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 49.6 $\Omega$ - 2.0 j $\Omega$ |
| Return Loss                          | - 33.9 dB                      |

### Antenna Parameters with Head TSL at 5600 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 56.5 $\Omega$ - 4.4 j $\Omega$ |
| Return Loss                          | - 22.7 dB                      |

### Antenna Parameters with Head TSL at 5800 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 56.6 $\Omega$ + 4.4 j $\Omega$ |
| Return Loss                          | - 22.6 dB                      |

### Antenna Parameters with Body TSL at 5200 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 51.9 $\Omega$ - 8.1 j $\Omega$ |
| Return Loss                          | - 21.8 dB                      |

### Antenna Parameters with Body TSL at 5300 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 54.5 $\Omega$ + 0.1 j $\Omega$ |
| Return Loss                          | - 27.3 dB                      |

### Antenna Parameters with Body TSL at 5500 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 50.2 $\Omega$ - 0.6 j $\Omega$ |
| Return Loss                          | - 43.8 dB                      |

### Antenna Parameters with Body TSL at 5600 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 57.5 $\Omega$ - 3.2 j $\Omega$ |
| Return Loss                          | - 22.4 dB                      |

### Antenna Parameters with Body TSL at 5800 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 57.2 $\Omega$ + 5.2 j $\Omega$ |
| Return Loss                          | - 21.7 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.202 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |                |
|-----------------|----------------|
| Manufactured by | SPEAG          |
| Manufactured on | April 01, 2014 |

## DASY5 Validation Report for Head TSL

Date: 25.09.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1191**

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

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 4.54$  S/m;  $\epsilon_r = 34.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5300$  MHz;  $\sigma = 4.64$  S/m;  $\epsilon_r = 34.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5500$  MHz;  $\sigma = 4.83$  S/m;  $\epsilon_r = 34.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.93$  S/m;  $\epsilon_r = 34.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.14$  S/m;  $\epsilon_r = 34.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.52, 5.52, 5.52); Calibrated: 30.12.2013, ConvF(5.2, 5.2, 5.2); Calibrated: 30.12.2013, ConvF(5.01, 5.01, 5.01); Calibrated: 30.12.2013, ConvF(4.86, 4.86, 4.86); Calibrated: 30.12.2013, ConvF(4.91, 4.91, 4.91); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.20 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 30.0 W/kg

**SAR(1 g) = 8.17 W/kg; SAR(10 g) = 2.33 W/kg**

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

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.90 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 32.7 W/kg

**SAR(1 g) = 8.64 W/kg; SAR(10 g) = 2.47 W/kg**

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

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

Reference Value = 65.91 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 35.3 W/kg

**SAR(1 g) = 8.93 W/kg; SAR(10 g) = 2.54 W/kg**

Maximum value of SAR (measured) = 20.9 W/kg

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

Reference Value = 65.29 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 34.8 W/kg

**SAR(1 g) = 8.76 W/kg; SAR(10 g) = 2.49 W/kg**

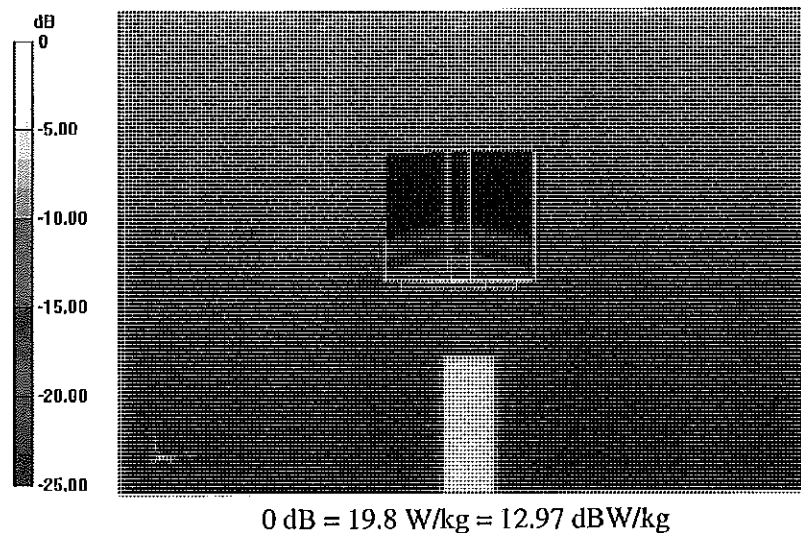
Maximum value of SAR (measured) = 20.7 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 62.74 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 34.4 W/kg

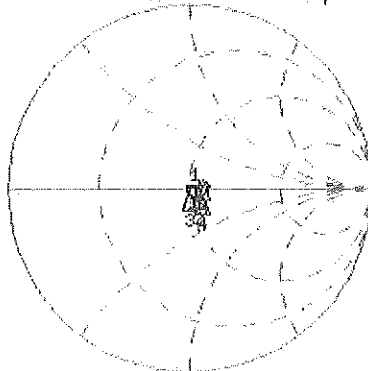
**SAR(1 g) = 8.3 W/kg; SAR(10 g) = 2.35 W/kg**



