

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 | 35.8 ± 6 % | 4.91 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL at 5600 MHz

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|-----------------------------------|
| SAR measured | 100 mW input power | 8.37 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 83.7 W / kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.38 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 23.8 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 | 35.5 ± 6 % | 5.11 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 ³ (1 g) of Head TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 7.97 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 79.7 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.26 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 22.6 W/kg ± 19.5 % (k=2) |

Body TSL parameters at 5250 MHz

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|---|-----------------|--------------|------------------|
| Nominal Body TSL parameters | 22.0 °C | 48.9 | 5.36 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 47.0 ± 6 % | 5.46 mho/m ± 6 % |
| Body TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Body TSL at 5250 MHz

| SAR averaged over 1 cm ³ (1 g) of Body TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 7.71 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 76.5 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.15 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 21.3 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 ³ (1 g) of Body TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 8.03 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 79.7 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (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 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 % | 6.20 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 ³ (1 g) of Body TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 7.75 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 76.9 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.15 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 21.3 W/kg ± 19.5 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5250 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 52.6 Ω - 6.7 j Ω |
| Return Loss | - 23.1 dB |

Antenna Parameters with Head TSL at 5600 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 55.6 Ω - 1.4 j Ω |
| Return Loss | - 25.2 dB |

Antenna Parameters with Head TSL at 5800 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 57.2 Ω + 4.0 j Ω |
| Return Loss | - 22.3 dB |

Antenna Parameters with Body TSL at 5250 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 52.3 Ω - 3.7 j Ω |
| Return Loss | - 27.5 dB |

Antenna Parameters with Body TSL at 5600 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 58.6 Ω - 0.6 j Ω |
| Return Loss | - 22.0 dB |

Antenna Parameters with Body TSL at 5800 MHz

| | |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 55.8 Ω + 3.8 j Ω |
| Return Loss | - 23.7 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.204 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 | February 05, 2004 |

DASY5 Validation Report for Head TSL

Date: 23.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1019

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5250$ MHz; $\sigma = 4.54$ S/m; $\epsilon_r = 36.3$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5600$ MHz; $\sigma = 4.91$ S/m; $\epsilon_r = 35.8$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5800$ MHz; $\sigma = 5.11$ S/m; $\epsilon_r = 35.5$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.58, 5.58, 5.58); Calibrated: 31.12.2016, ConvF(5.09, 5.09, 5.09); Calibrated: 31.12.2016, ConvF(5.01, 5.01, 5.01); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 69.55 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 28.9 W/kg

SAR(1 g) = 7.85 W/kg; SAR(10 g) = 2.23 W/kg

Maximum value of SAR (measured) = 17.8 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 = 70.84 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 32.6 W/kg

SAR(1 g) = 8.37 W/kg; SAR(10 g) = 2.38 W/kg

Maximum value of SAR (measured) = 19.4 W/kg

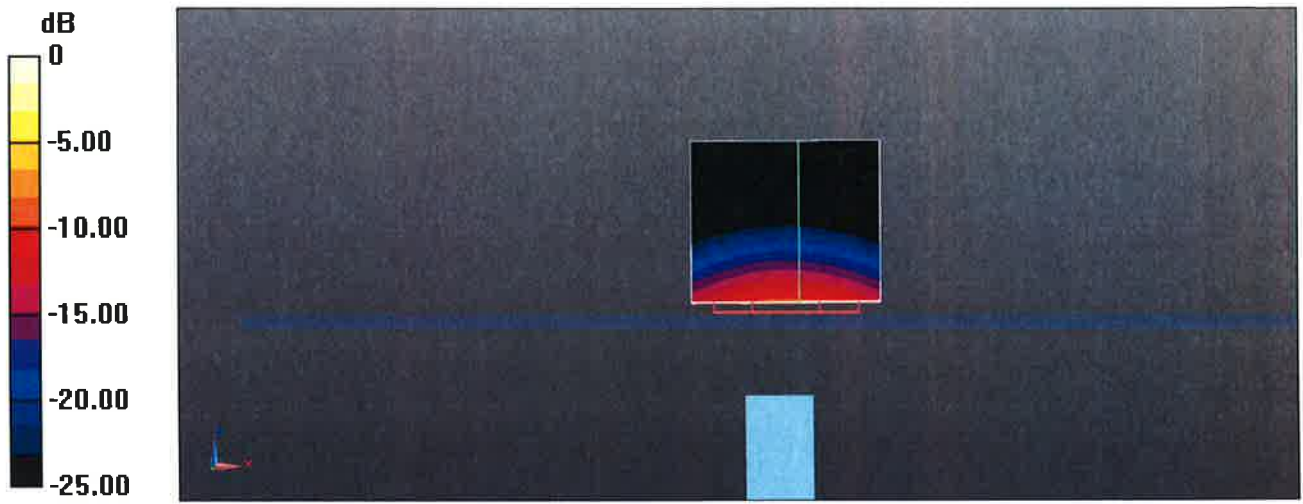
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 68.05 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 32.3 W/kg

SAR(1 g) = 7.97 W/kg; SAR(10 g) = 2.26 W/kg

Maximum value of SAR (measured) = 18.8 W/kg



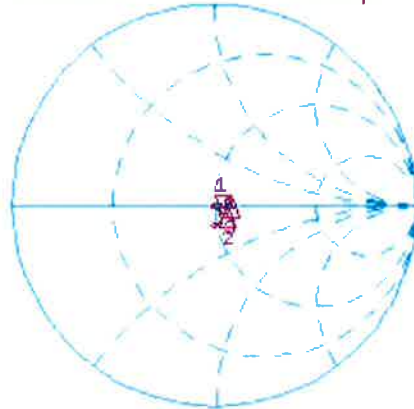
0 dB = 18.8 W/kg = 12.74 dBW/kg

Impedance Measurement Plot for Head TSL

23 Aug 2017 13:16:12

CH1 S11 1 U FS 1: 52.572 Ω -6.7422 Ω 4.4963 pF 5 250.000 000 MHz

*
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Cor
Avg
16
H1d



CH1 Markers
2: 55.625 Ω
-1.4473 Ω
5.60000 GHz
3: 57.238 Ω
4.0215 Ω
5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -23.074 dB 5 250.000 000 MHz

Cor
Avg
16
H1d



CH2 Markers
2: -25.194 dB
5.60000 GHz
3: -22.251 dB
5.80000 GHz

START 5 000.000 000 MHz

STOP 6 000.000 000 MHz

DASY5 Validation Report for Body TSL

Date: 22.08.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1019

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5250$ MHz; $\sigma = 5.46$ S/m; $\epsilon_r = 47$; $\rho = 1000$ kg/m³ ,

Medium parameters used: $f = 5600$ MHz; $\sigma = 5.93$ S/m; $\epsilon_r = 46.4$; $\rho = 1000$ kg/m³ ,

Medium parameters used: $f = 5800$ MHz; $\sigma = 6.2$ S/m; $\epsilon_r = 46.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.14, 5.14, 5.14); Calibrated: 31.12.2016, ConvF(4.57, 4.57, 4.57); Calibrated: 31.12.2016, ConvF(4.48, 4.48, 4.48); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.69 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 7.71 W/kg; SAR(10 g) = 2.15 W/kg

Maximum value of SAR (measured) = 18.1 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 = 65.85 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 33.8 W/kg

SAR(1 g) = 8.03 W/kg; SAR(10 g) = 2.25 W/kg

Maximum value of SAR (measured) = 19.5 W/kg

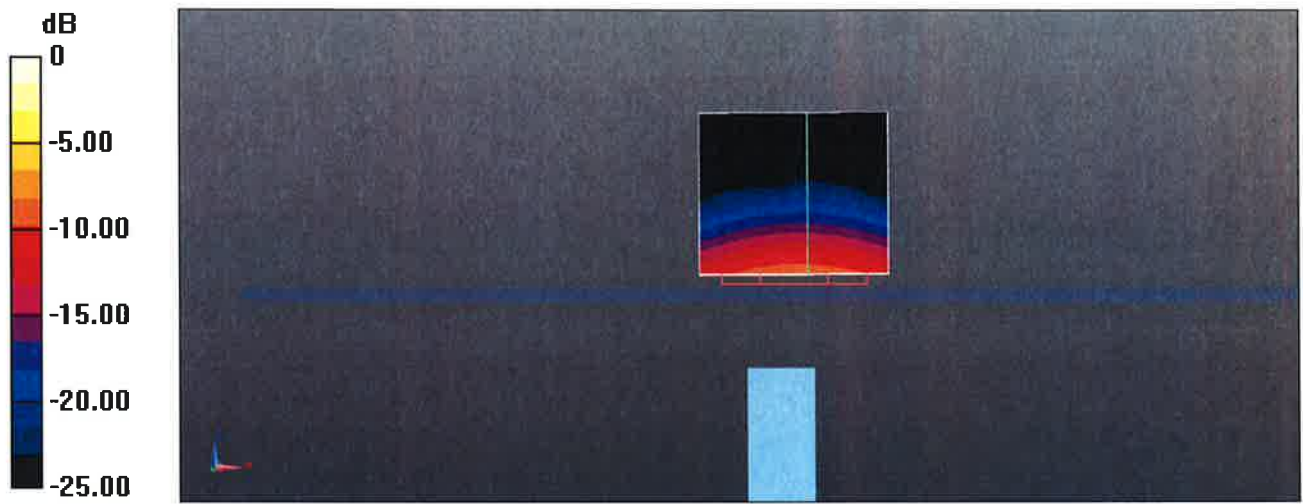
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 63.75 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 34.6 W/kg

