

## Attachment 3. – Probe Calibration Data

**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 0108**

Client **HCT (Dymstec)**

Certificate No: **EX3-3863\_Aug15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3863**

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: **August 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  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards          | ID              | Cal Date (Certificate No.)        | Scheduled Calibration  |
|----------------------------|-----------------|-----------------------------------|------------------------|
| Power meter E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: 55054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: 55277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: 55129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

|                                                                                                                 | Name          | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|---------------|-----------------------|-----------|
| Calibrated by:                                                                                                  | Jeton Kasrati | Laboratory Technician |           |
| Approved by:                                                                                                    | Katja Pokovic | Technical Manager     |           |
| Issued: August 29, 2015                                                                                         |               |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |               |                       |           |

Certificate No: EX3-3863\_Aug15

Page 1 of 11

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Accreditation No.: **SCS 0108**

#### Glossary:

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

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

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Methods Applied and Interpretation of Parameters:

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

EX3DV4 – SN:3863

August 27, 2015

# Probe EX3DV4

## SN:3863

Manufactured: February 2, 2012  
Calibrated: August 27, 2015

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

EX3DV4-- SN:3863

August 27, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3863

### Basic Calibration Parameters

|                                            | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|--------------------------------------------|----------|----------|----------|-----------|
| Norm ( $\mu V/(V/m)^{-0.5}$ ) <sup>A</sup> | 0.37     | 0.35     | 0.45     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                      | 101.9    | 103.9    | 98.9     |           |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A<br>dB | B<br>dB√μV | 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    | 131.8    | ±2.7 %                    |
|     |                           | Y | 0.0     | 0.0        | 1.0 |         | 129.9    |                           |
|     |                           | Z | 0.0     | 0.0        | 1.0 |         | 126.4    |                           |

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

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

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

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

EX3DV4- SN:3863

August 27, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3863

### Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) <sup>c</sup> | Relative Permittivity <sup>e</sup> | Conductivity (S/m) <sup>f</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>g</sup> | Depth <sup>g</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 150                  | 52.3                               | 0.76                            | 11.89   | 11.89   | 11.89   | 0.00               | 1.00                    | ± 13.3 %  |
| 450                  | 43.5                               | 0.87                            | 10.31   | 10.31   | 10.31   | 0.17               | 1.30                    | ± 13.3 %  |
| 750                  | 41.9                               | 0.89                            | 9.83    | 9.83    | 9.83    | 0.24               | 1.21                    | ± 12.0 %  |
| 835                  | 41.5                               | 0.90                            | 9.46    | 9.46    | 9.46    | 0.21               | 1.30                    | ± 12.0 %  |
| 900                  | 41.5                               | 0.97                            | 9.28    | 9.28    | 9.28    | 0.26               | 1.11                    | ± 12.0 %  |
| 1450                 | 40.5                               | 1.20                            | 8.31    | 8.31    | 8.31    | 0.15               | 1.81                    | ± 12.0 %  |
| 1750                 | 40.1                               | 1.37                            | 8.18    | 8.18    | 8.18    | 0.36               | 0.90                    | ± 12.0 %  |
| 1900                 | 40.0                               | 1.40                            | 7.84    | 7.84    | 7.84    | 0.21               | 1.07                    | ± 12.0 %  |
| 1950                 | 40.0                               | 1.40                            | 7.60    | 7.60    | 7.60    | 0.31               | 0.80                    | ± 12.0 %  |
| 2450                 | 39.2                               | 1.80                            | 7.04    | 7.04    | 7.04    | 0.27               | 0.98                    | ± 12.0 %  |
| 2600                 | 39.0                               | 1.96                            | 6.84    | 6.84    | 6.84    | 0.27               | 1.04                    | ± 12.0 %  |
| 3500                 | 37.9                               | 2.91                            | 6.77    | 6.77    | 6.77    | 0.38               | 1.06                    | ± 13.1 %  |
| 5250                 | 35.9                               | 4.71                            | 4.94    | 4.94    | 4.94    | 0.35               | 1.80                    | ± 13.1 %  |
| 5600                 | 35.5                               | 5.07                            | 4.44    | 4.44    | 4.44    | 0.45               | 1.80                    | ± 13.1 %  |
| 5750                 | 35.4                               | 5.22                            | 4.65    | 4.65    | 4.65    | 0.45               | 1.80                    | ± 13.1 %  |

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

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

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

EX3DV4-- SN:3863

August 27, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3863

### Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) <sup>c</sup> | Relative Permittivity <sup>f</sup> | Conductivity (S/m) <sup>f</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>g</sup> | Depth <sup>g</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 150                  | 61.9                               | 0.80                            | 11.68   | 11.68   | 11.68   | 0.00               | 1.00                    | ± 13.3 %  |
| 450                  | 56.7                               | 0.94                            | 10.67   | 10.67   | 10.67   | 0.10               | 1.20                    | ± 13.3 %  |
| 750                  | 55.5                               | 0.96                            | 9.76    | 9.76    | 9.76    | 0.25               | 1.16                    | ± 12.0 %  |
| 835                  | 55.2                               | 0.97                            | 9.40    | 9.40    | 9.40    | 0.23               | 1.44                    | ± 12.0 %  |
| 1750                 | 53.4                               | 1.49                            | 7.73    | 7.73    | 7.73    | 0.24               | 1.01                    | ± 12.0 %  |
| 1900                 | 53.3                               | 1.52                            | 7.48    | 7.48    | 7.48    | 0.39               | 0.80                    | ± 12.0 %  |
| 2450                 | 52.7                               | 1.95                            | 7.11    | 7.11    | 7.11    | 0.31               | 0.80                    | ± 12.0 %  |
| 2600                 | 52.5                               | 2.16                            | 6.97    | 6.97    | 6.97    | 0.33               | 0.80                    | ± 12.0 %  |
| 5250                 | 48.9                               | 5.36                            | 4.44    | 4.44    | 4.44    | 0.40               | 1.90                    | ± 13.1 %  |
| 5600                 | 48.5                               | 5.77                            | 3.77    | 3.77    | 3.77    | 0.50               | 1.90                    | ± 13.1 %  |
| 5750                 | 48.3                               | 5.94                            | 4.08    | 4.08    | 4.08    | 0.50               | 1.90                    | ± 13.1 %  |

<sup>c</sup> Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 126, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

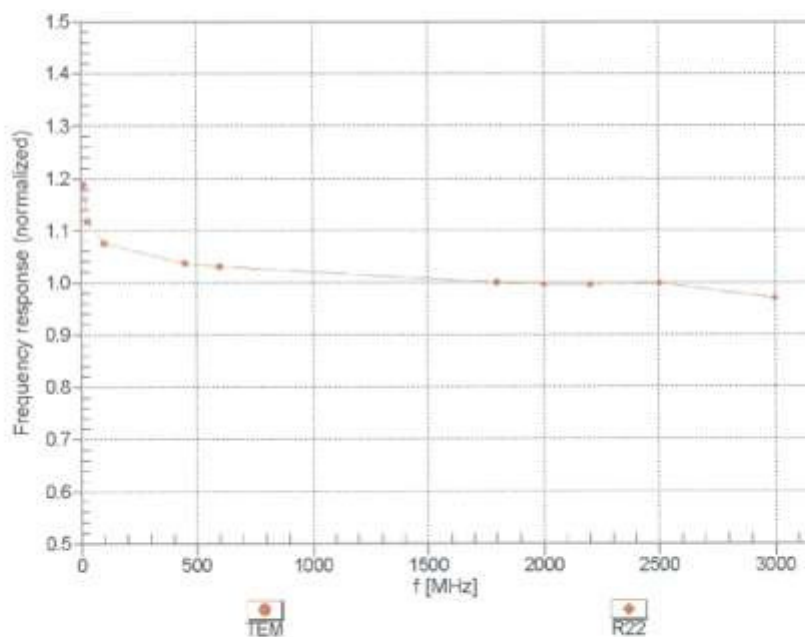
<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