# Impedance Measurement Plot for Head TSL

25 Sep 2014 11:07:52  
 [CH1] S11 1 U FS 1: 51.911  $\Omega$  -9.9180  $\Omega$  3.0060 pF 5 200.000 000 MHz

#  
 Del  
 Cor  
 Avg  
 0  
 H1d

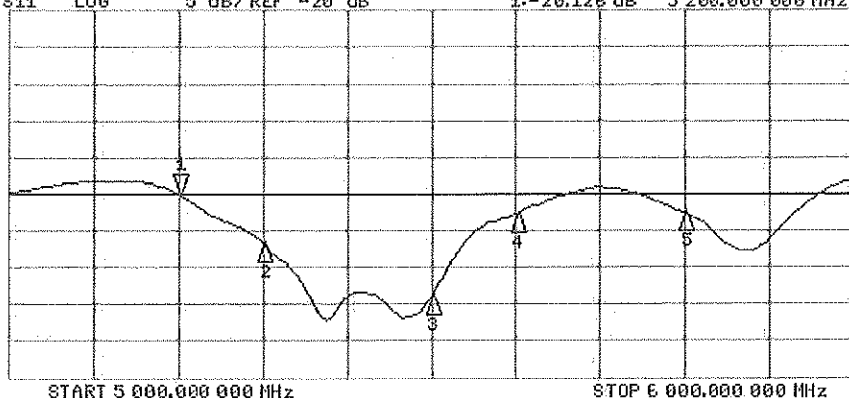


CH1 Markers

2: 54.518  $\Omega$   
 -1.5078  $\Omega$   
 5.30000 GHz  
 3: 49.566  $\Omega$   
 -1.9707  $\Omega$   
 5.50000 GHz  
 4: 56.516  $\Omega$   
 -4.3633  $\Omega$   
 5.60000 GHz  
 5: 56.555  $\Omega$   
 4.3904  $\Omega$   
 5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1:-20.126 dB 5 200.000 000 MHz

Cor  
 Avg  
 0  
 H1d



CH2 Markers

2:-26.825 dB  
 5.30000 GHz  
 3:-33.878 dB  
 5.50000 GHz  
 4:-22.660 dB  
 5.60000 GHz  
 5:-22.611 dB  
 5.80000 GHz

## DASY5 Validation Report for Body TSL

Date: 24.09.2014

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1191**

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

Medium parameters used:  $f = 5200$  MHz;  $\sigma = 5.4$  S/m;  $\epsilon_r = 47.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5300$  MHz;  $\sigma = 5.53$  S/m;  $\epsilon_r = 46.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5500$  MHz;  $\sigma = 5.79$  S/m;  $\epsilon_r = 46.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5600$  MHz;  $\sigma = 5.93$  S/m;  $\epsilon_r = 46.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Medium parameters used:  $f = 5800$  MHz;  $\sigma = 6.21$  S/m;  $\epsilon_r = 46.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.01, 5.01, 5.01); Calibrated: 30.12.2013, ConvF(4.76, 4.76, 4.76); Calibrated: 30.12.2013, ConvF(4.52, 4.52, 4.52); Calibrated: 30.12.2013, ConvF(4.3, 4.3, 4.3); Calibrated: 30.12.2013, ConvF(4.47, 4.47, 4.47); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 60.46 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 30.7 W/kg

**SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.18 W/kg**

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

**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 60.42 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 32.1 W/kg

**SAR(1 g) = 8.05 W/kg; SAR(10 g) = 2.25 W/kg**

Maximum value of SAR (measured) = 19.1 W/kg

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

Reference Value = 60.44 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 35.8 W/kg

**SAR(1 g) = 8.37 W/kg; SAR(10 g) = 2.32 W/kg**

Maximum value of SAR (measured) = 20.4 W/kg

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

Reference Value = 60.44 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 37.0 W/kg

**SAR(1 g) = 8.48 W/kg; SAR(10 g) = 2.35 W/kg**

Maximum value of SAR (measured) = 20.9 W/kg

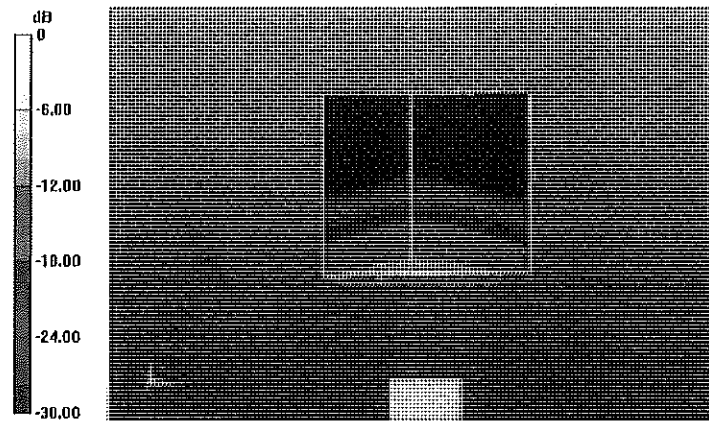
**Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 56.69 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 36.4 W/kg