SAR(1 g) = 7.75 W/kg; SAR(10 g) = 2.15 W/kg

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



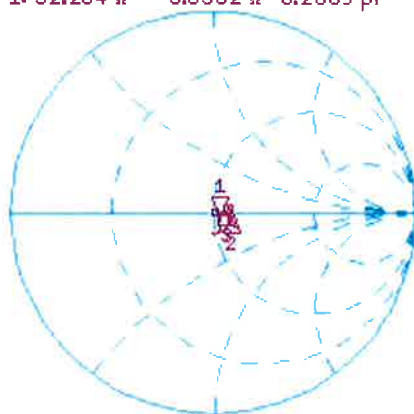
0 dB = 18.1 W/kg = 12.58 dBW/kg

Impedance Measurement Plot for Body TSL

22 Aug 2017 11:48:55

CH1 S11 1 U FS 1: 52.264 Ω -3.6582 Ω 8.2869 pF 5 250.000 000 MHz

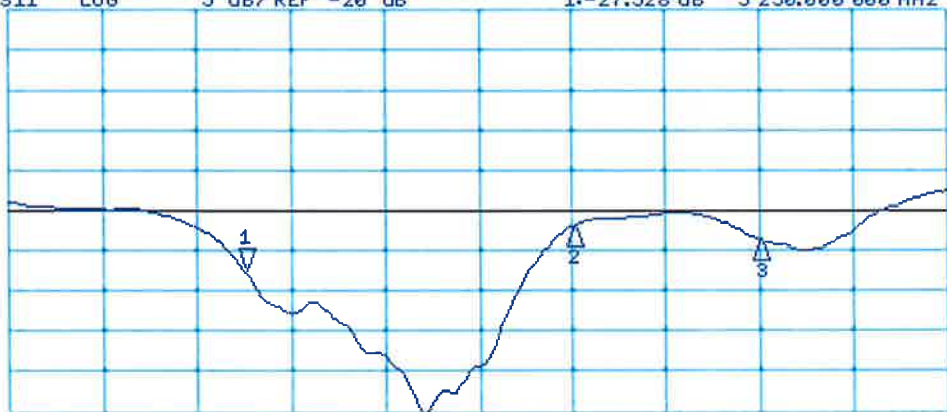
*
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Avg
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H1d



CH1 Markers
2: 58.646 Ω
-591.80 m Ω
5.60000 GHz
3: 55.795 Ω
3.7773 Ω
5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1:-27.528 dB 5 250.000 000 MHz

Cor
Avg
16
H1d



CH2 Markers
2:-21.961 dB
5.60000 GHz
3:-23.693 dB
5.80000 GHz



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Accreditation No.: **SCS 0108**

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

Client **B.V.ADT (Auden)**

Certificate No: **EX3-3650_Jul17**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3650**

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

Calibration date: **July 24, 2017**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|----------------------------|------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 04-Apr-17 (No. 217-02521/02522) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-17 (No. 217-02521) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-17 (No. 217-02525) | Apr-18 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 07-Apr-17 (No. 217-02528) | Apr-18 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-16 (No. ES3-3013_Dec16) | Dec-17 |
| DAE4 | SN: 660 | 7-Dec-16 (No. DAE4-660_Dec16) | Dec-17 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-16) | In house check: Jun-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

| | | | |
|---|------------------------------|--|-----------------------|
| Calibrated by: | Name Michael Weber | Function Laboratory Technician | Signature |
| Approved by: | Name Katja Pokovic | Function Technical Manager | |
| | | | Issued: July 25, 2017 |
| 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 _{x,y,z} | sensitivity in free space |
| ConvF | sensitivity in TSL / NORM _{x,y,z} |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), 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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z}** = NORM_{x,y,z} * 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_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}**: 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_{x,y,z} * 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 ± 50 MHz to ± 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_x (no uncertainty required).

Probe EX3DV4

SN:3650

Manufactured: March 18, 2008
Calibrated: July 24, 2017

Calibrated for DASYS/EASY Systems
(Note: non-compatible with DASYS2 system!)

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3650

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|----------|----------|----------|---------------|
| Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A | 0.40 | 0.40 | 0.40 | $\pm 10.1 \%$ |
| DCP (mV) ^B | 104.1 | 92.7 | 99.1 | |

Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB $\sqrt{\mu\text{V}}$ | C | D dB | VR mV | Unc ^E (k=2) |
|-----|---------------------------|---|---------|------------------------------|-----|---------|----------|---------------------------|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 136.1 | $\pm 1.9 \%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 139.7 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 136.4 | |

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%.

^A The uncertainties of Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Pages 5 and 6).

^B Numerical linearization parameter: uncertainty not required.

^E 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:3650

Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth (mm) ^G | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750 | 41.9 | 0.89 | 10.31 | 10.31 | 10.31 | 0.35 | 1.00 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 9.91 | 9.91 | 9.91 | 0.40 | 0.88 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 9.80 | 9.80 | 9.80 | 0.45 | 0.90 | ± 12.0 % |
| 1450 | 40.5 | 1.20 | 8.94 | 8.94 | 8.94 | 0.39 | 0.80 | ± 12.0 % |
| 1640 | 40.2 | 1.31 | 8.69 | 8.69 | 8.69 | 0.39 | 0.80 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.56 | 8.56 | 8.56 | 0.30 | 0.90 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.28 | 8.28 | 8.28 | 0.36 | 0.85 | ± 12.0 % |
| 2100 | 39.8 | 1.49 | 8.35 | 8.35 | 8.35 | 0.45 | 0.82 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 8.06 | 8.06 | 8.06 | 0.44 | 0.90 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.58 | 7.58 | 7.58 | 0.40 | 0.95 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.55 | 7.55 | 7.55 | 0.45 | 0.90 | ± 12.0 % |
| 3500 | 37.9 | 2.91 | 7.38 | 7.38 | 7.38 | 0.30 | 1.15 | ± 13.1 % |
| 3700 | 37.7 | 3.12 | 7.07 | 7.07 | 7.07 | 0.35 | 1.15 | ± 13.1 % |
| 5250 | 35.9 | 4.71 | 5.60 | 5.60 | 5.60 | 0.35 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.90 | 4.90 | 4.90 | 0.50 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 4.94 | 4.94 | 4.94 | 0.50 | 1.80 | ± 13.1 % |

^C 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.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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:3650

Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750 | 55.5 | 0.96 | 9.89 | 9.89 | 9.89 | 0.37 | 0.99 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 9.76 | 9.76 | 9.76 | 0.42 | 0.85 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 9.60 | 9.60 | 9.60 | 0.42 | 0.85 | ± 12.0 % |
| 1450 | 54.0 | 1.30 | 8.78 | 8.78 | 8.78 | 0.39 | 0.80 | ± 12.0 % |
| 1640 | 53.7 | 1.42 | 8.67 | 8.67 | 8.67 | 0.42 | 0.80 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.27 | 8.27 | 8.27 | 0.42 | 0.80 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 8.00 | 8.00 | 8.00 | 0.43 | 0.80 | ± 12.0 % |
| 2100 | 53.2 | 1.62 | 8.18 | 8.18 | 8.18 | 0.38 | 0.86 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.90 | 7.90 | 7.90 | 0.38 | 0.80 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.68 | 7.68 | 7.68 | 0.32 | 0.89 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.37 | 7.37 | 7.37 | 0.32 | 0.92 | ± 12.0 % |
| 3500 | 51.3 | 3.31 | 7.15 | 7.15 | 7.15 | 0.30 | 1.20 | ± 13.1 % |
| 3700 | 51.0 | 3.55 | 7.00 | 7.00 | 7.00 | 0.30 | 1.25 | ± 13.1 % |
| 5250 | 48.9 | 5.36 | 5.28 | 5.28 | 5.28 | 0.35 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 4.29 | 4.29 | 4.29 | 0.50 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.61 | 4.61 | 4.61 | 0.50 | 1.90 | ± 13.1 % |