EX3DV4- SN:3863

August 27, 2015

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

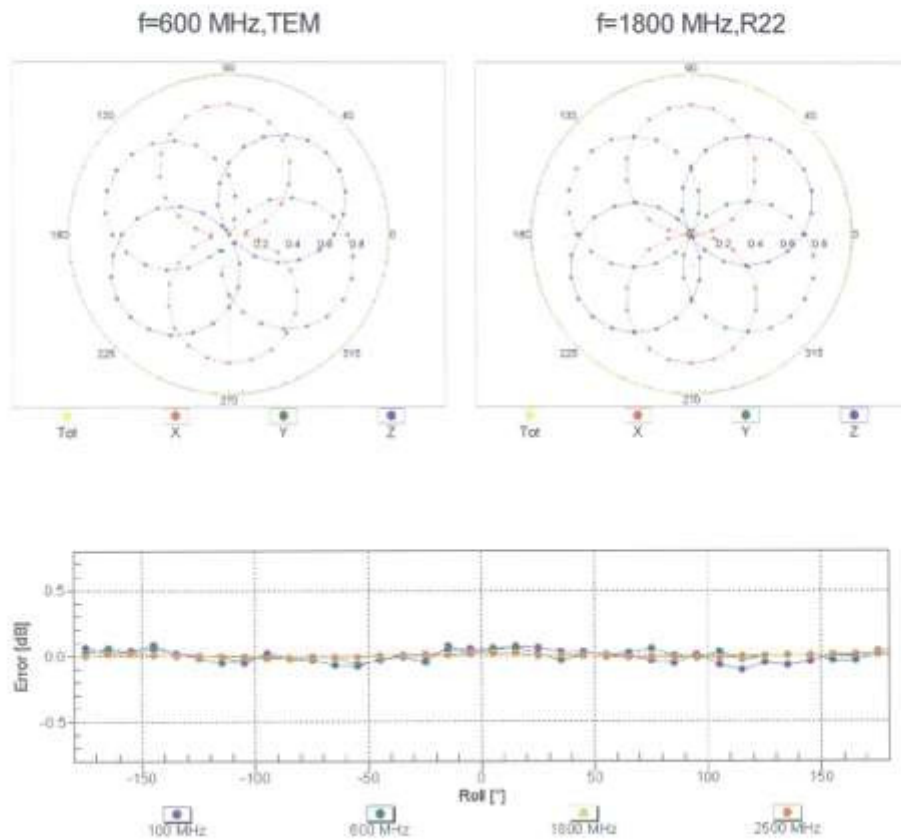


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

EX3DV4- SN:3863

August 27, 2015

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

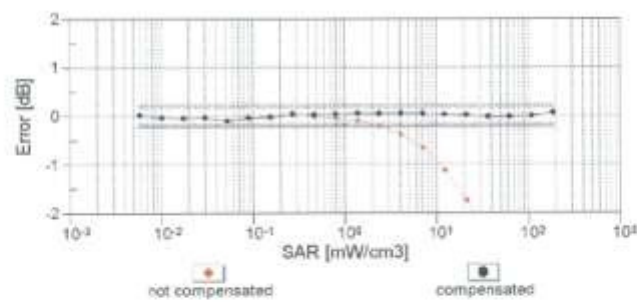
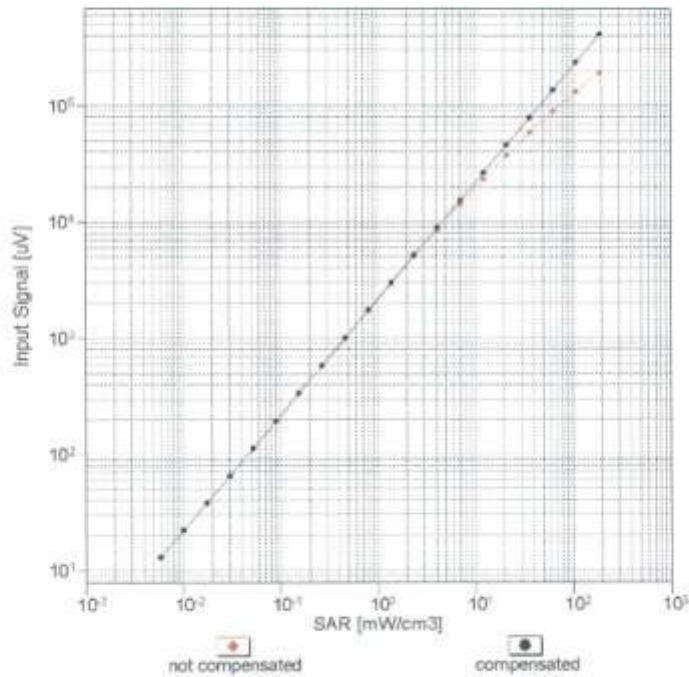


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

EX3DV4- SN:3863

August 27, 2015

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

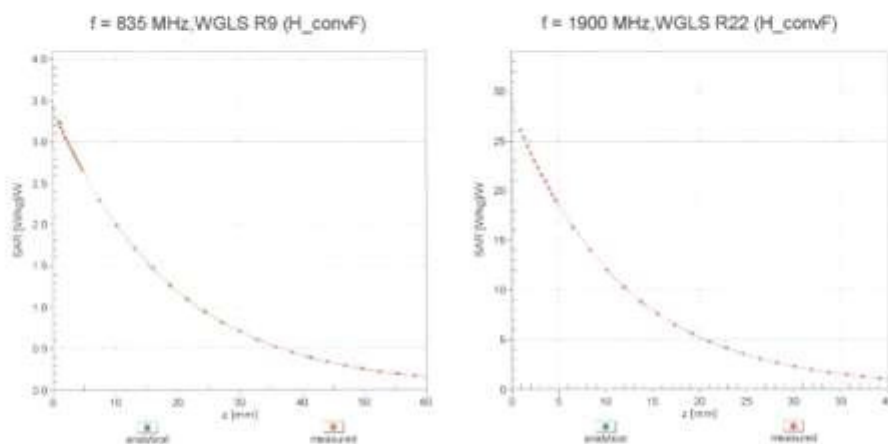


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

EX3DV4-SN:3863

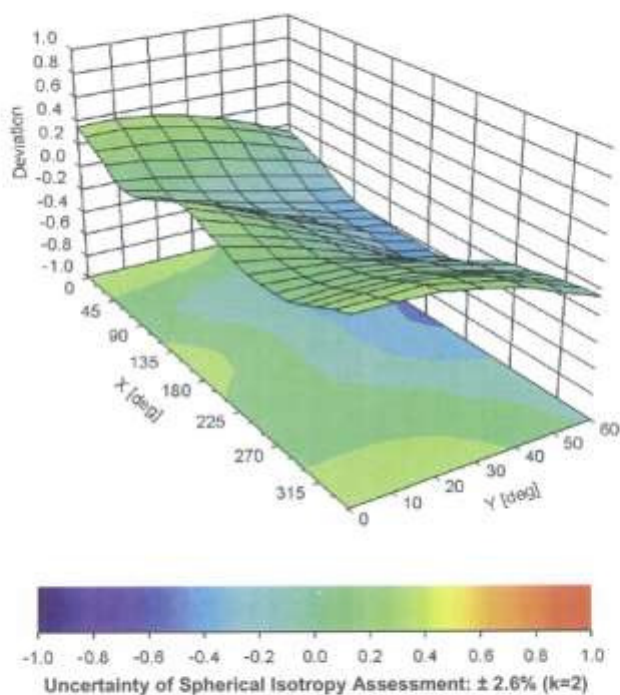
August 27, 2015

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



EX3DV4- SN:3863

August 27, 2015

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3863****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 105.3      |
| 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     |

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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **EX3-7370\_Sep15**

## CALIBRATION CERTIFICATE

Object: **EX3DV4 - SN:7370**

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: **September 1, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards          | ID              | Cal Date (Certificate No.)        | Scheduled Calibration  |
|----------------------------|-----------------|-----------------------------------|------------------------|
| Power meter E4419B         | GB41293874      | 01-Apr-15 (No. 217-02126)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 660         | 14-Jan-15 (No. DAE4-660_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

| Calibrated by:                                                                                                  | Name            | Function              | Signature |
|-----------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|-----------|
|                                                                                                                 | Ismail Elnasouq | Laboratory Technician |           |
| Approved by:                                                                                                    | Name            | Function              | Signature |
|                                                                                                                 | Katja Pokovic   | Technical Manager     |           |
| Issued: September 2, 2015                                                                                       |                 |                       |           |
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Certificate No: EX3-7370\_Sep15

Page 1 of 11

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**Glossary:**

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

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- Spherical Isotropy (3D deviation from isotropy): in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle: The angle is assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).

EX3DV4 – SN:7370

September 1, 2015

# Probe EX3DV4

## SN:7370

Manufactured: March 17, 2015  
Calibrated: September 1, 2015

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

EX3DV4—SN:7370

September 1, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7370

### Basic Calibration Parameters

|                                                           | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|-----------------------------------------------------------|----------|----------|----------|-----------|
| Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup> | 0.47     | 0.51     | 0.43     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                                     | 99.0     | 105.3    | 99.8     |           |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A<br>dB | B<br>dB $\sqrt{\mu\text{V}}$ | C   | D<br>dB | VR<br>mV | Unc <sup>E</sup><br>(k=2) |
|-----|---------------------------|---|---------|------------------------------|-----|---------|----------|---------------------------|
| 0   | CW                        | X | 0.0     | 0.0                          | 1.0 | 0.00    | 162.3    | ±3.3 %                    |
|     |                           | Y | 0.0     | 0.0                          | 1.0 |         | 164.9    |                           |
|     |                           | Z | 0.0     | 0.0                          | 1.0 |         | 167.7    |                           |

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

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

<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.

EX3DV4- SN:7370

September 1, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7370

### Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) <sup>c</sup> | Relative Permittivity <sup>e</sup> | Conductivity (S/m) <sup>f</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>g</sup> | Depth <sup>h</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 450                  | 43.5                               | 0.87                            | 10.67   | 10.67   | 10.67   | 0.16               | 1.70                    | ± 13.3 %  |
| 750                  | 41.9                               | 0.89                            | 9.81    | 9.81    | 9.81    | 0.26               | 1.24                    | ± 12.0 %  |
| 835                  | 41.5                               | 0.90                            | 9.57    | 9.57    | 9.57    | 0.27               | 1.17                    | ± 12.0 %  |
| 900                  | 41.5                               | 0.97                            | 9.29    | 9.29    | 9.29    | 0.29               | 1.12                    | ± 12.0 %  |
| 1450                 | 40.5                               | 1.20                            | 8.08    | 8.08    | 8.08    | 0.26               | 1.06                    | ± 12.0 %  |
| 1750                 | 40.1                               | 1.37                            | 8.05    | 8.05    | 8.05    | 0.34               | 0.80                    | ± 12.0 %  |
| 1900                 | 40.0                               | 1.40                            | 7.80    | 7.80    | 7.80    | 0.34               | 0.80                    | ± 12.0 %  |
| 1950                 | 40.0                               | 1.40                            | 7.57    | 7.57    | 7.57    | 0.40               | 0.80                    | ± 12.0 %  |
| 2300                 | 39.5                               | 1.67                            | 7.43    | 7.43    | 7.43    | 0.33               | 0.83                    | ± 12.0 %  |
| 2450                 | 39.2                               | 1.80                            | 6.94    | 6.94    | 6.94    | 0.32               | 0.92                    | ± 12.0 %  |
| 2600                 | 39.0                               | 1.96                            | 6.81    | 6.81    | 6.81    | 0.43               | 0.80                    | ± 12.0 %  |
| 3500                 | 37.9                               | 2.91                            | 6.92    | 6.92    | 6.92    | 0.29               | 1.39                    | ± 13.1 %  |
| 5200                 | 36.0                               | 4.66                            | 5.13    | 5.13    | 5.13    | 0.35               | 1.80                    | ± 13.1 %  |
| 5300                 | 35.9                               | 4.76                            | 4.95    | 4.95    | 4.95    | 0.35               | 1.80                    | ± 13.1 %  |
| 5500                 | 35.6                               | 4.96                            | 4.53    | 4.53    | 4.53    | 0.40               | 1.80                    | ± 13.1 %  |
| 5600                 | 35.5                               | 5.07                            | 4.35    | 4.35    | 4.35    | 0.40               | 1.80                    | ± 13.1 %  |
| 5800                 | 35.3                               | 5.27                            | 4.53    | 4.53    | 4.53    | 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>e</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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

EX3DV4-- SN:7370

September 1, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:7370

### 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>h</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 450                  | 56.7                               | 0.94                            | 11.08   | 11.08   | 11.08   | 0.11               | 1.60                    | ± 13.3 %  |
| 750                  | 55.5                               | 0.96                            | 9.82    | 9.82    | 9.82    | 0.24               | 1.27                    | ± 12.0 %  |
| 835                  | 55.2                               | 0.97                            | 9.66    | 9.66    | 9.66    | 0.29               | 1.25                    | ± 12.0 %  |
| 1750                 | 53.4                               | 1.49                            | 7.76    | 7.76    | 7.76    | 0.47               | 0.81                    | ± 12.0 %  |
| 1900                 | 53.3                               | 1.52                            | 7.49    | 7.49    | 7.49    | 0.41               | 0.80                    | ± 12.0 %  |
| 2450                 | 52.7                               | 1.95                            | 7.16    | 7.16    | 7.16    | 0.35               | 0.80                    | ± 12.0 %  |
| 2600                 | 52.5                               | 2.16                            | 7.07    | 7.07    | 7.07    | 0.29               | 0.80                    | ± 12.0 %  |
| 5200                 | 49.0                               | 5.30                            | 4.64    | 4.64    | 4.64    | 0.45               | 1.90                    | ± 13.1 %  |
| 5300                 | 48.9                               | 5.42                            | 4.46    | 4.46    | 4.46    | 0.45               | 1.90                    | ± 13.1 %  |
| 5500                 | 48.6                               | 5.65                            | 4.03    | 4.03    | 4.03    | 0.50               | 1.90                    | ± 13.1 %  |
| 5600                 | 48.5                               | 5.77                            | 3.85    | 3.85    | 3.85    | 0.50               | 1.90                    | ± 13.1 %  |
| 5800                 | 48.2                               | 6.00                            | 4.03    | 4.03    | 4.03    | 0.50               | 1.90                    | ± 13.1 %  |