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

Maximum value of SAR (measured) = 19.7 W/kg

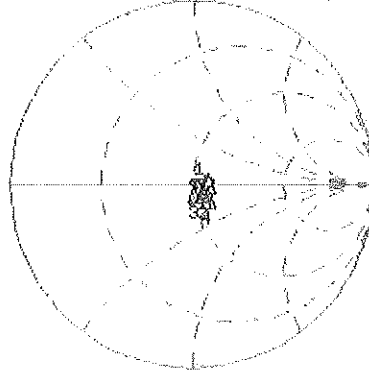


0 dB = 19.7 W/kg = 12.94 dBW/kg

# Impedance Measurement Plot for Body TSL

24 Sep 2014 11:05:50  
 [CH1] S11 1 U FS 1: 51.867  $\Omega$  -8.0566  $\Omega$  3.7989 pF 5 200.000 000 MHz

#  
 Del  
 Cor  
 Avg  
 16  
 H1d

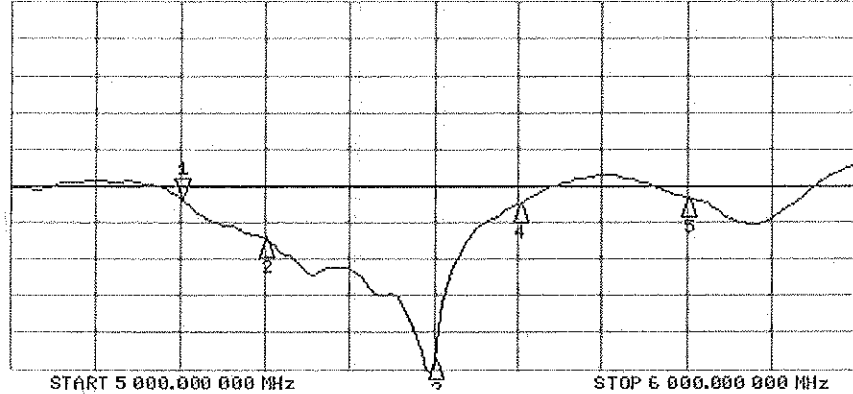


CH1 Markers

2: 54.531  $\Omega$   
 0.1015  $\Omega$   
 5.30000 GHz  
 3: 50.207  $\Omega$   
 -613.28  $\Omega$   
 5.50000 GHz  
 4: 57.480  $\Omega$   
 -3.1563  $\Omega$   
 5.60000 GHz  
 5: 57.150  $\Omega$   
 5.1934  $\Omega$   
 5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -21.835 dB 5 200.000 000 MHz

Cor  
 Avg  
 16  
 H1d



CH2 Markers

2: -27.251 dB  
 5.30000 GHz  
 3: -43.776 dB  
 5.50000 GHz  
 4: -22.442 dB  
 5.60000 GHz  
 5: -21.682 dB  
 5.80000 GHz



## APPENDIX D: SAR TISSUE SPECIFICATIONS

Measurement Procedure for Tissue verification:

- 1) The network analyzer and probe system was configured and calibrated.
- 2) The probe was immersed in the tissue. The tissue was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
- 3) The complex admittance with respect to the probe aperture was measured
- 4) The complex relative permittivity  $\epsilon$  can be calculated from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\epsilon_r\epsilon_0}{[\ln(b/a)]^2} \int_a^b \int_a^b \int_0^\pi \cos\phi' \frac{\exp[-j\omega r(\mu_0\epsilon_r'\epsilon_0)^{1/2}]}{r} d\phi' d\rho' d\rho$$

where  $Y$  is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively,  $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$ ,  $\omega$  is the angular frequency, and  $j = \sqrt{-1}$ .

**Table D-I**  
**Composition of the Tissue Equivalent Matter**

| Frequency (MHz)           | 750  | 750  | 835   | 835   | 1750 | 1750 | 1900  | 1900  | 2450-2600 | 2450-2600 | 5200-5800 | 5200-5800 |
|---------------------------|------|------|-------|-------|------|------|-------|-------|-----------|-----------|-----------|-----------|
| Tissue                    | Head | Body | Head  | Body  | Head | Body | Head  | Body  | Head      | Body      | Head      | Body      |
| Ingredients (% by weight) |      |      |       |       |      |      |       |       |           |           |           |           |
| Bactericide               |      |      | 0.1   | 0.1   |      |      |       |       |           |           |           |           |
| DGBE                      |      |      |       |       | 47   | 31   | 44.92 | 29.44 |           | 26.7      |           |           |
| HEC                       |      |      | 1     | 1     |      |      |       |       |           |           |           |           |
| NaCl                      |      |      | 1.45  | 0.94  | 0.4  | 0.2  | 0.18  | 0.39  |           | 0.1       |           |           |
| Sucrose                   |      |      | 57    | 44.9  |      |      |       |       |           |           |           |           |
| Polysorbate (Tween) 80    |      |      |       |       |      |      |       |       |           |           |           | 20        |
| Water                     |      |      | 40.45 | 53.06 | 52.6 | 68.8 | 54.9  | 70.17 |           | 73.2      |           | 80        |

|                                    |                                                                                     |                       |                                                                                       |                                 |
|------------------------------------|-------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|---------------------------------|
| FCC ID: ZNFH811                    |  | SAR EVALUATION REPORT |  | Reviewed by:<br>Quality Manager |
| Test Dates:<br>04/13/15 - 04/20/15 | DUT Type:<br>Portable Handset                                                       |                       |                                                                                       | APPENDIX D:<br>Page 1 of 5      |

## 2 Composition / Information on ingredients

The Item is composed of the following ingredients:

|                                                                  |                                                                                                                                                     |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| H <sub>2</sub> O                                                 | Water, 35 – 58%                                                                                                                                     |
| Sucrose                                                          | Sugar, white, refined, 40 – 60%                                                                                                                     |
| NaCl                                                             | Sodium Chloride, 0 – 6%                                                                                                                             |
| Hydroxyethyl-cellulose                                           | Medium Viscosity (CAS# 9004-62-0), <0.3%                                                                                                            |
| Preventol-D7                                                     | Preservative: aqueous preparation, (CAS# 55965-84-9), containing 5-chloro-2-methyl-3(2H)-isothiazolone and 2-methyl-3(2H)-isothiazolone, 0.1 – 0.7% |
| Relevant for safety; Refer to the respective Safety Data Sheet*. |                                                                                                                                                     |

**Figure D-1**

### Composition of 750 MHz Head and Body Tissue Equivalent Matter

**Note:** 750MHz liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

#### Measurement Certificate / Material Test

|              |                                          |
|--------------|------------------------------------------|
| Item Name    | Body Tissue Simulating Liquid (MSL750V2) |
| Product No.  | SL AAM 075 AA (Charge: 130828-1)         |
| Manufacturer | SPEAG                                    |

#### Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

#### Setup Validation

Validation results were within  $\pm 2.5\%$  towards the target values of Methanol.

#### Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

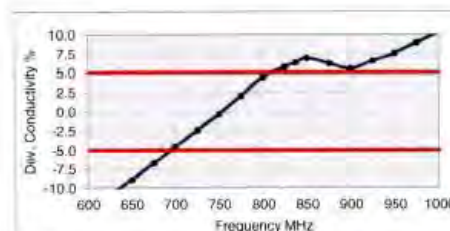
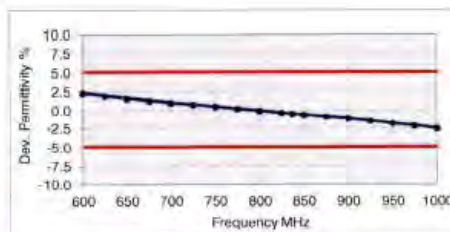
#### Test Condition

|                 |                                                             |
|-----------------|-------------------------------------------------------------|
| Ambient         | Environment temperatur ( $22 \pm 3$ )°C and humidity < 70%. |
| TSL Temperature | 22°C                                                        |
| Test Date       | 28-Aug-13                                                   |
| Operator        | IEN                                                         |

#### Additional Information

|                   |                         |
|-------------------|-------------------------|
| TSL Density       | 1.212 g/cm <sup>3</sup> |
| TSL Heat-capacity | 3.006 kJ/(kg·K)         |

| f [MHz] | Measured |        |       | Target |       | Diff. to Target [%] |         |
|---------|----------|--------|-------|--------|-------|---------------------|---------|
|         | HP-e'    | HP-e'' | sigma | eps    | sigma | Δ-eps               | Δ-sigma |
| 600     | 57.4     | 24.76  | 0.83  | 56.1   | 0.95  | 2.3                 | -13.2   |
| 625     | 57.1     | 24.42  | 0.85  | 56.0   | 0.95  | 2.0                 | -11.0   |
| 650     | 56.8     | 24.09  | 0.87  | 55.9   | 0.96  | 1.6                 | -8.9    |
| 675     | 56.6     | 23.80  | 0.89  | 55.8   | 0.96  | 1.3                 | -6.7    |
| 700     | 56.3     | 23.52  | 0.92  | 55.7   | 0.96  | 1.0                 | -4.5    |
| 725     | 56.1     | 23.27  | 0.94  | 55.6   | 0.96  | 0.8                 | -2.4    |
| 750     | 55.8     | 23.03  | 0.96  | 55.5   | 0.96  | 0.5                 | -0.3    |
| 775     | 55.6     | 22.87  | 0.99  | 55.4   | 0.97  | 0.2                 | 2.1     |
| 800     | 55.3     | 22.71  | 1.01  | 55.3   | 0.97  | -0.1                | 4.5     |
| 825     | 55.1     | 22.54  | 1.03  | 55.2   | 0.98  | -0.3                | 5.8     |
| 850     | 54.9     | 22.45  | 1.05  | 55.2   | 0.98  | -0.5                | 6.4     |
| 875     | 54.8     | 22.37  | 1.06  | 55.2   | 0.99  | -0.6                | 7.0     |
| 900     | 54.6     | 22.25  | 1.08  | 55.1   | 1.02  | -0.9                | 6.2     |
| 925     | 54.4     | 22.13  | 1.11  | 55.0   | 1.05  | -1.1                | 5.5     |
| 950     | 54.2     | 22.02  | 1.13  | 55.0   | 1.06  | -1.5                | 6.6     |
| 975     | 53.9     | 21.91  | 1.16  | 54.9   | 1.08  | -1.8                | 7.7     |
| 1000    | 53.7     | 21.84  | 1.18  | 54.9   | 1.09  | -2.2                | 9.0     |
| 1000    | 53.5     | 21.77  | 1.21  | 54.8   | 1.10  | -2.5                | 10.3    |



**Figure D-2**

### 750MHz Body Tissue Equivalent Matter

|                                    |                                                                                     |                       |                                                                                       |                                 |
|------------------------------------|-------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|---------------------------------|
| FCC ID: ZNFH811                    |  | SAR EVALUATION REPORT |  | Reviewed by:<br>Quality Manager |
| Test Dates:<br>04/13/15 - 04/20/15 | DUT Type:<br>Portable Handset                                                       |                       |                                                                                       | APPENDIX D:<br>Page 2 of 5      |

## Measurement Certificate / Material Test

Item Name **Head Tissue Simulating Liquid (HSL750V2)**  
 Product No. SL AAH 075 AA (Charge: 130826-2)  
 Manufacturer SPEAG

### Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

### Setup Validation

Validation results were within  $\pm 2.5\%$  towards the target values of Methanol.

### Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

### Test Condition

Ambient Environment temperatur ( $22 \pm 3$ )°C and humidity  $< 70\%$ .  
 TSL Temperature 22°C  
 Test Date 28-Aug-13  
 Operator IEN

### Additional Information

TSL Density 1.284 g/cm<sup>3</sup>  
 TSL Heat-capacity 2.701 kJ/(kg\*K)