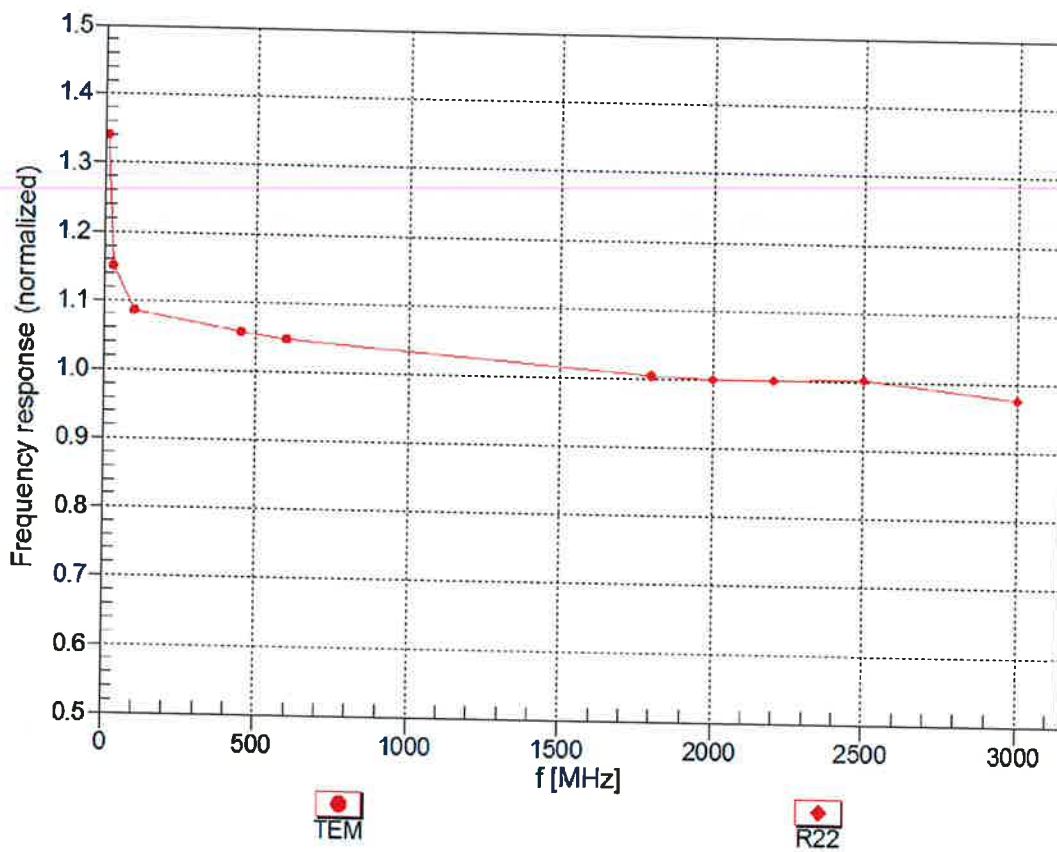
^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is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

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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.

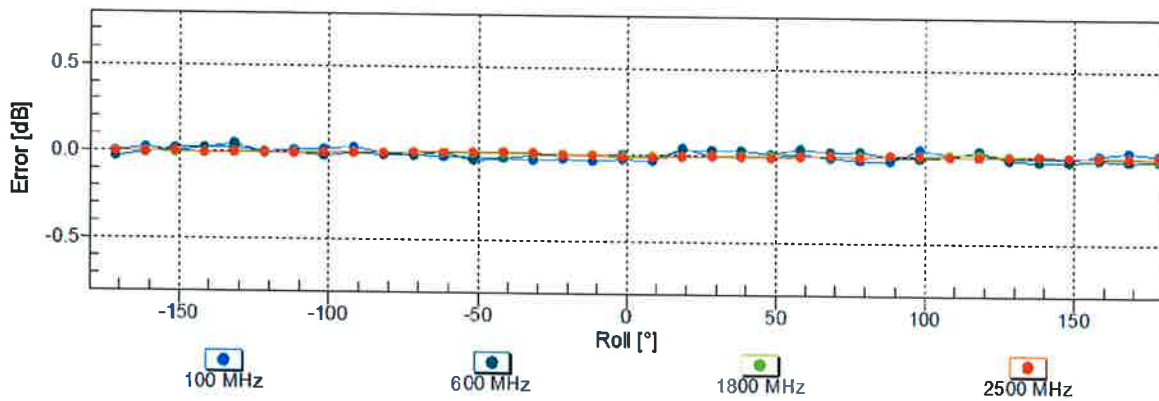
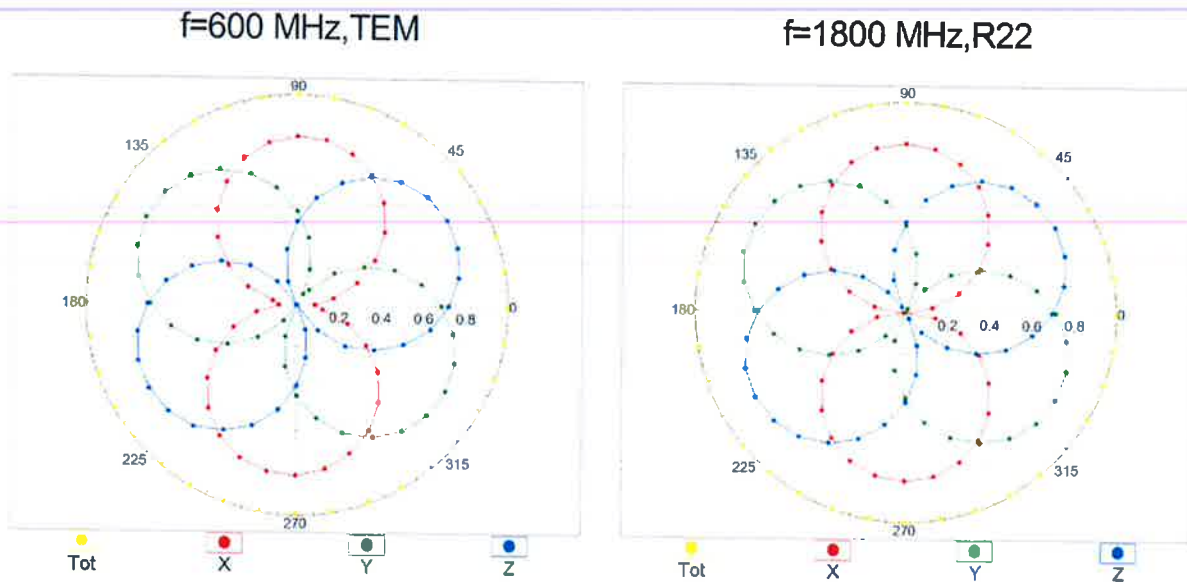
Frequency Response of E-Field

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



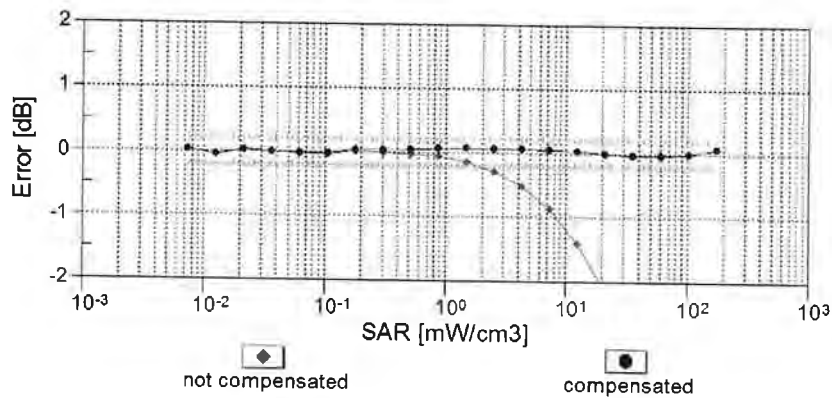
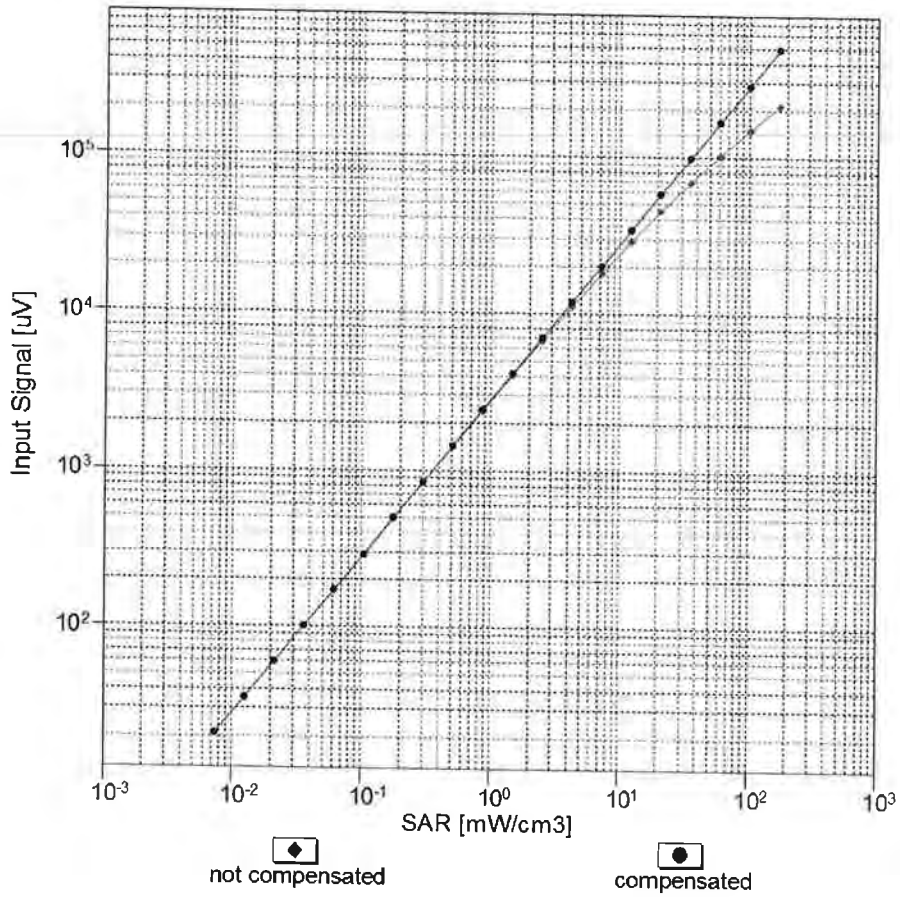
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