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

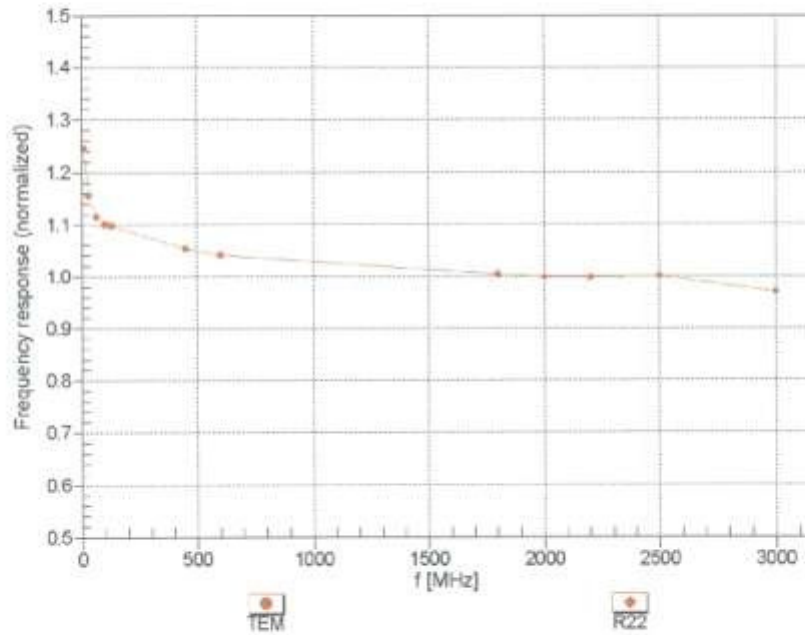
<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

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

EX3DV4- SN:7370

September 1, 2015

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

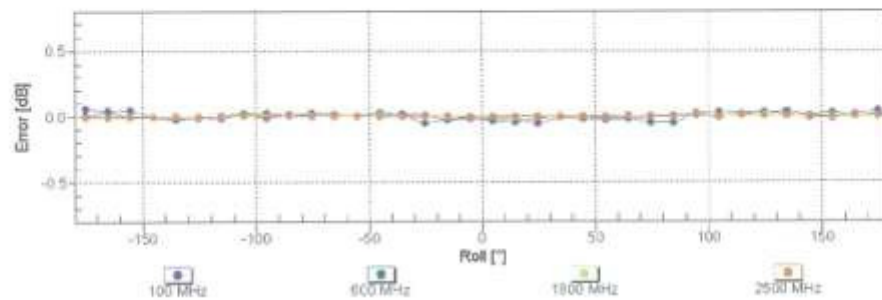
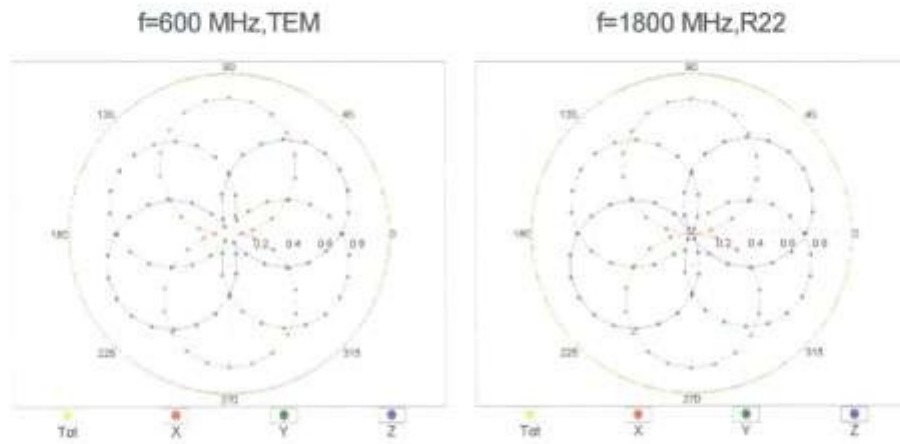


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

EX3DV4- SN:7370

September 1, 2015

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

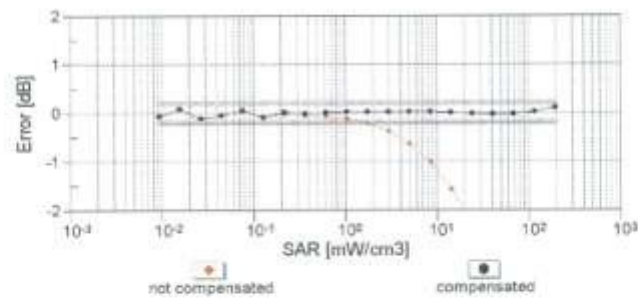
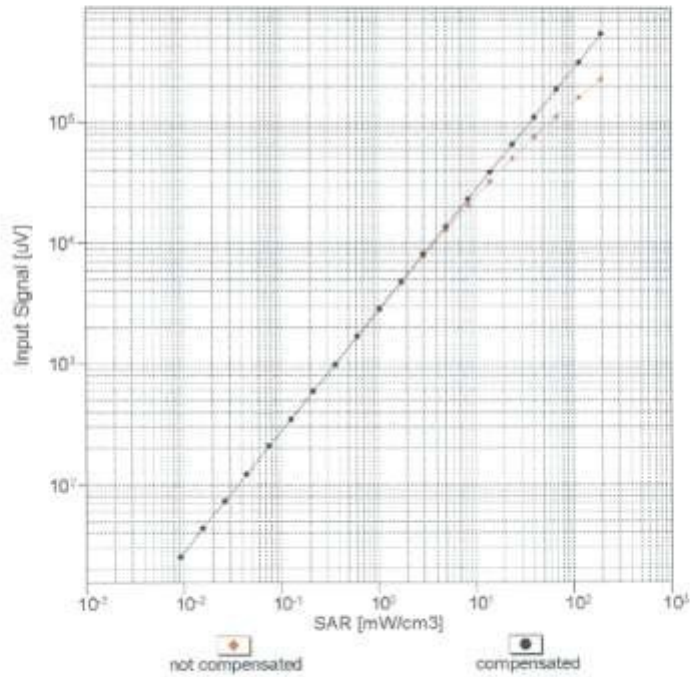


Uncertainty of Axial isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

EX3DV4-SN:7370

September 1, 2015

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

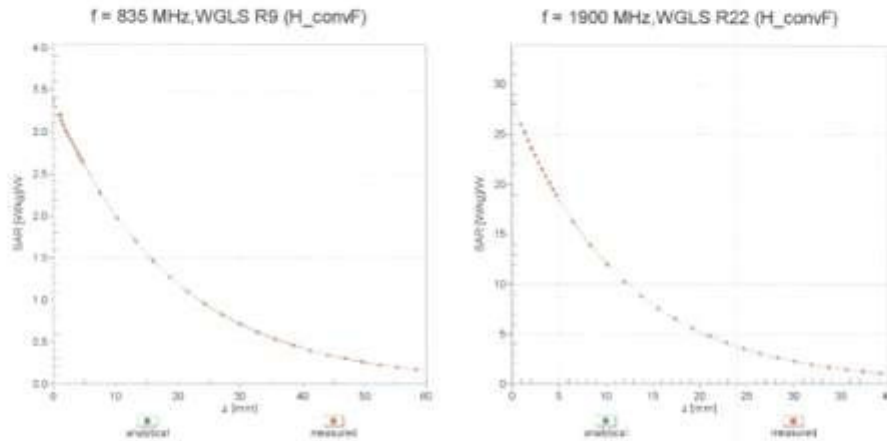


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

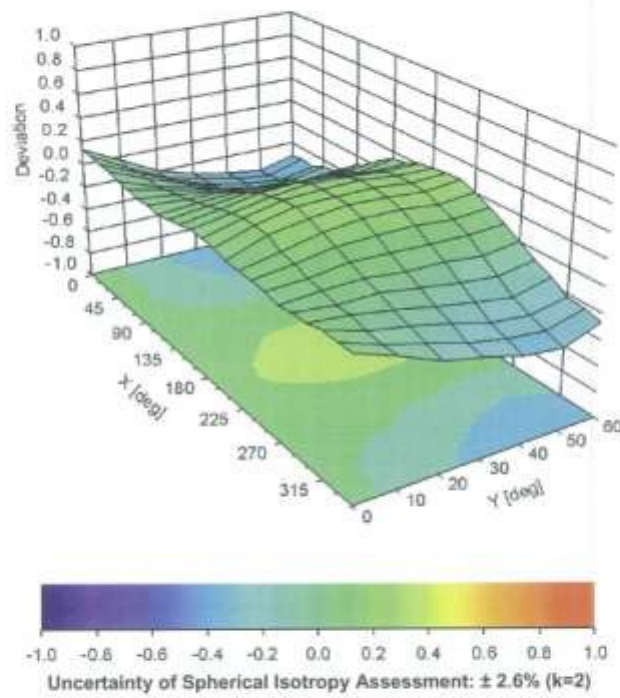
EX3DV4- SN:7370

September 1, 2015

## Conversion Factor Assessment



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



EX3DV4- SN:7370

September 1, 2015

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:7370****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 94.7       |
| 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     |

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



**S** Schweizerischer Kalibrierdienst  
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**S** Servizio svizzero di taratura  
**S** 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 0108**

Client **HCT (Dymstec)**

Certificate No: **EX3-3968\_Jun15**

## CALIBRATION CERTIFICATE

Object **EX3DV4 - SN:3968**

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: **June 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  $(22 \pm 3)^{\circ}\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

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

| Calibrated by:                                                                                                  | Name:          | Function:             | Signature |
|-----------------------------------------------------------------------------------------------------------------|----------------|-----------------------|-----------|
|                                                                                                                 | Jeton Kastrati | Laboratory Technician |           |
| Approved by:                                                                                                    | Name:          | Function:             | Signature |
|                                                                                                                 | Katja Pokovic  | Technical Manager     |           |
| Issued: June 18, 2015                                                                                           |                |                       |           |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                |                       |           |

Certificate No: EX3-3968\_Jun15

Page 1 of 11

**Calibration Laboratory of**  
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**S** Servizio svizzero di taratura  
**S** 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 0108**

**Glossary:**

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

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

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

**Methods Applied and Interpretation of Parameters:**

- NORM<sub>x,y,z</sub>:** Assessed for E-field polarization  $\theta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the  $E^2$ -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).