| f [MHz] | Measured |        |       | Target |       | Diff.to Target (%) |                 |
|---------|----------|--------|-------|--------|-------|--------------------|-----------------|
|         | HP-e'    | HP-e'' | sigma | eps    | sigma | $\Delta$ -eps      | $\Delta$ -sigma |
| 600     | 44.4     | 23.32  | 0.78  | 42.7   | 0.88  | 3.9                | -11.7           |
| 625     | 44.0     | 23.05  | 0.80  | 42.6   | 0.88  | 3.4                | -9.3            |
| 650     | 43.6     | 22.78  | 0.82  | 42.5   | 0.89  | 2.8                | -7.0            |
| 675     | 43.3     | 22.54  | 0.85  | 42.3   | 0.89  | 2.2                | -4.7            |
| 700     | 42.9     | 22.30  | 0.87  | 42.2   | 0.89  | 1.6                | -2.4            |
| 725     | 42.6     | 22.10  | 0.89  | 42.1   | 0.89  | 1.2                | 0.0             |
| 750     | 42.3     | 21.90  | 0.91  | 41.9   | 0.89  | 0.8                | 2.3             |
| 775     | 41.9     | 21.74  | 0.94  | 41.8   | 0.90  | 0.2                | 4.6             |
| 800     | 41.6     | 21.57  | 0.96  | 41.7   | 0.90  | -0.3               | 7.0             |
| 825     | 41.3     | 21.42  | 0.98  | 41.6   | 0.91  | -0.8               | 8.4             |
| 838     | 41.1     | 21.35  | 0.99  | 41.5   | 0.91  | -1.0               | 9.1             |
| 850     | 41.0     | 21.27  | 1.01  | 41.5   | 0.92  | -1.3               | 9.8             |
| 875     | 40.7     | 21.14  | 1.03  | 41.5   | 0.94  | -2.0               | 9.1             |
| 900     | 40.4     | 21.00  | 1.05  | 41.5   | 0.97  | -2.6               | 8.4             |
| 925     | 40.1     | 20.89  | 1.07  | 41.5   | 0.98  | -3.2               | 9.4             |
| 950     | 39.9     | 20.78  | 1.10  | 41.4   | 0.99  | -3.8               | 10.4            |
| 975     | 39.6     | 20.69  | 1.12  | 41.4   | 1.00  | -4.4               | 11.7            |
| 1000    | 39.3     | 20.60  | 1.15  | 41.3   | 1.01  | -4.9               | 12.9            |

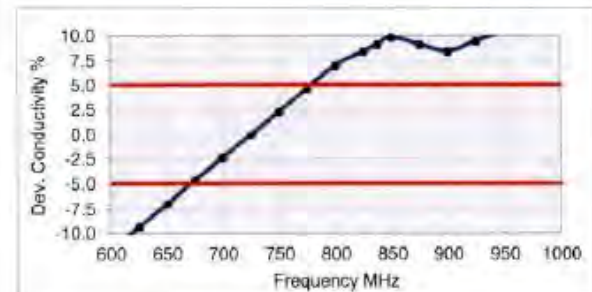
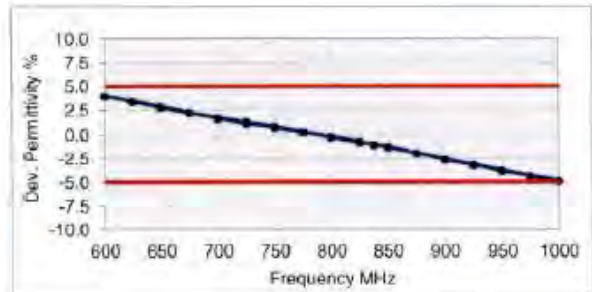


Figure D-3  
750MHz Head Tissue Equivalent Matter

|                                    |                                                                                     |                       |                                                                                       |                                 |
|------------------------------------|-------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|---------------------------------|
| FCC ID: ZNFH811                    |  | SAR EVALUATION REPORT |  | Reviewed by:<br>Quality Manager |
| Test Dates:<br>04/13/15 - 04/20/15 | DUT Type:<br>Portable Handset                                                       |                       |                                                                                       | APPENDIX D:<br>Page 3 of 5      |

## 2 Composition / Information on ingredients

The Item is composed of the following ingredients:

|                                               |                                                                                                                                                                                           |
|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| H <sub>2</sub> O                              | Water, 52 – 75%                                                                                                                                                                           |
| C <sub>8</sub> H <sub>18</sub> O <sub>3</sub> | Diethylene glycol monobutyl ether (DGBE), 25 – 48%<br>(CAS-No. 112-34-5, EC-No. 203-961-6, EC-index-No. 603-096-00-8)<br>Relevant for safety; Refer to the respective Safety Data Sheet*. |
| NaCl                                          | Sodium Chloride, <1.0%                                                                                                                                                                    |

Figure D-4

### Composition of 2.4-2.6 GHz Head Tissue Equivalent Matter

**Note:** 2.4-2.6 GHz head liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

#### Measurement Certificate / Material Test

|              |                                           |
|--------------|-------------------------------------------|
| Item Name    | Head Tissue Simulating Liquid (HSL2450V2) |
| Product No.  | SL AAH 245 BA (Charge: 130926-1)          |
| Manufacturer | SPEAG                                     |

#### Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

#### Setup Validation

Validation results were within  $\pm 2.5\%$  towards the target values of Methanol.

#### Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

#### Test Condition

|                 |                                                                       |
|-----------------|-----------------------------------------------------------------------|
| Ambient         | Environment temperatur ( $22 \pm 3^\circ\text{C}$ and humidity < 70%. |
| TSL Temperature | $23^\circ\text{C}$                                                    |
| Test Date       | 2-Oct-13                                                              |
| Operator        | CL                                                                    |

#### Additional Information

|                   |                         |
|-------------------|-------------------------|
| TSL Density       | 0.988 g/cm <sup>3</sup> |
| TSL Heat-capacity | 3.680 kJ/(kg*K)         |