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



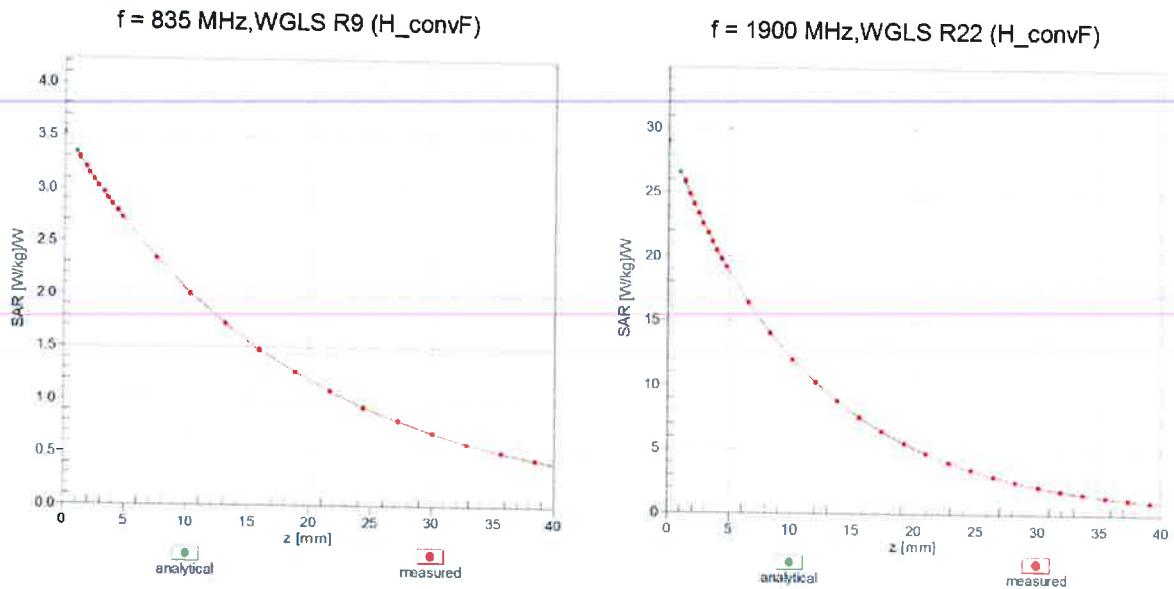
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

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

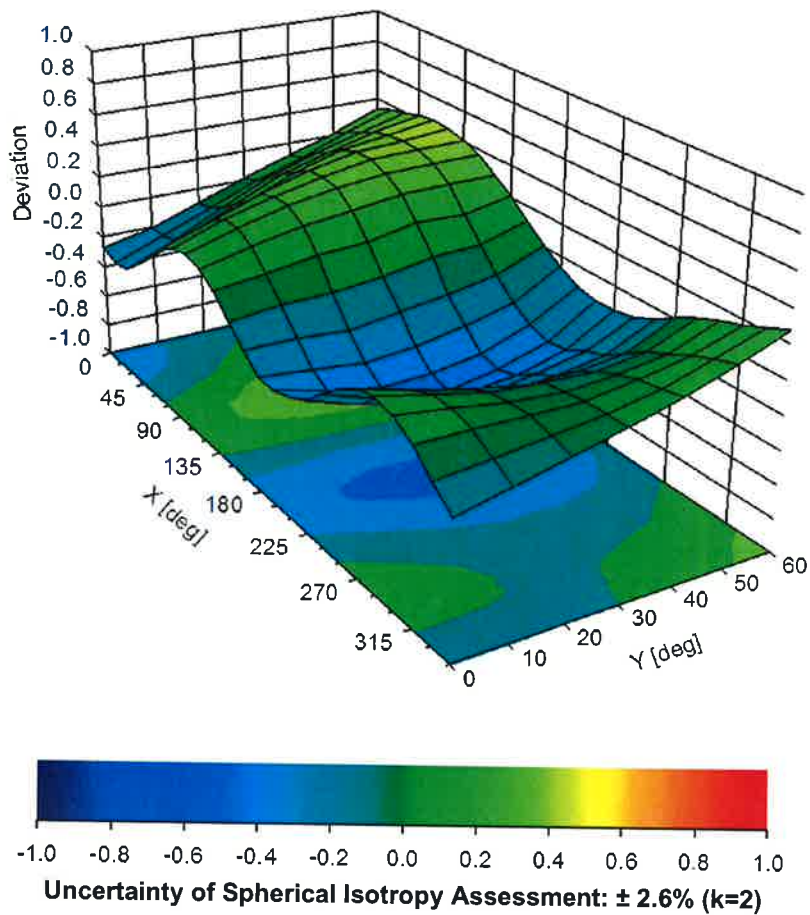


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ, ϑ), f = 900 MHz



DASY/EASY - Parameters of Probe: EX3DV4 - SN:3650**Other Probe Parameters**

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | -21.6 |
| 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 **B.V.ADT (Auden)**

Certificate No: **EX3-3971_Mar17**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3971**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v4, QA CAL-23.v5,
QA CAL-25.v6
Calibration procedure for dosimetric E-field probes**

Calibration date: **March 24, 2017**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|----------------------------|------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 05-Apr-16 (No. 217-02293) | Apr-17 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-16 (No. ES3-3013_Dec16) | Dec-17 |
| DAE4 | SN: 660 | 7-Dec-16 (No. DAE4-660_Dec16) | Dec-17 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-16) | In house check: Jun-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

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

Issued: March 24, 2017

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 0108**

Glossary:

| | |
|--------------------------|---|
| TSL | tissue simulating liquid |
| NORM _{x,y,z} | sensitivity in free space |
| ConvF | sensitivity in TSL / NORM _{x,y,z} |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), 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:

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

Methods Applied and Interpretation of Parameters:

- **NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- **NORM(f)_{x,y,z} = NORM_{x,y,z} * 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_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- **PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- **A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}; 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_{x,y,z} * 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 ± 50 MHz to ± 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_x (no uncertainty required).

Probe EX3DV4

SN:3971

Manufactured: December 30, 2013
Calibrated: March 24, 2017

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3971

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|----------|----------|----------|---------------|
| Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A | 0.40 | 0.50 | 0.48 | $\pm 10.1 \%$ |
| DCP (mV) ^B | 101.4 | 99.2 | 100.2 | |

Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB $\sqrt{\mu\text{V}}$ | C | D dB | VR mV | Unc ^E (k=2) |
|-----|---------------------------|---|---------|------------------------------|-----|---------|----------|---------------------------|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 156.0 | $\pm 3.0 \%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 141.4 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 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%.

^A The uncertainties of Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Pages 5 and 6).

^B Numerical linearization parameter: uncertainty not required.

^E 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:3971

Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 6 | 55.5 | 0.75 | 21.45 | 21.45 | 21.45 | 0.00 | 1.00 | ± 13.3 % |
| 13 | 55.5 | 0.75 | 18.18 | 18.18 | 18.18 | 0.00 | 1.00 | ± 13.3 % |
| 750 | 41.9 | 0.89 | 10.91 | 10.91 | 10.91 | 0.46 | 0.95 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 10.67 | 10.67 | 10.67 | 0.40 | 0.95 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 10.51 | 10.51 | 10.51 | 0.46 | 0.85 | ± 12.0 % |
| 1450 | 40.5 | 1.20 | 8.99 | 8.99 | 8.99 | 0.30 | 0.90 | ± 12.0 % |
| 1640 | 40.2 | 1.31 | 8.94 | 8.94 | 8.94 | 0.36 | 0.80 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.92 | 8.92 | 8.92 | 0.34 | 0.81 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.59 | 8.59 | 8.59 | 0.33 | 0.84 | ± 12.0 % |
| 2000 | 40.0 | 1.40 | 8.54 | 8.54 | 8.54 | 0.33 | 0.84 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 8.12 | 8.12 | 8.12 | 0.29 | 0.84 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.77 | 7.77 | 7.77 | 0.35 | 0.80 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.59 | 7.59 | 7.59 | 0.39 | 0.80 | ± 12.0 % |
| 5250 | 35.9 | 4.71 | 5.34 | 5.34 | 5.34 | 0.35 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 5.14 | 5.14 | 5.14 | 0.40 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.96 | 4.96 | 4.96 | 0.40 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 4.98 | 4.98 | 4.98 | 0.40 | 1.80 | ± 13.1 % |

^C 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.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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:3971