EX3DV4 – SN:3968

June 18, 2015

# Probe EX3DV4

## SN:3968

Manufactured: September 30, 2013  
Calibrated: June 18, 2015

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

Certificate No: EX3-3968\_Jun15

Page 3 of 11

EX3DV4- SN:3968

June 18, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3968

### Basic Calibration Parameters

|                                       | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---------------------------------------|----------|----------|----------|-----------|
| Norm ( $\mu V/(V/m)^2$ ) <sup>A</sup> | 0.36     | 0.35     | 0.42     | ± 10.1 %  |
| DCP (mV) <sup>B</sup>                 | 103.1    | 102.8    | 96.8     |           |

### Modulation Calibration Parameters

| UID | Communication System Name |   | A<br>dB | B<br>dB√μV | 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    | 130.3    | ±3.0 %                    |
|     |                           | Y | 0.0     | 0.0        | 1.0 |         | 129.8    |                           |
|     |                           | Z | 0.0     | 0.0        | 1.0 |         | 142.3    |                           |

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

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

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

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

EX3DV4- SN:3968

June 18, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3968

### Calibration Parameter Determined in Head Tissue Simulating Media

| f (MHz) <sup>c</sup> | Relative Permittivity <sup>e</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) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 150                  | 52.3                               | 0.76                            | 13.09   | 13.09   | 13.09   | 0.00               | 1.00                    | ± 13.3 %    |
| 300                  | 45.3                               | 0.87                            | 12.28   | 12.28   | 12.28   | 0.10               | 1.20                    | ± 13.3 %    |
| 450                  | 43.5                               | 0.87                            | 10.61   | 10.61   | 10.61   | 0.18               | 1.20                    | ± 13.3 %    |
| 750                  | 41.9                               | 0.89                            | 9.92    | 9.92    | 9.92    | 0.18               | 1.57                    | ± 12.0 %    |
| 835                  | 41.5                               | 0.90                            | 9.60    | 9.60    | 9.60    | 0.21               | 1.64                    | ± 12.0 %    |
| 900                  | 41.5                               | 0.97                            | 9.45    | 9.45    | 9.45    | 0.22               | 1.25                    | ± 12.0 %    |
| 1450                 | 40.5                               | 1.20                            | 8.28    | 8.28    | 8.28    | 0.26               | 1.02                    | ± 12.0 %    |
| 1750                 | 40.1                               | 1.37                            | 8.23    | 8.23    | 8.23    | 0.31               | 0.80                    | ± 12.0 %    |
| 1900                 | 40.0                               | 1.40                            | 7.95    | 7.95    | 7.95    | 0.30               | 0.80                    | ± 12.0 %    |
| 1950                 | 40.0                               | 1.40                            | 7.66    | 7.66    | 7.66    | 0.38               | 0.80                    | ± 12.0 %    |
| 2300                 | 39.5                               | 1.67                            | 7.51    | 7.51    | 7.51    | 0.37               | 0.80                    | ± 12.0 %    |
| 2450                 | 39.2                               | 1.80                            | 7.21    | 7.21    | 7.21    | 0.36               | 0.80                    | ± 12.0 %    |
| 2600                 | 39.0                               | 1.96                            | 7.06    | 7.06    | 7.06    | 0.39               | 0.89                    | ± 12.0 %    |
| 3500                 | 37.9                               | 2.91                            | 6.82    | 6.82    | 6.82    | 0.29               | 1.33                    | ± 13.1 %    |
| 5200                 | 36.0                               | 4.66                            | 5.26    | 5.26    | 5.26    | 0.30               | 1.80                    | ± 13.1 %    |
| 5300                 | 35.9                               | 4.76                            | 5.09    | 5.09    | 5.09    | 0.35               | 1.80                    | ± 13.1 %    |
| 5500                 | 35.6                               | 4.96                            | 4.86    | 4.86    | 4.86    | 0.40               | 1.80                    | ± 13.1 %    |
| 5600                 | 35.5                               | 5.07                            | 4.59    | 4.59    | 4.59    | 0.40               | 1.80                    | ± 13.1 %    |
| 5800                 | 35.3                               | 5.27                            | 4.68    | 4.68    | 4.68    | 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>e</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

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

EX3DV4- SN:3968

June 18, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3968

### 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>h</sup> (mm) | Unct. (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-------------|
| 150                  | 61.9                               | 0.80                            | 12.40   | 12.40   | 12.40   | 0.00               | 1.00                    | ± 13.3 %    |
| 300                  | 58.2                               | 0.92                            | 11.34   | 11.34   | 11.34   | 0.05               | 1.10                    | ± 13.3 %    |
| 450                  | 56.7                               | 0.94                            | 10.86   | 10.86   | 10.86   | 0.12               | 1.20                    | ± 13.3 %    |
| 750                  | 55.5                               | 0.96                            | 9.49    | 9.49    | 9.49    | 0.34               | 1.03                    | ± 12.0 %    |
| 835                  | 55.2                               | 0.97                            | 9.55    | 9.55    | 9.55    | 0.50               | 0.80                    | ± 12.0 %    |
| 900                  | 55.0                               | 1.05                            | 9.34    | 9.34    | 9.34    | 0.42               | 0.93                    | ± 12.0 %    |
| 1750                 | 53.4                               | 1.49                            | 7.87    | 7.87    | 7.87    | 0.42               | 0.80                    | ± 12.0 %    |
| 1900                 | 53.3                               | 1.52                            | 7.60    | 7.60    | 7.60    | 0.33               | 0.95                    | ± 12.0 %    |
| 2450                 | 52.7                               | 1.95                            | 7.25    | 7.25    | 7.25    | 0.36               | 0.80                    | ± 12.0 %    |
| 2600                 | 52.5                               | 2.16                            | 7.10    | 7.10    | 7.10    | 0.24               | 0.80                    | ± 12.0 %    |
| 5200                 | 49.0                               | 5.30                            | 4.71    | 4.71    | 4.71    | 0.40               | 1.90                    | ± 13.1 %    |
| 5300                 | 48.9                               | 5.42                            | 4.44    | 4.44    | 4.44    | 0.40               | 1.90                    | ± 13.1 %    |
| 5500                 | 48.6                               | 5.65                            | 4.14    | 4.14    | 4.14    | 0.45               | 1.90                    | ± 13.1 %    |
| 5600                 | 48.5                               | 5.77                            | 3.93    | 3.93    | 3.93    | 0.45               | 1.90                    | ± 13.1 %    |
| 5800                 | 48.2                               | 6.00                            | 4.27    | 4.27    | 4.27    | 0.45               | 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.

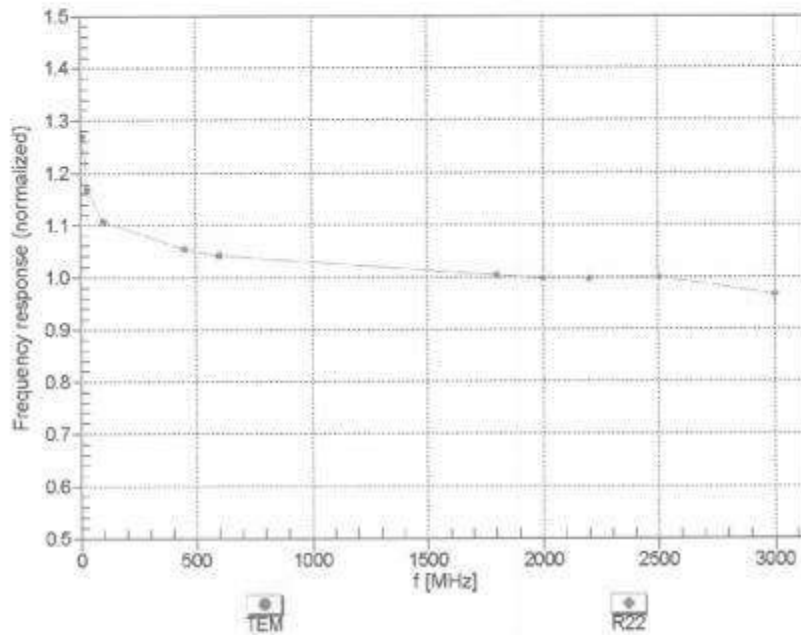
<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

EX3DV4- SN:3968

June 18, 2015

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



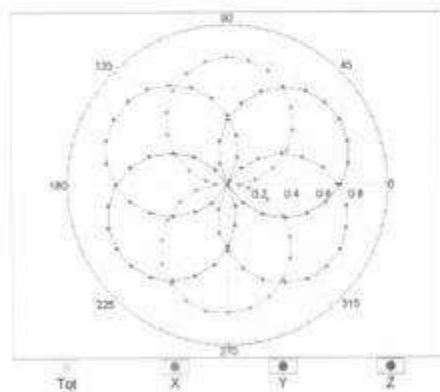
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

EX3DV4-- SN:3968

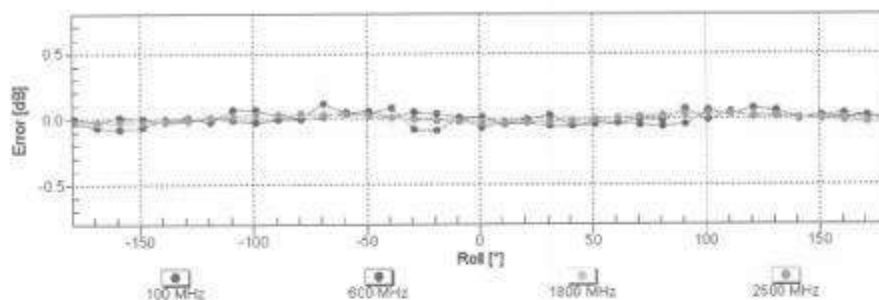
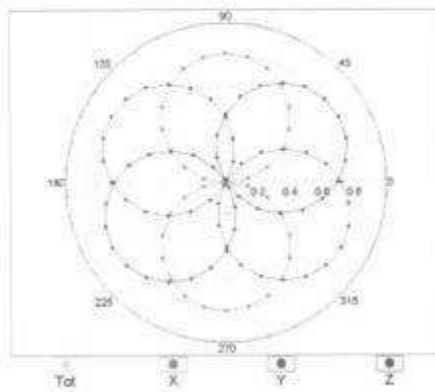
June 18, 2015