| f (MHz) | HP-e' | HP-e'' | sigma | eps  | sigma | Δ-eps | Δ-sigma |
|---------|-------|--------|-------|------|-------|-------|---------|
| 1900    | 40.3  | 11.88  | 1.26  | 40.0 | 1.40  | 0.9   | -10.3   |
| 1925    | 40.3  | 11.98  | 1.28  | 40.0 | 1.40  | 0.6   | -8.3    |
| 1950    | 40.2  | 12.08  | 1.31  | 40.0 | 1.40  | 0.4   | -6.4    |
| 1975    | 40.1  | 12.15  | 1.34  | 40.0 | 1.40  | 0.2   | -4.6    |
| 2000    | 40.0  | 12.23  | 1.36  | 40.0 | 1.40  | -0.1  | -2.8    |
| 2025    | 39.9  | 12.34  | 1.39  | 40.0 | 1.42  | -0.2  | -2.3    |
| 2050    | 39.8  | 12.45  | 1.42  | 39.9 | 1.44  | -0.3  | -1.7    |
| 2075    | 39.7  | 12.54  | 1.45  | 39.9 | 1.47  | -0.4  | -1.3    |
| 2100    | 39.6  | 12.64  | 1.48  | 39.8 | 1.49  | -0.5  | -0.8    |
| 2125    | 39.5  | 12.69  | 1.50  | 39.8 | 1.51  | -0.7  | -0.7    |
| 2150    | 39.4  | 12.75  | 1.52  | 39.7 | 1.53  | -0.8  | -0.6    |
| 2175    | 39.3  | 12.84  | 1.55  | 39.7 | 1.56  | -1.0  | 0.1     |
| 2200    | 39.2  | 12.94  | 1.58  | 39.6 | 1.58  | -1.2  | 0.4     |
| 2225    | 39.1  | 13.00  | 1.61  | 39.6 | 1.60  | -1.3  | 0.6     |
| 2250    | 39.0  | 13.07  | 1.64  | 39.6 | 1.62  | -1.4  | 0.8     |
| 2275    | 38.9  | 13.15  | 1.66  | 39.5 | 1.64  | -1.5  | 1.2     |
| 2300    | 38.8  | 13.22  | 1.69  | 39.5 | 1.67  | -1.7  | 1.5     |
| 2325    | 38.7  | 13.32  | 1.72  | 39.4 | 1.69  | -1.9  | 2.0     |
| 2350    | 38.6  | 13.42  | 1.75  | 39.4 | 1.71  | -2.0  | 2.5     |
| 2375    | 38.5  | 13.49  | 1.78  | 39.3 | 1.73  | -2.1  | 2.8     |
| 2400    | 38.4  | 13.56  | 1.81  | 39.3 | 1.76  | -2.3  | 3.1     |
| 2425    | 38.3  | 13.63  | 1.84  | 39.2 | 1.78  | -2.5  | 3.5     |
| 2450    | 38.2  | 13.71  | 1.87  | 39.2 | 1.80  | -2.6  | 3.8     |
| 2475    | 38.1  | 13.79  | 1.90  | 39.2 | 1.83  | -2.8  | 3.9     |
| 2500    | 38.0  | 13.87  | 1.93  | 39.1 | 1.85  | -3.0  | 4.0     |
| 2525    | 37.9  | 13.96  | 1.96  | 39.1 | 1.88  | -3.1  | 4.2     |
| 2550    | 37.8  | 14.05  | 1.99  | 39.1 | 1.91  | -3.3  | 4.4     |
| 2575    | 37.7  | 14.11  | 2.02  | 39.0 | 1.94  | -3.5  | 4.4     |
| 2600    | 37.5  | 14.17  | 2.05  | 39.0 | 1.96  | -3.8  | 4.4     |
| 2625    | 37.4  | 14.23  | 2.08  | 39.0 | 1.99  | -4.0  | 4.4     |
| 2650    | 37.3  | 14.30  | 2.11  | 38.9 | 2.02  | -4.2  | 4.5     |
| 2675    | 37.2  | 14.37  | 2.14  | 38.9 | 2.05  | -4.4  | 4.6     |
| 2700    | 37.1  | 14.45  | 2.17  | 38.9 | 2.07  | -4.6  | 4.7     |

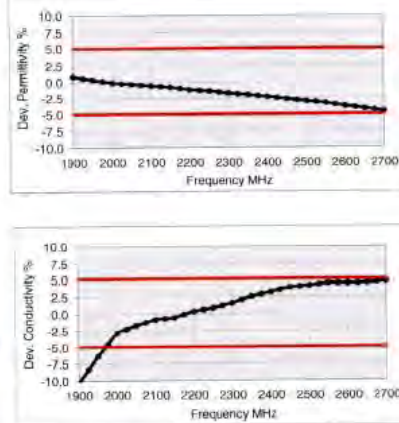


Figure D-5

### 2.4-2.6 GHz Head Tissue Equivalent Matter

|                                    |                                                                                     |                            |                                                                                       |                                 |
|------------------------------------|-------------------------------------------------------------------------------------|----------------------------|---------------------------------------------------------------------------------------|---------------------------------|
| FCC ID: ZNFH811                    |  | SAR EVALUATION REPORT      |  | Reviewed by:<br>Quality Manager |
| Test Dates:<br>04/13/15 - 04/20/15 | DUT Type:<br>Portable Handset                                                       | APPENDIX D:<br>Page 4 of 5 |                                                                                       |                                 |



## 2 Composition / Information on ingredients

The Item is composed of the following ingredients:

|             |          |
|-------------|----------|
| Water       | 50 – 65% |
| Mineral oil | 10 – 30% |
| Emulsifiers | 8 – 25%  |
| Sodium salt | 0 – 1.5% |

**Figure D-6**  
**Composition of 5 GHz Head Tissue Equivalent Matter**

**Note:** 5GHz head liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

### Measurement Certificate / Material Test

|              |                                                 |
|--------------|-------------------------------------------------|
| Item Name    | Head Tissue Simulating Liquid (HBBL3500-5800V5) |
| Product No.  | SL AAH 502 AC (Charge: 130903-1)                |
| Manufacturer | SPEAG                                           |

### Measurement Method

TSL dielectric parameters measured using calibrated OCP probe

### Setup Validation

Validation results were within  $\pm 2.5\%$  towards the target values of Methanol

### Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

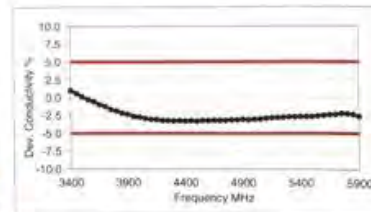
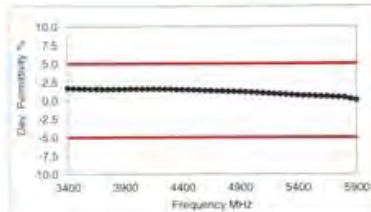
### Test Condition

|                 |                                                            |
|-----------------|------------------------------------------------------------|
| Ambient         | Environment temperatur ( $22 \pm 3$ )°C and humidity < 70% |
| TSL Temperature | 22°C                                                       |
| Test Date       | 4-Sep-13                                                   |
| Operator        | IEN                                                        |

### Additional Information

|                   |                         |
|-------------------|-------------------------|
| TSL Density       | 0.985 g/cm <sup>3</sup> |
| TSL Heat-capacity | 3.383 kJ/(kg·K)         |

| f [MHz] | HP-ε' | HP-ε'' | sigma | eps  | sigma | Δ-eps | Δ-sigma |
|---------|-------|--------|-------|------|-------|-------|---------|
| 3400    | 38.7  | 15.01  | 2.84  | 38.0 | 2.81  | 1.7   | 1.1     |
| 3500    | 38.5  | 14.98  | 2.92  | 37.9 | 2.91  | 1.5   | 0.3     |
| 3600    | 38.4  | 14.98  | 3.00  | 37.8 | 3.02  | 1.5   | -0.5    |
| 3700    | 38.3  | 14.97  | 3.08  | 37.7 | 3.12  | 1.6   | -1.2    |
| 3800    | 38.3  | 14.96  | 3.16  | 37.6 | 3.22  | 1.6   | -1.8    |
| 3900    | 38.1  | 14.96  | 3.25  | 37.5 | 3.32  | 1.7   | -2.3    |
| 4000    | 37.9  | 14.96  | 3.33  | 37.4 | 3.43  | 1.5   | -2.8    |
| 4100    | 37.6  | 15.00  | 3.42  | 37.2 | 3.53  | 1.5   | -3.0    |
| 4200    | 37.7  | 15.04  | 3.51  | 37.1 | 3.63  | 1.5   | -3.3    |
| 4300    | 37.6  | 15.10  | 3.61  | 37.0 | 3.73  | 1.6   | -3.3    |
| 4400    | 37.4  | 15.16  | 3.71  | 36.9 | 3.84  | 1.4   | -3.3    |
| 4500    | 37.3  | 15.22  | 3.81  | 36.8 | 3.94  | 1.4   | -3.2    |
| 4600    | 37.2  | 15.29  | 3.91  | 36.7 | 4.04  | 1.4   | -3.2    |
| 4700    | 37.0  | 15.34  | 4.01  | 36.6 | 4.14  | 1.2   | -3.2    |
| 4800    | 36.9  | 15.41  | 4.11  | 36.4 | 4.25  | 1.3   | -3.2    |
| 4850    | 36.8  | 15.43  | 4.16  | 36.4 | 4.30  | 1.1   | -3.2    |
| 4900    | 36.8  | 15.47  | 4.22  | 36.3 | 4.35  | 1.3   | -2.9    |
| 4950    | 36.7  | 15.49  | 4.26  | 36.3 | 4.40  | 1.2   | -3.2    |
| 5000    | 36.6  | 15.52  | 4.32  | 36.2 | 4.45  | 1.1   | -2.9    |
| 5050    | 36.5  | 15.55  | 4.37  | 36.2 | 4.50  | 0.9   | -2.9    |
| 5100    | 36.5  | 15.59  | 4.42  | 36.1 | 4.55  | 1.1   | -2.9    |
| 5150    | 36.4  | 15.62  | 4.47  | 36.0 | 4.60  | 1.0   | -2.9    |
| 5200    | 36.3  | 15.65  | 4.53  | 36.0 | 4.66  | 0.9   | -2.7    |
| 5250    | 36.2  | 15.67  | 4.58  | 35.9 | 4.71  | 0.8   | -2.7    |
| 5300    | 36.2  | 15.71  | 4.63  | 35.9 | 4.76  | 0.9   | -2.7    |
| 5350    | 36.1  | 15.73  | 4.68  | 35.8 | 4.81  | 0.8   | -2.7    |
| 5400    | 36.0  | 15.75  | 4.73  | 35.8 | 4.86  | 0.7   | -2.7    |
| 5450    | 35.9  | 15.78  | 4.78  | 35.7 | 4.91  | 0.6   | -2.7    |
| 5500    | 35.8  | 15.79  | 4.83  | 35.6 | 4.96  | 0.7   | -2.7    |
| 5550    | 35.8  | 15.83  | 4.89  | 35.6 | 5.01  | 0.6   | -2.5    |
| 5600    | 35.7  | 15.86  | 4.94  | 35.5 | 5.07  | 0.5   | -2.5    |
| 5650    | 35.7  | 15.89  | 5.00  | 35.5 | 5.12  | 0.6   | -2.3    |
| 5700    | 35.6  | 15.92  | 5.05  | 35.4 | 5.17  | 0.5   | -2.3    |
| 5750    | 35.5  | 15.96  | 5.11  | 35.4 | 5.22  | 0.4   | -2.1    |
| 5800    | 35.5  | 15.97  | 5.15  | 35.3 | 5.27  | 0.6   | -2.3    |
| 5850    | 35.4  | 16.02  | 5.21  | 35.3 | 5.34  | 0.3   | -2.3    |
| 5900    | 35.3  | 16.03  | 5.26  | 35.3 | 5.40  | 0.0   | -2.6    |



**Figure D-7**  
**5GHz Head Tissue Equivalent Matter**

|                                    |                                                                                     |                       |                                                                                       |                                 |
|------------------------------------|-------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------|---------------------------------|
| FCC ID: ZNFH811                    |  | SAR EVALUATION REPORT |  | Reviewed by:<br>Quality Manager |
| Test Dates:<br>04/13/15 - 04/20/15 | DUT Type:<br>Portable Handset                                                       |                       |                                                                                       | APPENDIX D:<br>Page 5 of 5      |