Calibration Parameter Determined in Body Tissue Simulating Media

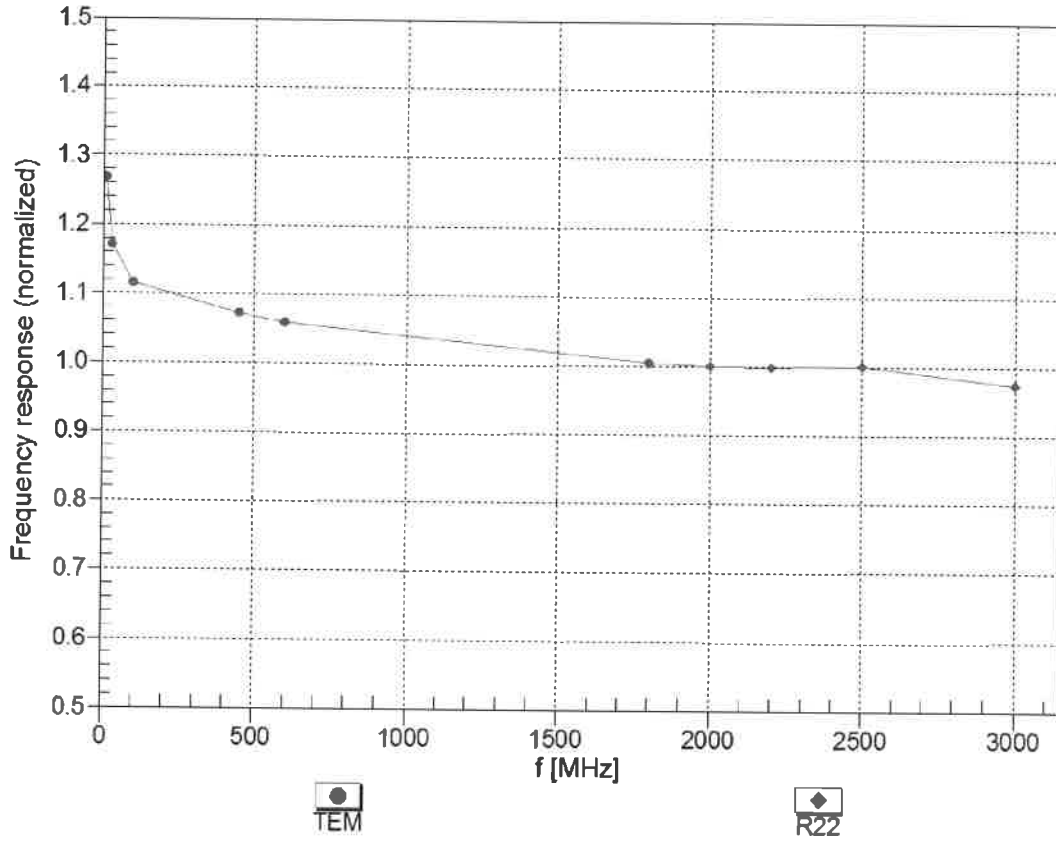
| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750 | 55.5 | 0.96 | 10.61 | 10.61 | 10.61 | 0.49 | 0.80 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 10.52 | 10.52 | 10.52 | 0.44 | 0.80 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 10.48 | 10.48 | 10.48 | 0.47 | 0.82 | ± 12.0 % |
| 1450 | 54.0 | 1.30 | 8.80 | 8.80 | 8.80 | 0.33 | 0.80 | ± 12.0 % |
| 1640 | 53.7 | 1.42 | 8.73 | 8.73 | 8.73 | 0.40 | 0.80 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.51 | 8.51 | 8.51 | 0.34 | 0.89 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 8.26 | 8.26 | 8.26 | 0.27 | 0.95 | ± 12.0 % |
| 2000 | 53.3 | 1.52 | 8.43 | 8.43 | 8.43 | 0.33 | 0.88 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.85 | 7.85 | 7.85 | 0.36 | 0.80 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.67 | 7.67 | 7.67 | 0.30 | 0.85 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.32 | 7.32 | 7.32 | 0.21 | 0.99 | ± 12.0 % |
| 5250 | 48.9 | 5.36 | 4.70 | 4.70 | 4.70 | 0.45 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.32 | 4.32 | 4.32 | 0.50 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 4.10 | 4.10 | 4.10 | 0.50 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.22 | 4.22 | 4.22 | 0.50 | 1.90 | ± 13.1 % |

^C 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 $\pm 10, 25, 40, 50$ and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to $\pm 5\%$. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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)

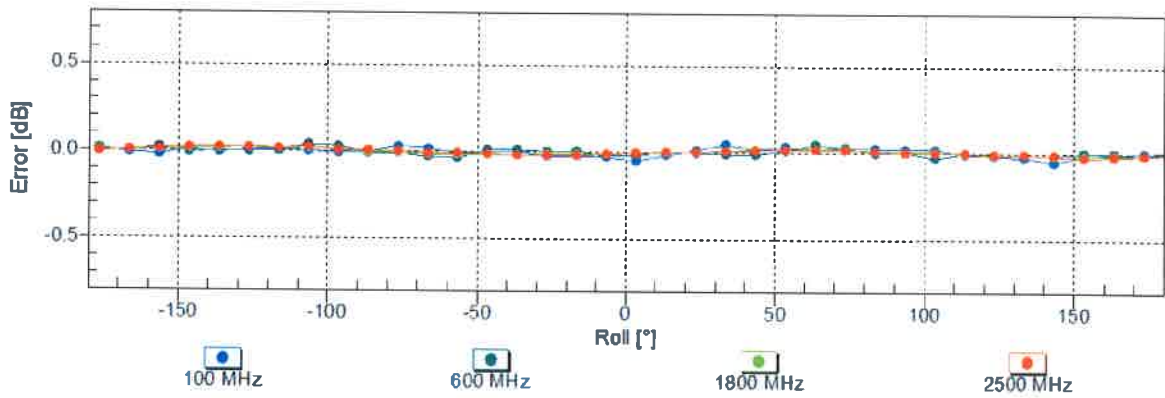
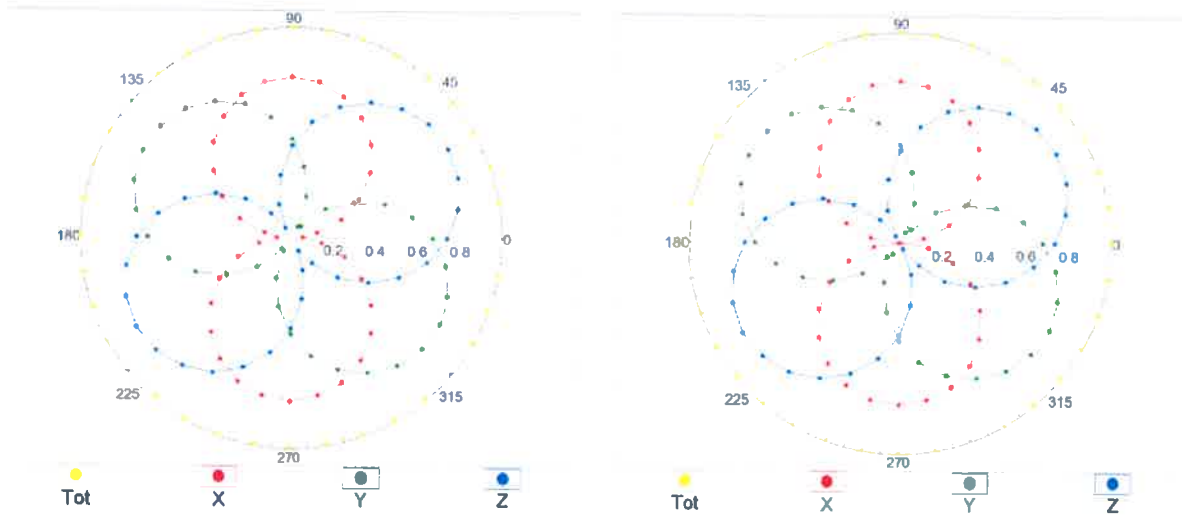


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

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

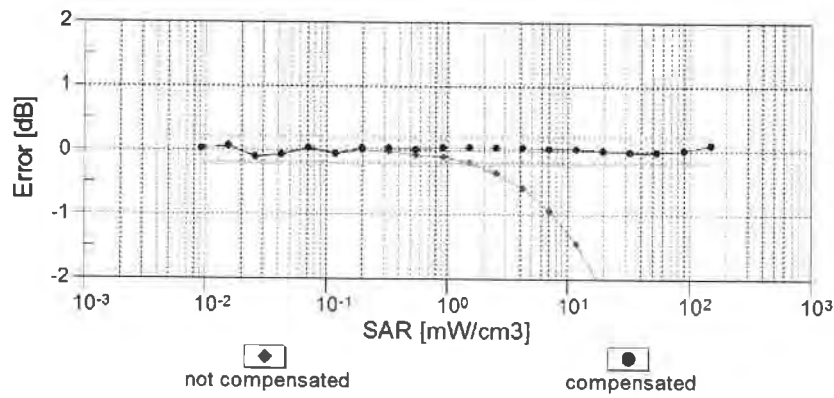
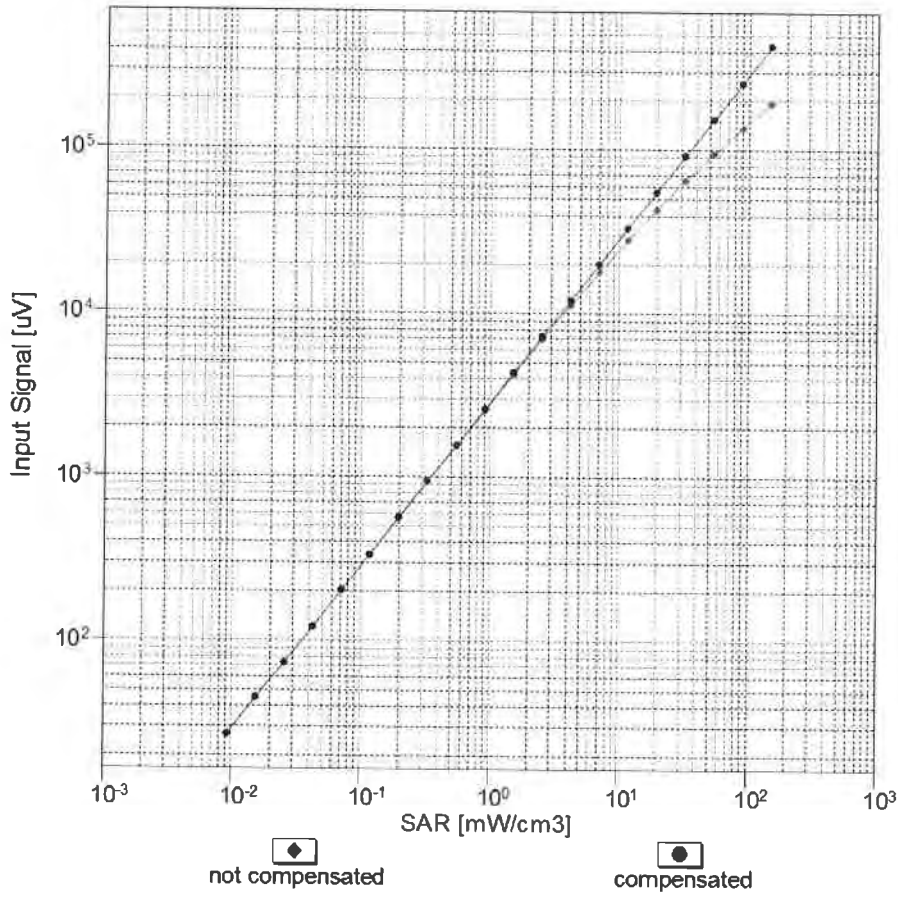
f=600 MHz,TEM