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

f=600 MHz,TEM



f=1800 MHz,R22

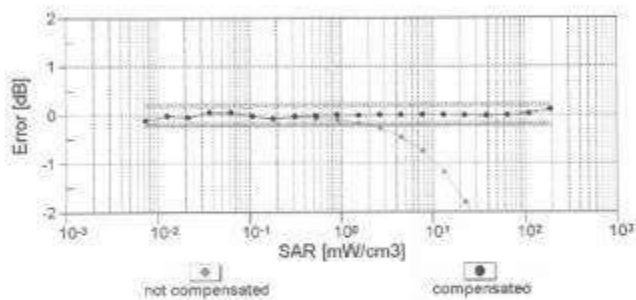
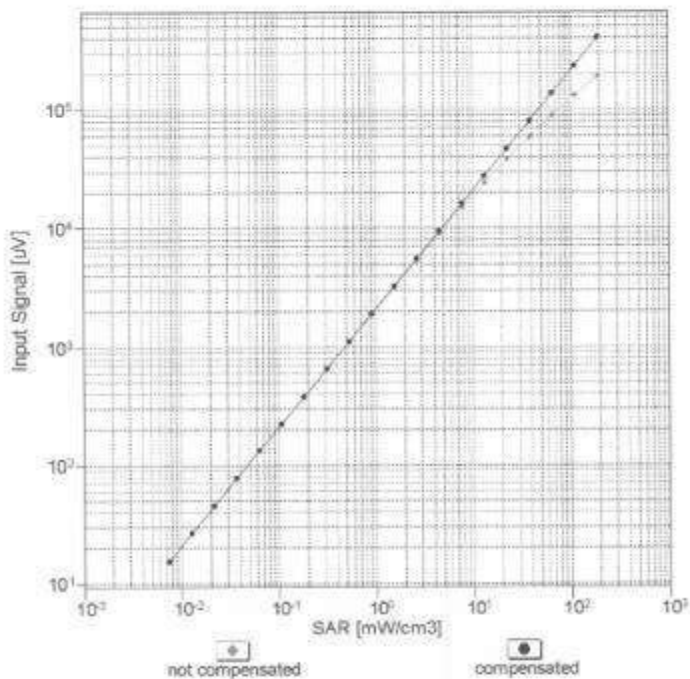


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

EX3DV4- SN:3968

June 18, 2015

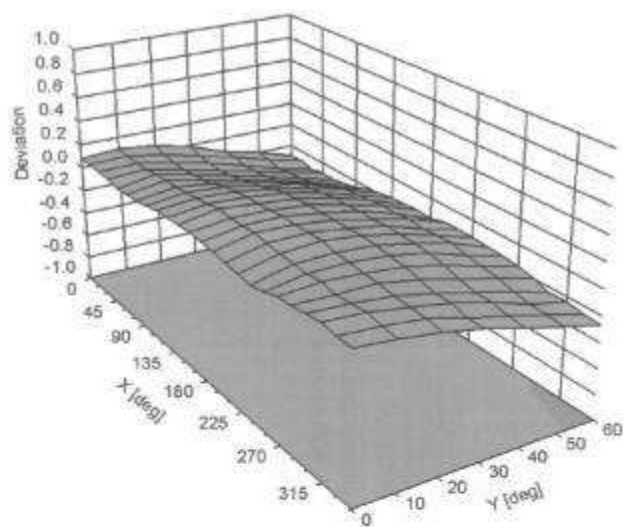
### Dynamic Range f(SAR<sub>head</sub>) (TEM cell, f<sub>eval</sub> = 1900 MHz)



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

June 18, 2015

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



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

EX3DV4- SN:3968

June 18, 2015

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3968****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | 61.1       |
| Mechanical Surface Detection Mode             | enabled    |
| Optical Surface Detection Mode                | disabled   |
| Probe Overall Length                          | 337 mm     |
| Probe Body Diameter                           | 10 mm      |
| Tip Length                                    | 9 mm       |
| Tip Diameter                                  | 2.5 mm     |
| Probe Tip to Sensor X Calibration Point       | 1 mm       |
| Probe Tip to Sensor Y Calibration Point       | 1 mm       |
| Probe Tip to Sensor Z Calibration Point       | 1 mm       |
| Recommended Measurement Distance from Surface | 1.4 mm     |

**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  
**S** 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 0108**

Client: **HCT (Dymstec)**

Certificate No: **EX3-3967\_Dec15**

## CALIBRATION CERTIFICATE

Object: **EX3DV4 - SN:3967**

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**

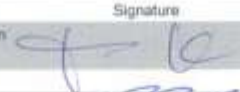
Calibration date: **December 16, 2015**

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 ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards          | ID              | Cal Date (Certificate No.)        | Scheduled Calibration  |
|----------------------------|-----------------|-----------------------------------|------------------------|
| Power meter E4419B         | GB41293874      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Power sensor E4412A        | MY41498087      | 01-Apr-15 (No. 217-02128)         | Mar-16                 |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 01-Apr-15 (No. 217-02129)         | Mar-16                 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132)         | Mar-16                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133)         | Mar-16                 |
| Reference Probe ES3DV2     | SN: 3013        | 30-Dec-14 (No. ES3-3013_Dec14)    | Dec-15                 |
| DAE4                       | SN: 680         | 14-Jan-15 (No. DAE4-680_Jan15)    | Jan-16                 |
| Secondary Standards        | ID              | Check Date (in house)             | Scheduled Check        |
| RF generator HP 8648C      | US3642UD1700    | 4-Aug-99 (in house check Apr-13)  | In house check: Apr-16 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

|                                                                                                                 | Name           | Function              | Signature                                                                            |
|-----------------------------------------------------------------------------------------------------------------|----------------|-----------------------|--------------------------------------------------------------------------------------|
| Calibrated by:                                                                                                  | Jeton Kastrati | Laboratory Technician |  |
| Approved by:                                                                                                    | Katja Pokovic  | Technical Manager     |  |
| Issued: December 16, 2015                                                                                       |                |                       |                                                                                      |
| This calibration certificate shall not be reproduced except in full without written approval of the laboratory. |                |                       |                                                                                      |

**Calibration Laboratory of  
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**C** Service suisse d'étalonnage  
**S** Servizio svizzero di taratura  
**S** Swiss Calibration Service

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 $\theta$  | $\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center),<br>i.e., $\theta = 0$ is normal to probe axis |
| Connector Angle        | information used in DASY system to align probe sensor X to the robot coordinate system                                                            |

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

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\theta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E-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).

EX3DV4 – SN:3967

December 16, 2015

# Probe EX3DV4

## SN:3967

Manufactured: September 30, 2013  
Calibrated: December 16, 2015

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

EX3DV4- SN:3967

December 16, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967

### Basic Calibration Parameters

|                                                    | Sensor X | Sensor Y | Sensor Z | Unc (k=2)     |
|----------------------------------------------------|----------|----------|----------|---------------|
| Norm ( $\mu\text{V}/(\text{V/m})^2$ ) <sup>A</sup> | 0.54     | 0.38     | 0.48     | $\pm 10.1 \%$ |
| DCP (mV) <sup>B</sup>                              | 101.3    | 97.8     | 101.0    |               |

### 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    | 145.0    | $\pm 3.5 \%$              |
|     |                           | Y | 0.0     | 0.0                          | 1.0 |         | 143.7    |                           |
|     |                           | Z | 0.0     | 0.0                          | 1.0 |         | 138.2    |                           |

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

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

<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.

EX3DV4- SN:3967

December 16, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967

### 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>h</sup> (mm) | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750                  | 41.9                               | 0.89                            | 10.27   | 10.27   | 10.27   | 0.21               | 1.39                    | ± 12.0 %  |
| 835                  | 41.5                               | 0.90                            | 9.87    | 9.87    | 9.87    | 0.20               | 1.38                    | ± 12.0 %  |
| 900                  | 41.5                               | 0.97                            | 9.70    | 9.70    | 9.70    | 0.25               | 1.15                    | ± 12.0 %  |
| 1450                 | 40.5                               | 1.20                            | 8.19    | 8.19    | 8.19    | 0.29               | 0.92                    | ± 12.0 %  |
| 1750                 | 40.1                               | 1.37                            | 8.39    | 8.39    | 8.39    | 0.25               | 0.88                    | ± 12.0 %  |
| 1900                 | 40.0                               | 1.40                            | 8.11    | 8.11    | 8.11    | 0.39               | 0.80                    | ± 12.0 %  |
| 1950                 | 40.0                               | 1.40                            | 7.90    | 7.90    | 7.90    | 0.38               | 0.86                    | ± 12.0 %  |
| 2300                 | 39.5                               | 1.67                            | 7.73    | 7.73    | 7.73    | 0.37               | 0.84                    | ± 12.0 %  |
| 2450                 | 39.2                               | 1.80                            | 7.42    | 7.42    | 7.42    | 0.40               | 0.80                    | ± 12.0 %  |
| 2600                 | 39.0                               | 1.96                            | 7.17    | 7.17    | 7.17    | 0.41               | 0.83                    | ± 12.0 %  |
| 3500                 | 37.9                               | 2.91                            | 7.69    | 7.69    | 7.69    | 0.94               | 0.63                    | ± 13.1 %  |
| 5200                 | 36.0                               | 4.66                            | 5.37    | 5.37    | 5.37    | 0.35               | 1.80                    | ± 13.1 %  |
| 5300                 | 35.9                               | 4.76                            | 5.04    | 5.04    | 5.04    | 0.40               | 1.80                    | ± 13.1 %  |
| 5500                 | 35.6                               | 4.96                            | 4.87    | 4.87    | 4.87    | 0.45               | 1.80                    | ± 13.1 %  |
| 5600                 | 35.5                               | 5.07                            | 4.65    | 4.65    | 4.65    | 0.50               | 1.80                    | ± 13.1 %  |
| 5800                 | 35.3                               | 5.27                            | 4.69    | 4.69    | 4.69    | 0.50               | 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.

EX3DV4- SN:3967

December 16, 2015

## DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967

### Calibration Parameter Determined in Body Tissue Simulating Media

| f (MHz) <sup>c</sup> | Relative Permittivity <sup>e</sup> | Conductivity (S/m) <sup>e</sup> | ConvF X | ConvF Y | ConvF Z | Alpha <sup>g</sup> | Depth (mm) <sup>g</sup> | Unc (k=2) |
|----------------------|------------------------------------|---------------------------------|---------|---------|---------|--------------------|-------------------------|-----------|
| 750                  | 55.5                               | 0.96                            | 9.92    | 9.92    | 9.92    | 0.22               | 1.41                    | ± 12.0 %  |
| 835                  | 55.2                               | 0.97                            | 9.76    | 9.76    | 9.76    | 0.24               | 1.28                    | ± 12.0 %  |
| 1750                 | 53.4                               | 1.49                            | 8.04    | 8.04    | 8.04    | 0.40               | 0.85                    | ± 12.0 %  |
| 1900                 | 53.3                               | 1.52                            | 7.95    | 7.95    | 7.95    | 0.35               | 0.92                    | ± 12.0 %  |
| 2450                 | 52.7                               | 1.95                            | 7.31    | 7.31    | 7.31    | 0.40               | 0.86                    | ± 12.0 %  |
| 2600                 | 52.5                               | 2.16                            | 7.19    | 7.19    | 7.19    | 0.25               | 1.05                    | ± 12.0 %  |
| 3500                 | 51.3                               | 3.31                            | 6.86    | 6.86    | 6.86    | 0.36               | 1.14                    | ± 13.1 %  |
| 5200                 | 49.0                               | 5.30                            | 4.32    | 4.32    | 4.32    | 0.55               | 1.90                    | ± 13.1 %  |
| 5300                 | 48.9                               | 5.42                            | 4.23    | 4.23    | 4.23    | 0.55               | 1.90                    | ± 13.1 %  |
| 5500                 | 48.6                               | 5.65                            | 3.80    | 3.80    | 3.80    | 0.60               | 1.90                    | ± 13.1 %  |
| 5600                 | 48.5                               | 5.77                            | 3.70    | 3.70    | 3.70    | 0.60               | 1.90                    | ± 13.1 %  |
| 5800                 | 48.2                               | 6.00                            | 3.82    | 3.82    | 3.82    | 0.60               | 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.