## APPENDIX E: SAR SYSTEM VALIDATION

Per FCC KDB 865664 D02v01, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01 v01 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

**Table E-1**  
**SAR System Validation Summary- 1g**

| SAR SYSTEM # | FREQ. [MHz] | DATE       | PROBE SN | PROBE TYPE | PROBE CAL. POINT |      | COND.        | PERM.            | CW VALIDATION |                 |                | MOD. VALIDATION |             |      |
|--------------|-------------|------------|----------|------------|------------------|------|--------------|------------------|---------------|-----------------|----------------|-----------------|-------------|------|
|              |             |            |          |            |                  |      | ( $\sigma$ ) | ( $\epsilon_r$ ) | SENSI- TIVITY | PROBE LINEARITY | PROBE ISOTROPY | MOD. TYPE       | DUTY FACTOR | PAR  |
| G            | 750         | 4/20/2015  | 3318     | ES3DV3     | 750              | Head | 0.911        | 41.11            | PASS          | PASS            | PASS           | N/A             | N/A         | N/A  |
| C            | 835         | 11/10/2014 | 3333     | ES3DV3     | 835              | Head | 0.929        | 41.57            | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| B            | 1750        | 1/4/2015   | 3334     | ES3DV3     | 1750             | Head | 1.369        | 39.91            | PASS          | PASS            | PASS           | N/A             | N/A         | N/A  |
| J            | 1900        | 9/8/2014   | 3022     | ES3DV2     | 1900             | Head | 1.457        | 39.72            | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| K            | 1900        | 10/16/2014 | 3288     | ES3DV3     | 1900             | Head | 1.454        | 39.51            | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| H            | 2450        | 4/9/2015   | 3258     | ES3DV3     | 2450             | Head | 1.779        | 38.17            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| H            | 2600        | 4/9/2015   | 3258     | ES3DV3     | 2600             | Head | 1.945        | 37.62            | PASS          | PASS            | PASS           | TDD             | PASS        | N/A  |
| A            | 5300        | 3/2/2015   | 3914     | EX3DV4     | 5300             | Head | 4.931        | 36.29            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| A            | 5600        | 3/2/2015   | 3914     | EX3DV4     | 5600             | Head | 5.276        | 35.68            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| A            | 5800        | 3/2/2015   | 3914     | EX3DV4     | 5800             | Head | 5.110        | 35.10            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| E            | 750         | 11/11/2014 | 3332     | ES3DV3     | 750              | Body | 0.991        | 55.42            | PASS          | PASS            | PASS           | N/A             | N/A         | N/A  |
| D            | 835         | 4/8/2015   | 3209     | ES3DV3     | 835              | Body | 1.007        | 54.13            | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| J            | 1750        | 9/26/2014  | 3022     | ES3DV2     | 1750             | Body | 1.471        | 51.49            | PASS          | PASS            | PASS           | N/A             | N/A         | N/A  |
| K            | 1900        | 10/15/2014 | 3288     | ES3DV3     | 1900             | Body | 1.532        | 50.91            | PASS          | PASS            | PASS           | GMSK            | PASS        | N/A  |
| B            | 2450        | 1/5/2015   | 3334     | ES3DV3     | 2450             | Body | 2.044        | 50.90            | PASS          | PASS            | PASS           | OFDM/TDD        | N/A         | PASS |
| B            | 2600        | 1/5/2015   | 3334     | ES3DV3     | 2600             | Body | 2.247        | 50.38            | PASS          | PASS            | PASS           | TDD             | N/A         | PASS |
| A            | 5300        | 2/19/2015  | 3914     | EX3DV4     | 5300             | Body | 5.181        | 47.44            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| A            | 5600        | 2/19/2015  | 3914     | EX3DV4     | 5600             | Body | 5.607        | 46.70            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| A            | 5800        | 2/19/2015  | 3914     | EX3DV4     | 5800             | Body | 5.942        | 46.31            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |

**Table E-2**  
**SAR System Validation Summary- 10g**

| SAR SYSTEM # | FREQ. [MHz] | DATE      | PROBE SN | PROBE TYPE | PROBE CAL. POINT |      | COND.        | PERM.            | CW VALIDATION |                 |                | MOD. VALIDATION |             |      |
|--------------|-------------|-----------|----------|------------|------------------|------|--------------|------------------|---------------|-----------------|----------------|-----------------|-------------|------|
|              |             |           |          |            |                  |      | ( $\sigma$ ) | ( $\epsilon_r$ ) | SENSI- TIVITY | PROBE LINEARITY | PROBE ISOTROPY | MOD. TYPE       | DUTY FACTOR | PAR  |
| A            | 5300        | 2/19/2015 | 3914     | EX3DV4     | 5300             | Body | 5.181        | 47.44            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |
| A            | 5600        | 2/19/2015 | 3914     | EX3DV4     | 5600             | Body | 5.607        | 46.70            | PASS          | PASS            | PASS           | OFDM            | N/A         | PASS |

NOTE: While the probes have been calibrated for both CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5 dB), such as OFDM according to KDB 865664.

|                                    |                                                                                                                                   |                            |                                                                                                 |                                 |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------------------|---------------------------------|
| FCC ID: ZNFH811                    |  <b>PCTEST</b><br>ENGINEERING LABORATORY, INC. | SAR EVALUATION REPORT      |  <b>LG</b> | Reviewed by:<br>Quality Manager |
| Test Dates:<br>04/13/15 - 04/20/15 | DUT Type:<br>Portable Handset                                                                                                     | APPENDIX E:<br>Page 1 of 1 |                                                                                                 |                                 |