f=1800 MHz,R22



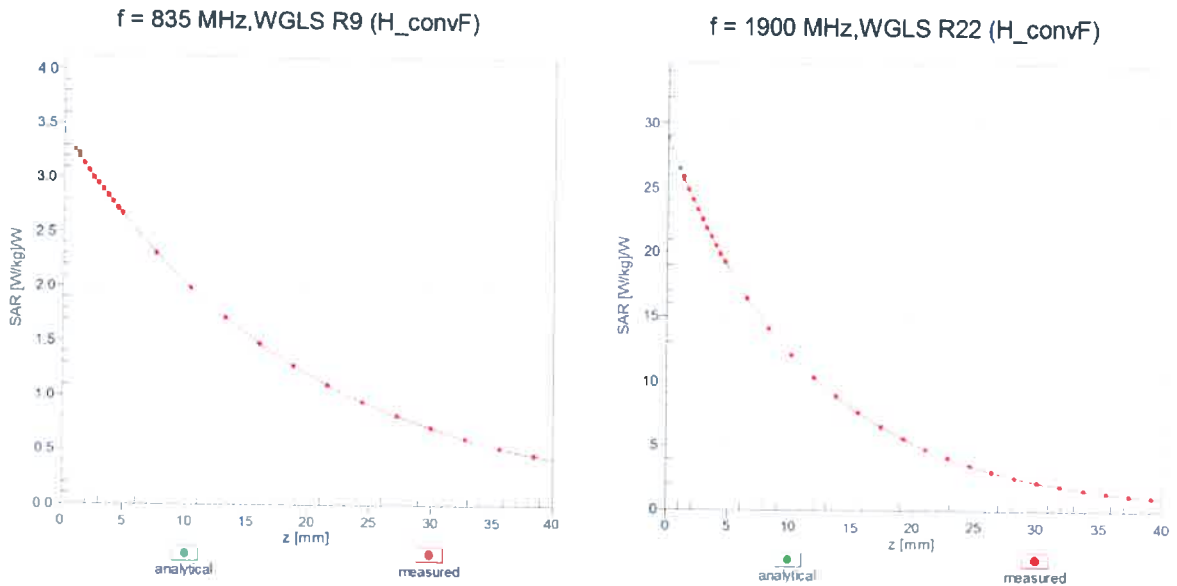
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

Dynamic Range f(SAR_{head}) (TEM cell , f_{eval}= 1900 MHz)

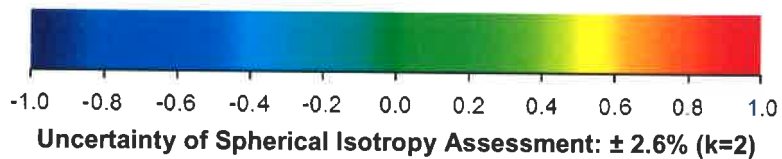
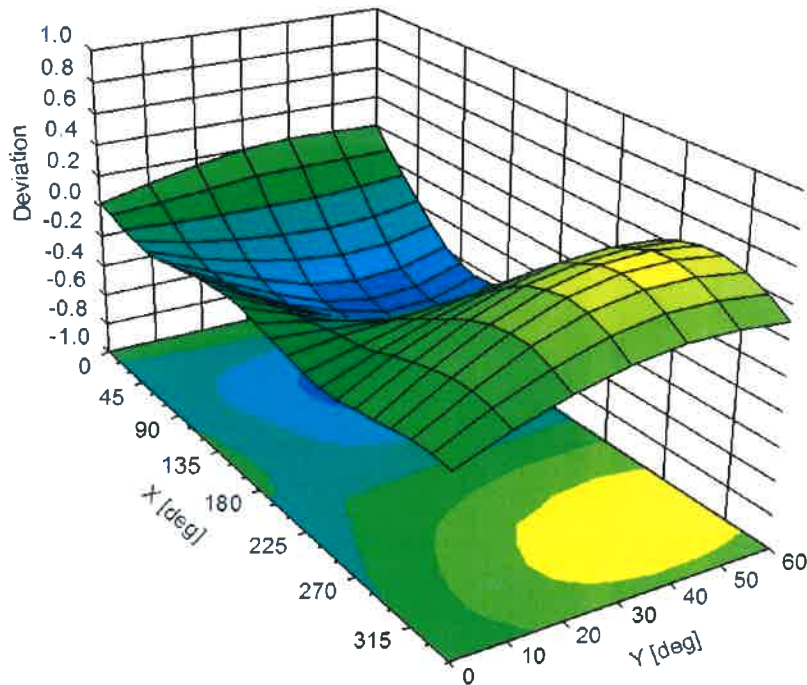


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ, θ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3971

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 73.4 |
| 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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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 **Auden**

Certificate No: **EX3-7375_Dec17**

CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:7375**

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: **December 18, 2017**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|----------------------------|------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 04-Apr-17 (No. 217-02521/02522) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-17 (No. 217-02521) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-17 (No. 217-02525) | Apr-18 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 07-Apr-17 (No. 217-02528) | Apr-18 |
| Reference Probe ES3DV2 | SN: 3013 | 31-Dec-16 (No. ES3-3013_Dec16) | Dec-17 |
| DAE4 | SN: 654 | 24-Jul-17 (No. DAE4-654_Jul17) | Jul-18 |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-16) | In house check: Jun-18 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-16) | In house check: Jun-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-17) | In house check: Oct-18 |

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

Issued: December 21, 2017

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 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Methods Applied and Interpretation of Parameters:

- *NORM_{x,y,z}*: Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). *NORM_{x,y,z}* are only intermediate values, i.e., the uncertainties of *NORM_{x,y,z}* does not affect the E²-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)_{x,y,z} = NORM_{x,y,z} * 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_{x,y,z}*: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR*: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}; 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 ≤ 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_{x,y,z} * 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 ± 50 MHz to ± 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_x* (no uncertainty required).

Probe EX3DV4

SN:7375

Manufactured: April 13, 2015
Calibrated: December 18, 2017

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7375

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|----------|----------|----------|---------------|
| Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A | 0.49 | 0.42 | 0.46 | $\pm 10.1 \%$ |
| DCP (mV) ^B | 97.7 | 95.2 | 96.1 | |

Modulation Calibration Parameters

| UID | Communication System Name | | A dB | B dB $\sqrt{\mu\text{V}}$ | C | D dB | VR mV | Unc ^E (k=2) |
|-----|---------------------------|---|---------|------------------------------|-----|---------|----------|---------------------------|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 139.8 | $\pm 3.3 \%$ |
| | | Y | 0.0 | 0.0 | 1.0 | | 142.5 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 131.3 | |

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%.

^A The uncertainties of Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Pages 5 and 6).

^B Numerical linearization parameter: uncertainty not required.