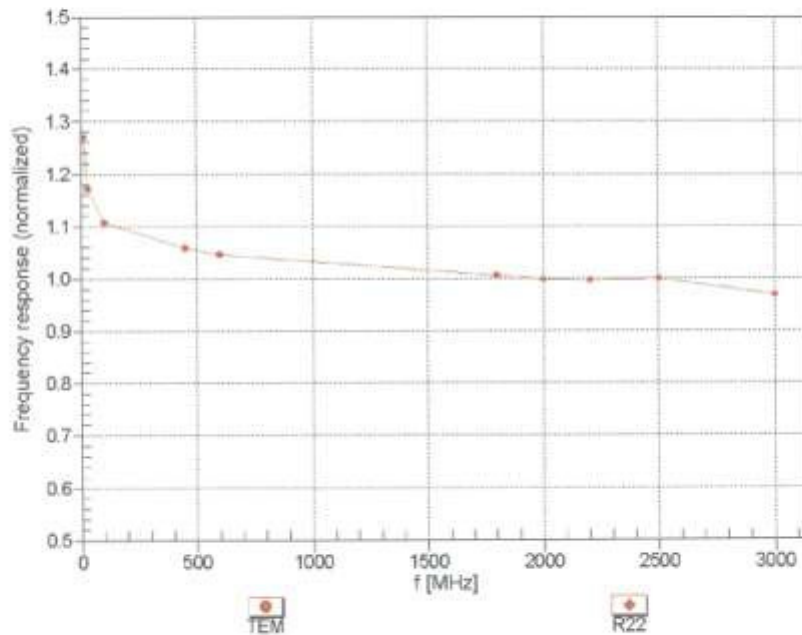
<sup>e</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

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

EX3DV4-SN:3967

December 16, 2015

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

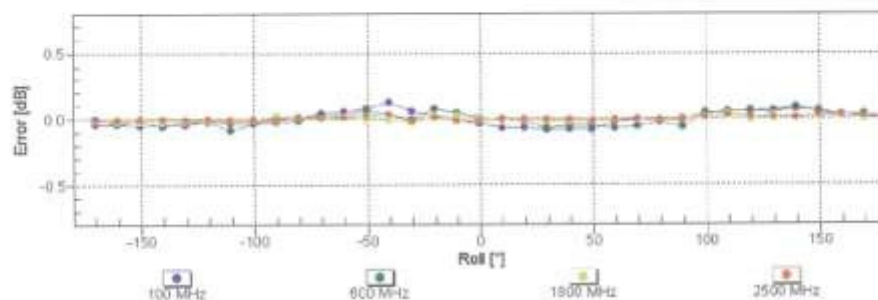
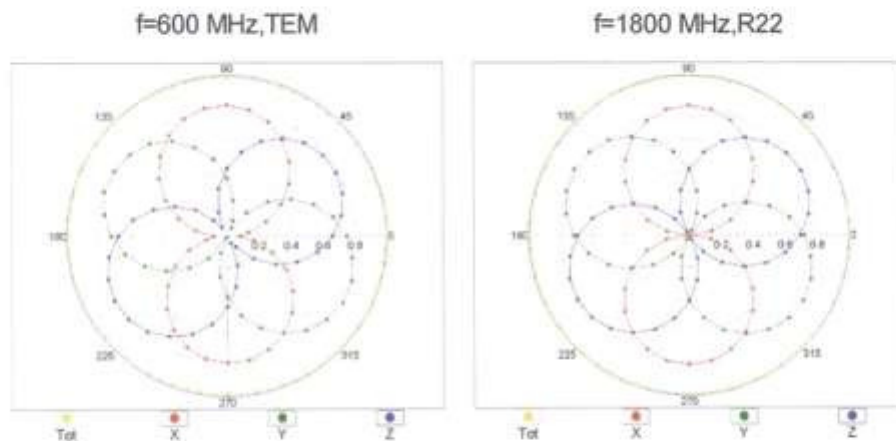


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

EX3DV4-- SN:3967

December 16, 2015

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

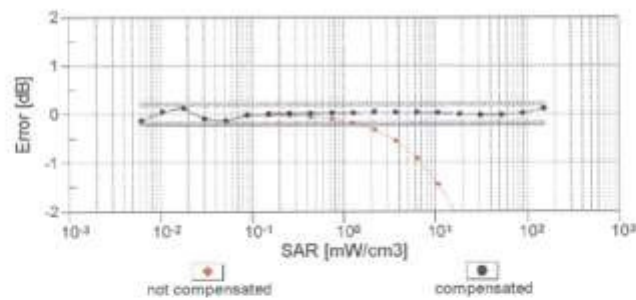
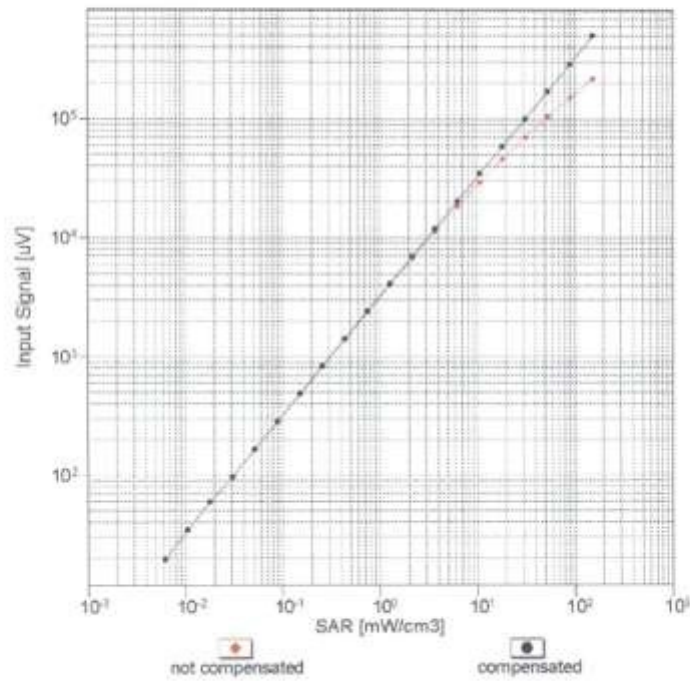


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

EX3DV4- SN:3967

December 16, 2015

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

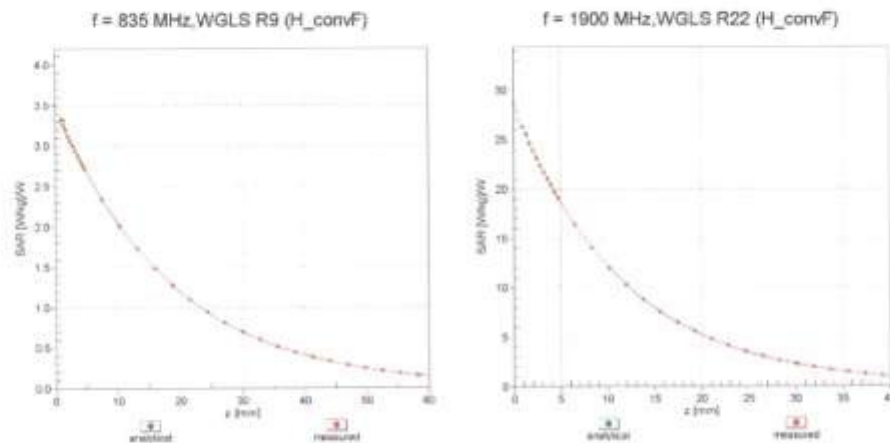


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

EX3DV4- SN:3967

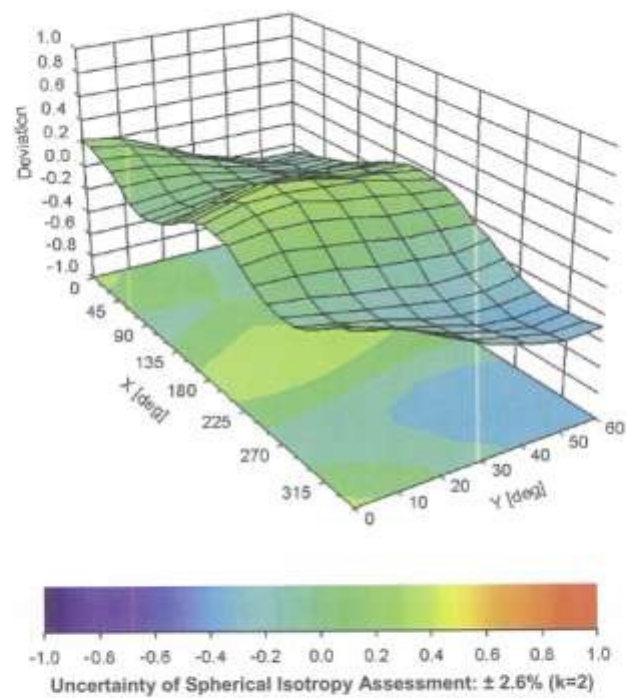
December 16, 2015

## Conversion Factor Assessment



## Deviation from Isotropy in Liquid

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



EX3DV4- SN:3967

December 16, 2015

**DASY/EASY - Parameters of Probe: EX3DV4 - SN:3967****Other Probe Parameters**

|                                               |            |
|-----------------------------------------------|------------|
| Sensor Arrangement                            | Triangular |
| Connector Angle (°)                           | ~20.6      |
| 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     |

## Attachment 4. – Dipole Calibration Data

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **HCT (Dymstec)**

Certificate No: **D750V3-1014\_Jul15**

## CALIBRATION CERTIFICATE

Object **D750V3 - SN: 1014**

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

Calibration date: **July 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 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)     | 01-Apr-15 (No. 217-02131)         | Mar-16                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134)         | Mar-16                 |
| 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**  
*M. Weber*

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

*K. Pokovic*

Issued: July 23, 2015

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

Certificate No: D750V3-1014\_Jul15

Page 1 of 8

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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**