^E 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:7375

Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750 | 41.9 | 0.89 | 10.59 | 10.59 | 10.59 | 0.46 | 0.88 | ± 12.0 % |
| 835 | 41.5 | 0.90 | 10.31 | 10.31 | 10.31 | 0.39 | 0.94 | ± 12.0 % |
| 900 | 41.5 | 0.97 | 10.02 | 10.02 | 10.02 | 0.50 | 0.80 | ± 12.0 % |
| 1750 | 40.1 | 1.37 | 8.81 | 8.81 | 8.81 | 0.35 | 0.86 | ± 12.0 % |
| 1900 | 40.0 | 1.40 | 8.41 | 8.41 | 8.41 | 0.34 | 0.84 | ± 12.0 % |
| 2000 | 40.0 | 1.40 | 8.34 | 8.34 | 8.34 | 0.38 | 0.84 | ± 12.0 % |
| 2300 | 39.5 | 1.67 | 7.88 | 7.88 | 7.88 | 0.35 | 0.84 | ± 12.0 % |
| 2450 | 39.2 | 1.80 | 7.65 | 7.65 | 7.65 | 0.40 | 0.80 | ± 12.0 % |
| 2600 | 39.0 | 1.96 | 7.34 | 7.34 | 7.34 | 0.38 | 0.88 | ± 12.0 % |
| 5200 | 36.0 | 4.66 | 5.34 | 5.34 | 5.34 | 0.40 | 1.80 | ± 13.1 % |
| 5300 | 35.9 | 4.76 | 5.15 | 5.15 | 5.15 | 0.40 | 1.80 | ± 13.1 % |
| 5500 | 35.6 | 4.96 | 4.94 | 4.94 | 4.94 | 0.40 | 1.80 | ± 13.1 % |
| 5600 | 35.5 | 5.07 | 4.72 | 4.72 | 4.72 | 0.40 | 1.80 | ± 13.1 % |
| 5800 | 35.3 | 5.27 | 4.80 | 4.80 | 4.80 | 0.40 | 1.80 | ± 13.1 % |

^C 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.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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:7375

Calibration Parameter Determined in Body Tissue Simulating Media

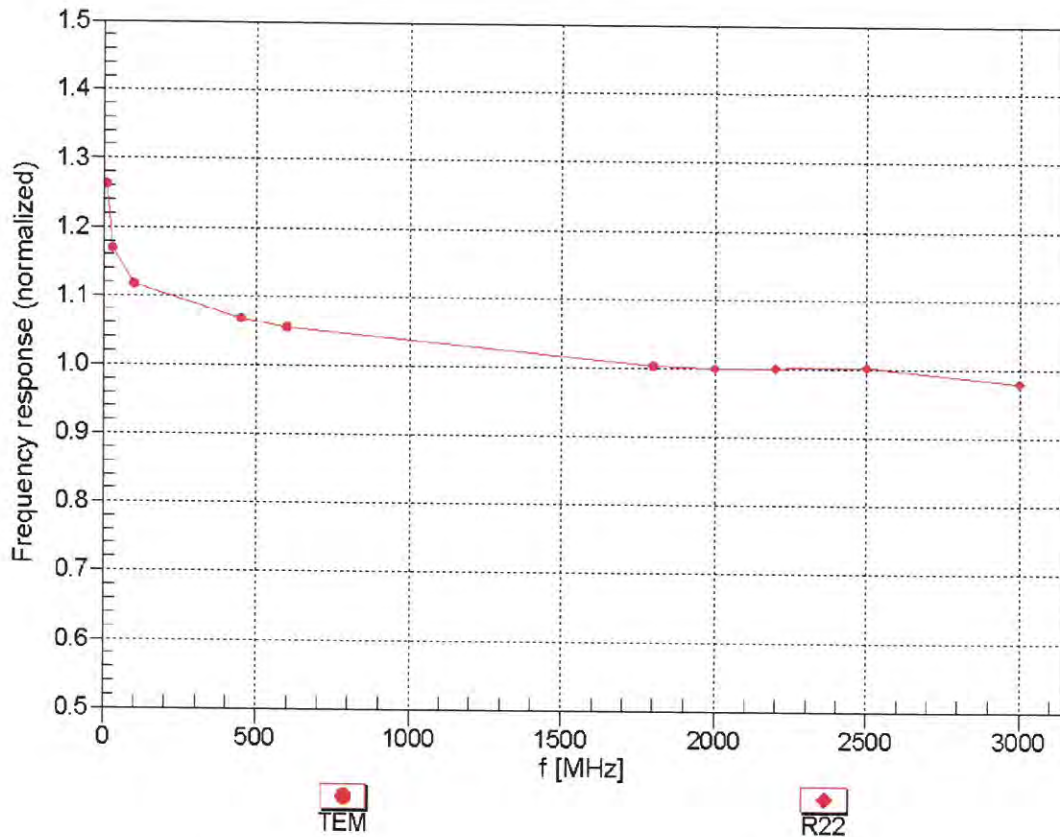
| f (MHz) ^C | Relative Permittivity ^F | Conductivity (S/m) ^F | ConvF X | ConvF Y | ConvF Z | Alpha ^G | Depth ^G (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750 | 55.5 | 0.96 | 10.49 | 10.49 | 10.49 | 0.53 | 0.94 | ± 12.0 % |
| 835 | 55.2 | 0.97 | 10.14 | 10.14 | 10.14 | 0.44 | 1.00 | ± 12.0 % |
| 900 | 55.0 | 1.05 | 10.06 | 10.06 | 10.06 | 0.58 | 0.82 | ± 12.0 % |
| 1750 | 53.4 | 1.49 | 8.99 | 8.99 | 8.99 | 0.39 | 0.84 | ± 12.0 % |
| 1900 | 53.3 | 1.52 | 8.44 | 8.44 | 8.44 | 0.47 | 0.80 | ± 12.0 % |
| 2000 | 53.3 | 1.52 | 8.38 | 8.38 | 8.38 | 0.43 | 0.83 | ± 12.0 % |
| 2300 | 52.9 | 1.81 | 7.93 | 7.93 | 7.93 | 0.44 | 0.80 | ± 12.0 % |
| 2450 | 52.7 | 1.95 | 7.83 | 7.83 | 7.83 | 0.38 | 0.89 | ± 12.0 % |
| 2600 | 52.5 | 2.16 | 7.43 | 7.43 | 7.43 | 0.44 | 0.83 | ± 12.0 % |
| 5200 | 49.0 | 5.30 | 4.84 | 4.84 | 4.84 | 0.45 | 1.90 | ± 13.1 % |
| 5300 | 48.9 | 5.42 | 4.64 | 4.64 | 4.64 | 0.45 | 1.90 | ± 13.1 % |
| 5500 | 48.6 | 5.65 | 4.22 | 4.22 | 4.22 | 0.45 | 1.90 | ± 13.1 % |
| 5600 | 48.5 | 5.77 | 4.10 | 4.10 | 4.10 | 0.45 | 1.90 | ± 13.1 % |
| 5800 | 48.2 | 6.00 | 4.41 | 4.41 | 4.41 | 0.45 | 1.90 | ± 13.1 % |

^C 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.

^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) 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 (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G 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)

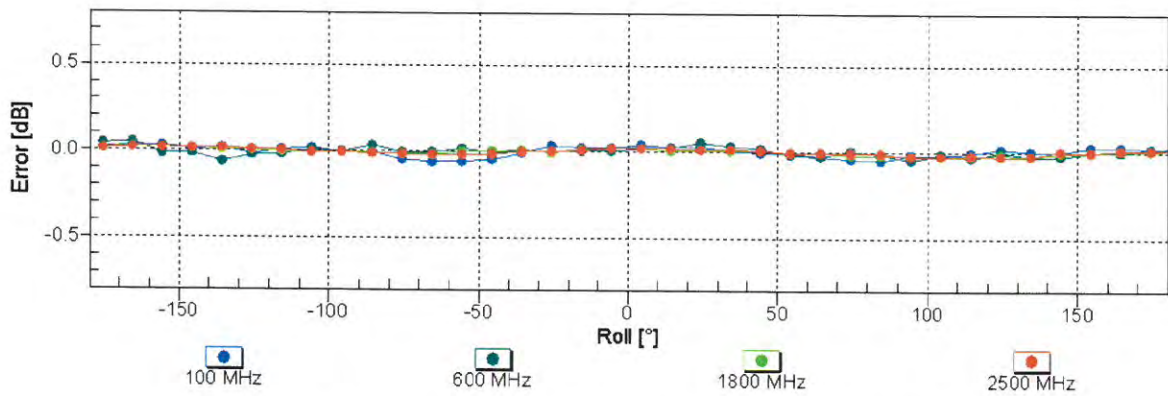
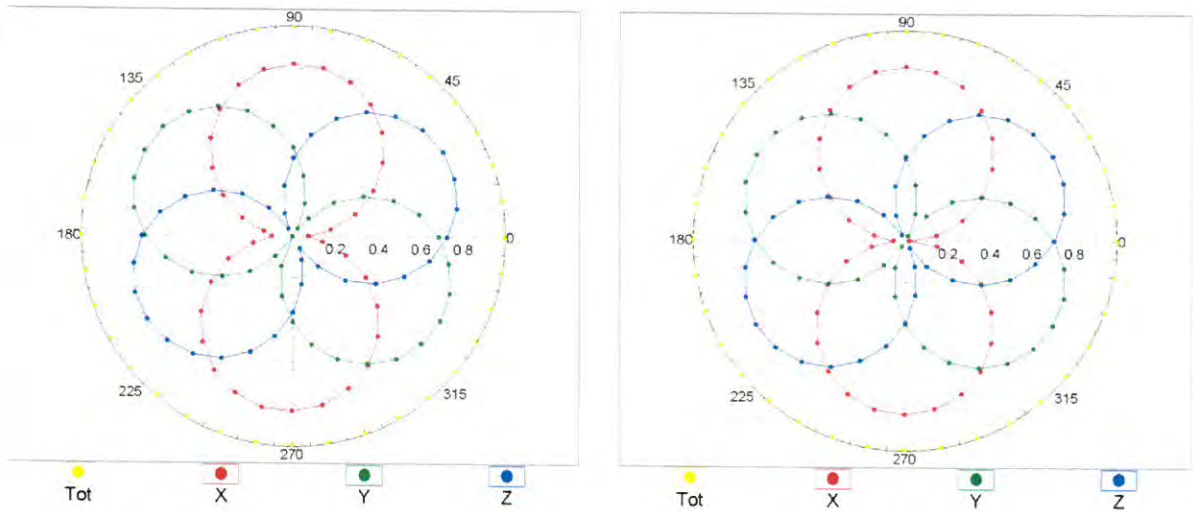


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

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

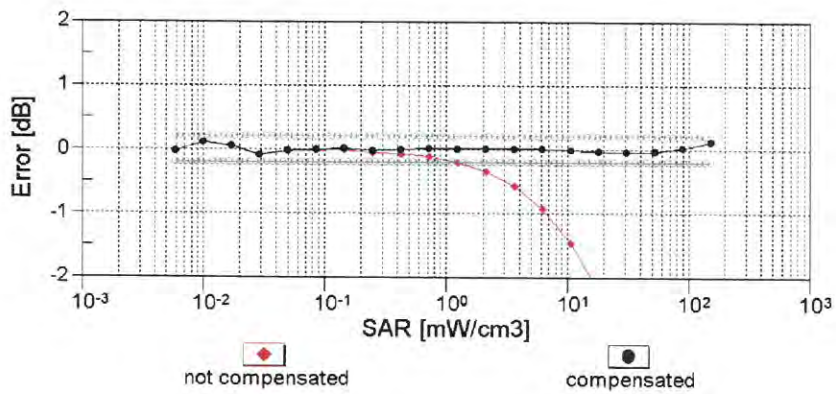
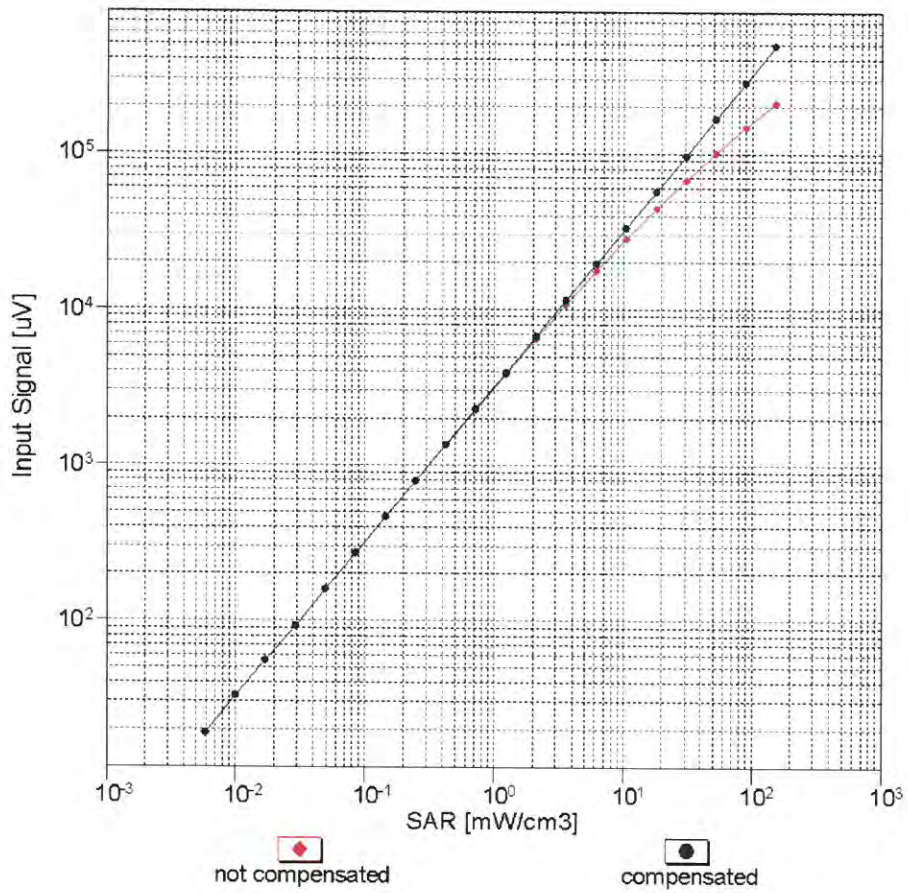
f=600 MHz,TEM

f=1800 MHz,R22



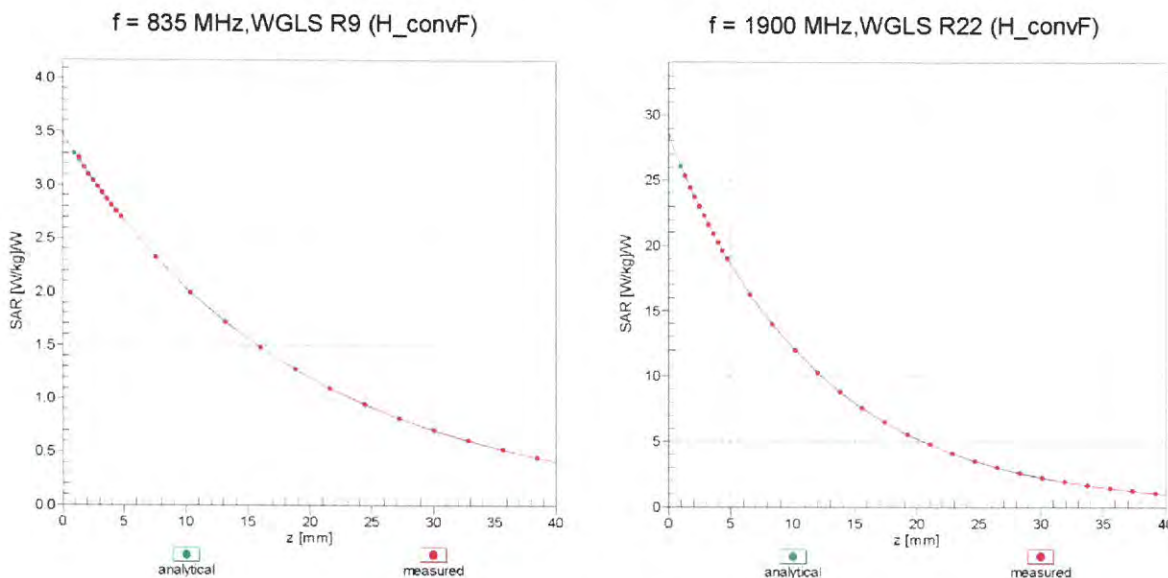
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

Dynamic Range f(SAR_{head}) (TEM cell , f_{eval}= 1900 MHz)

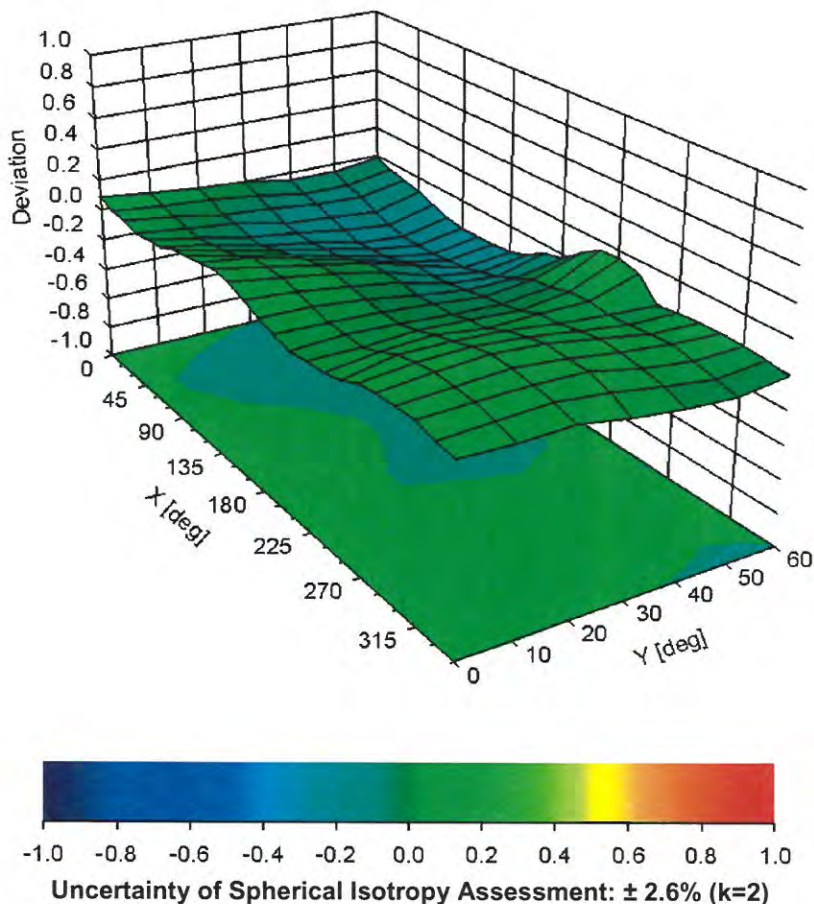


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ, ϑ), f = 900 MHz



DASY/EASY - Parameters of Probe: EX3DV4 - SN:7375

Other Probe Parameters

| | |
|---|------------|
| Sensor Arrangement | Triangular |
| Connector Angle (°) | 14.3 |
| 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 |