**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
- 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"

**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                    | 750 MHz $\pm$ 1 MHz    |             |

### Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 41.9           | 0.89 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 42.5 $\pm$ 6 % | 0.90 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 | 2.05 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 8.15 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 | 1.34 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 5.33 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             | 55.5           | 0.96 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 55.1 $\pm$ 6 % | 0.98 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 | 2.16 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 8.49 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 | 1.42 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 5.60 W/kg $\pm$ 16.5 % (k=2) |

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

### Antenna Parameters with Head TSL

|                                      |                               |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 53.9 $\Omega$ + 1.7 $j\Omega$ |
| Return Loss                          | - 27.8 dB                     |

### Antenna Parameters with Body TSL

|                                      |                               |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 49.1 $\Omega$ - 1.3 $j\Omega$ |
| Return Loss                          | - 36.0 dB                     |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.036 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 22, 2010 |

**DASY5 Validation Report for Head TSL**

Date: 14.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1014**

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

Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.9$  S/m;  $\epsilon_r = 42.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

**DASY52 Configuration:**

- Probe: ES3DV3 - SN3205; ConvF(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:**

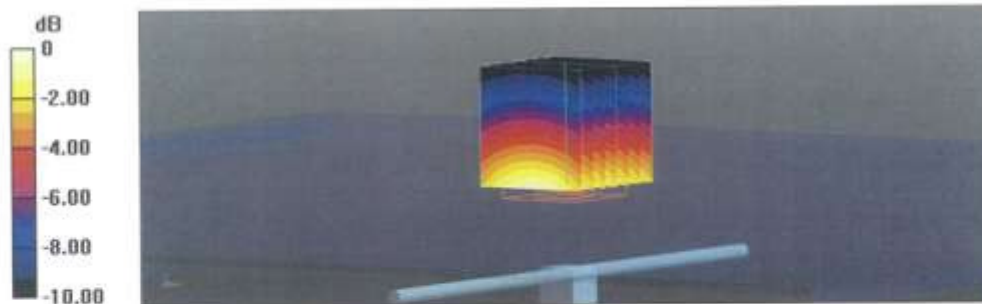
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 53.32 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 3.05 W/kg

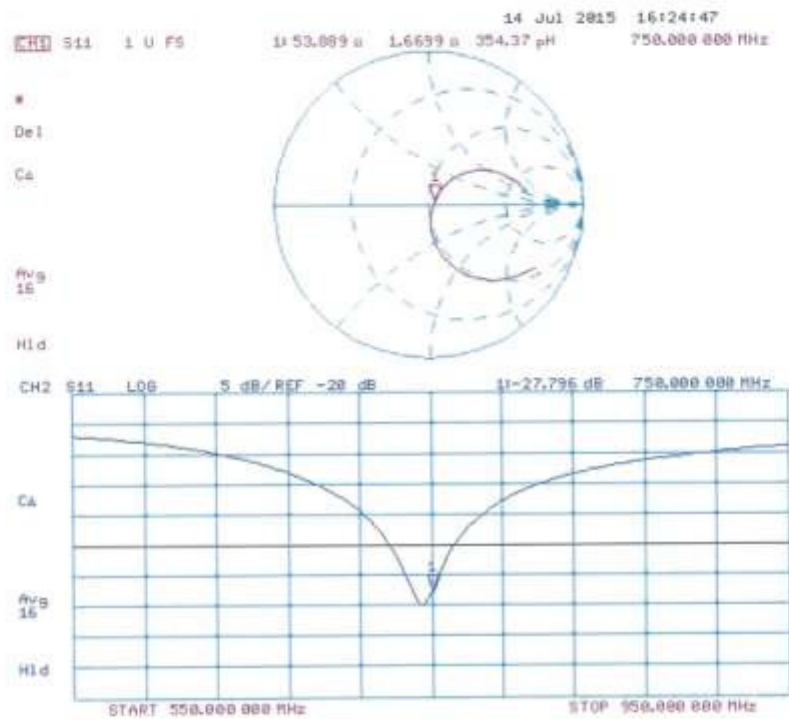
**SAR(1 g) = 2.05 W/kg; SAR(10 g) = 1.34 W/kg**

Maximum value of SAR (measured) = 2.40 W/kg



0 dB = 2.40 W/kg = 3.80 dBW/kg

# Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 23.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN: 1014**

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

Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.98$  S/m;  $\epsilon_r = 55.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.21, 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:**

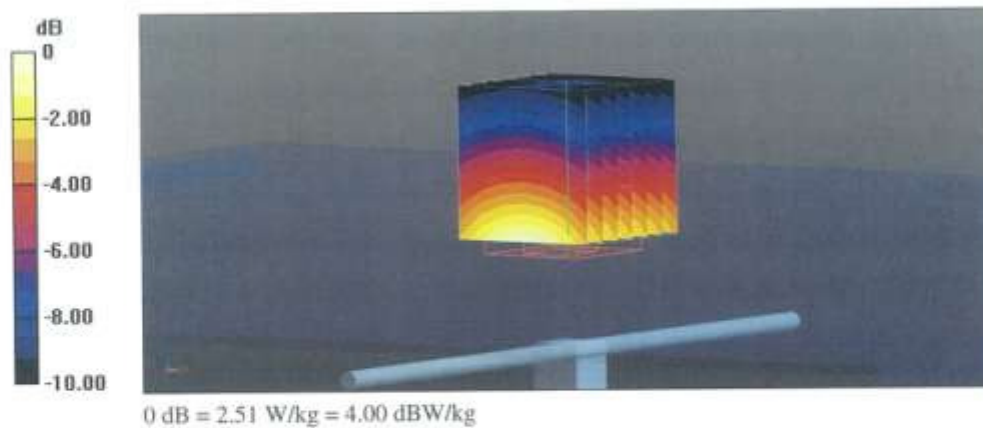
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 52.42 V/m; Power Drift = 0.01 dB

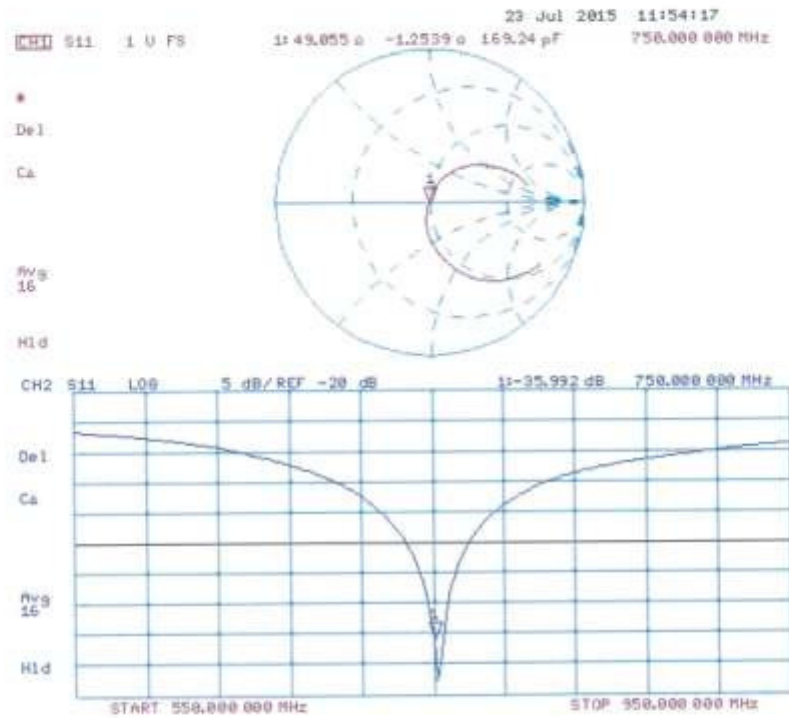
Peak SAR (extrapolated) = 3.15 W/kg

**SAR(1 g) = 2.16 W/kg; SAR(10 g) = 1.42 W/kg**

Maximum value of SAR (measured) = 2.51 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 **HCT (Dymstec)**

Certificate No: **D835V2-4d165\_Nov15**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN: 4d165**

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

Calibration date: **November 24, 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 ± 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-15 (No. 217-02222)      | Oct-16                |
| Power sensor HP 8481A       | US37292783         | 07-Oct-15 (No. 217-02222)      | Oct-16                |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-15 (No. 217-02223)      | Oct-16                |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 01-Apr-15 (No. 217-02131)      | Mar-16                |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134)      | Mar-16                |
| Reference Probe EX3DV4      | SN: 7349           | 30-Dec-14 (No. EX3-7349_Dec14) | Dec-15                |
| DAE4                        | SN: 601            | 17-Aug-15 (No. DAE4-601_Aug15) | Aug-16                |

| Secondary Standards       | ID #             | Check Date (in house)             | Scheduled Check        |
|---------------------------|------------------|-----------------------------------|------------------------|
| RF generator R&S SMT-06   | 100972           | 15-Jun-15 (in house check Jun-15) | In house check: Jun-16 |
| Network Analyzer HP 8753E | US37390585 S4206 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

Calibrated by: **Name: Michael Weber** **Function: Laboratory Technician** **Signature: M. Weber**

Approved by: **Katja Polovic** **Technical Manager** **Signature: Katja Polovic**

Issued: November 24, 2015

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Certificate No: D835V2-4d165\_Nov15

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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
- 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"

**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 | 42.6 $\pm$ 6 % | 0.92 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 | 2.29 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 9.06 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 | 1.49 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 5.90 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 | 55.6 $\pm$ 6 % | 0.99 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 | 2.40 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 9.47 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 | 1.58 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 6.25 W/kg $\pm$ 16.5 % (k=2) |

**Appendix (Additional assessments outside the scope of SCS 0108)****Antenna Parameters with Head TSL**

|                                      |                               |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 52.1 $\Omega$ - 4.7 $j\Omega$ |
| Return Loss                          | - 26.0 dB                     |

**Antenna Parameters with Body TSL**

|                                      |                               |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 47.8 $\Omega$ - 6.8 $j\Omega$ |
| Return Loss                          | - 22.7 dB                     |

**General Antenna Parameters and Design**

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.440 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 | December 28, 2012 |

**DASY5 Validation Report for Head TSL**

Date: 24.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d165**

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

Medium parameters used:  $f = 835$  MHz;  $\sigma = 0.92$  S/m;  $\epsilon_r = 42.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.77, 9.77, 9.77); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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:**

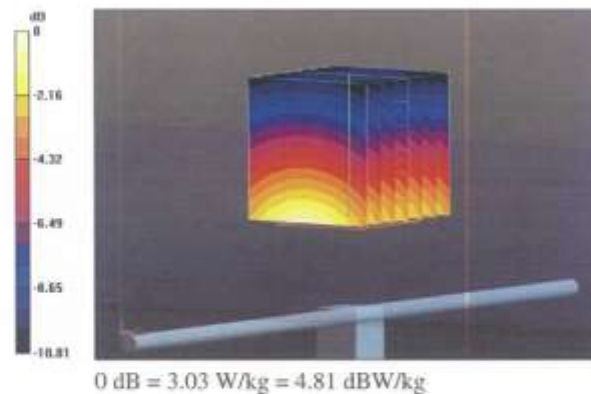
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 60.39 V/m; Power Drift = 0.02 dB

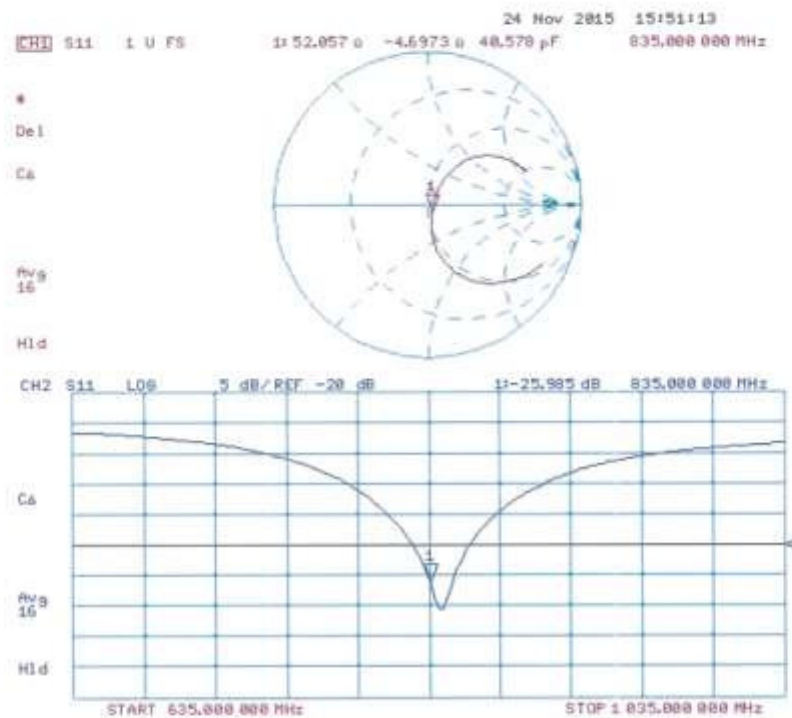
Peak SAR (extrapolated) = 3.40 W/kg

**SAR(1 g) = 2.29 W/kg; SAR(10 g) = 1.49 W/kg**

Maximum value of SAR (measured) = 3.03 W/kg



### Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 24.11.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d165**

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

Medium parameters used:  $f = 835$  MHz;  $\sigma = 0.99$  S/m;  $\epsilon_r = 55.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.72, 9.72, 9.72); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- 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:**

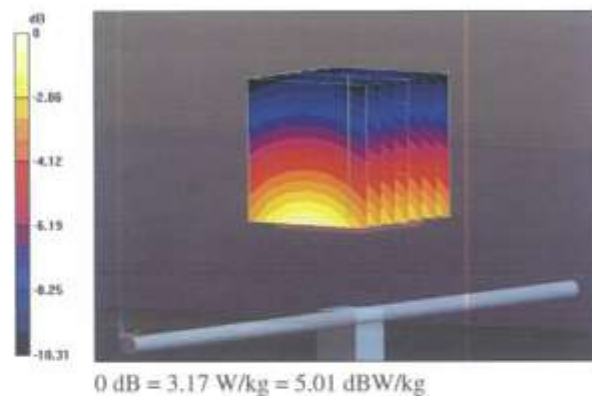
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 61.95 V/m; Power Drift = -0.02 dB

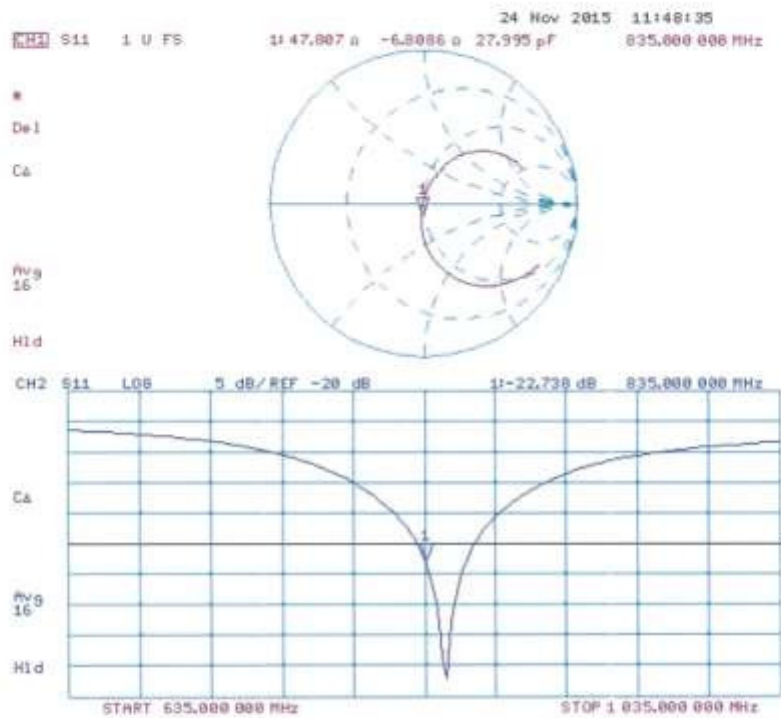
Peak SAR (extrapolated) = 3.54 W/kg

**SAR(1 g) = 2.4 W/kg; SAR(10 g) = 1.58 W/kg**

Maximum value of SAR (measured) = 3.17 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D1800V2-2d006\_Jan16**

## CALIBRATION CERTIFICATE

Object **D1800V2 - SN: 2d006**

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

Calibration date: **January 22, 2016**

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-15 (No. 217-02222)         | Oct-16                 |
| Power sensor HP 8481A       | US37292783         | 07-Oct-15 (No. 217-02222)         | Oct-16                 |
| Power sensor HP 8481A       | MY41092317         | 07-Oct-15 (No. 217-02223)         | Oct-16                 |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 01-Apr-15 (No. 217-02131)         | Mar-16                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134)         | Mar-16                 |
| Reference Probe EX3DV4      | SN: 7349           | 31-Dec-15 (No. EX3-7349_Dec15)    | Dec-16                 |
| DAE4                        | SN: 601            | 30-Dec-15 (No. DAE4-601_Dec15)    | Dec-16                 |
| Secondary Standards         | ID #               | Check Date (in house)             | Scheduled Check        |
| RF generator R&S SMT-06     | 100972             | 15-Jun-15 (in house check Jun-15) | In house check: Jun-16 |
| Network Analyzer HP 8753E   | US37390585 S4206   | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

|                |                            |                                        |            |
|----------------|----------------------------|----------------------------------------|------------|
| Calibrated by: | Name: <b>Michael Weber</b> | Function: <b>Laboratory Technician</b> | Signature: |
| Approved by:   | Name: <b>Katja Pokovic</b> | Function: <b>Technical Manager</b>     | Signature: |

Issued: January 25, 2016

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Certificate No: **D1800V2-2d006\_Jan16**

Page 1 of 8

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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
- 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"

**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                    | 1800 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 | 40.1 $\pm$ 6 % | 1.39 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 | 9.57 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 38.5 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 | 5.03 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 20.2 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 | 53.7 $\pm$ 6 % | 1.52 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 | 9.57 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 38.3 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 | 5.05 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 20.2 W/kg $\pm$ 16.5 % (k=2) |

**Appendix (Additional assessments outside the scope of SCS 0108)****Antenna Parameters with Head TSL**

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 46.5 $\Omega$ - 6.8 j $\Omega$ |
| Return Loss                          | - 22.1 dB                      |

**Antenna Parameters with Body TSL**

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 44.7 $\Omega$ - 6.2 j $\Omega$ |
| Return Loss                          | - 21.3 dB                      |

**General Antenna Parameters and Design**

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.208 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 23, 2001 |

**DASY5 Validation Report for Head TSL**

Date: 22.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN: 2d006**

Communication System: UID 0 - CW; Frequency: 1800 MHz

Medium parameters used:  $f = 1800 \text{ MHz}$ ;  $\sigma = 1.39 \text{ S/m}$ ;  $\epsilon_r = 40.1$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.26, 8.26, 8.26); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$ 

Reference Value = 106.1 V/m; Power Drift = 0.04 dB

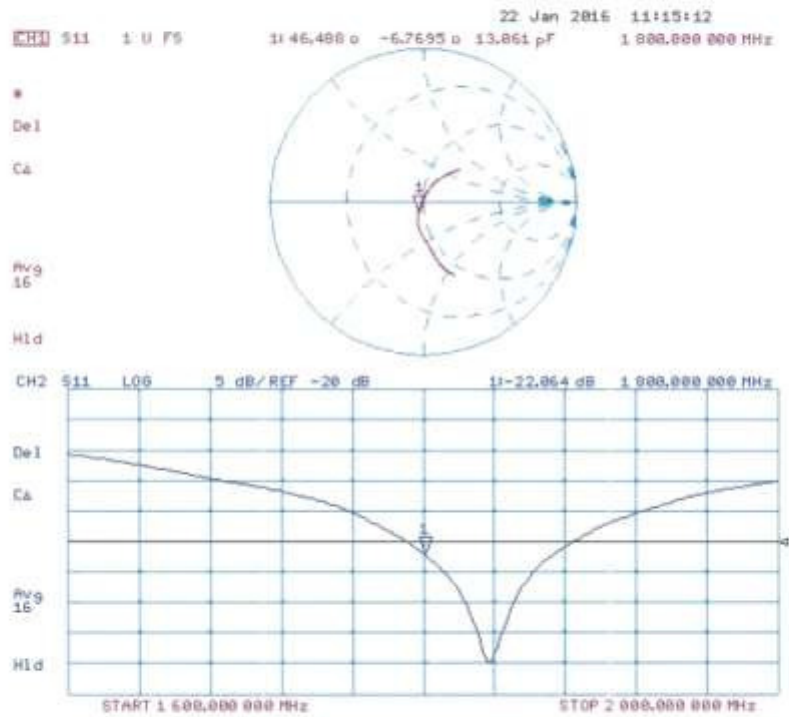
Peak SAR (extrapolated) = 17.5 W/kg

SAR(1 g) = 9.57 W/kg; SAR(10 g) = 5.03 W/kg

Maximum value of SAR (measured) = 14.5 W/kg



Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 22.01.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1800 MHz; Type: D1800V2; Serial: D1800V2 - SN: 2d006**

Communication System: UID 0 - CW; Frequency: 1800 MHz

Medium parameters used:  $f = 1800 \text{ MHz}$ ;  $\sigma = 1.52 \text{ S/m}$ ;  $\epsilon_r = 53.7$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.17, 8.17, 8.17); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

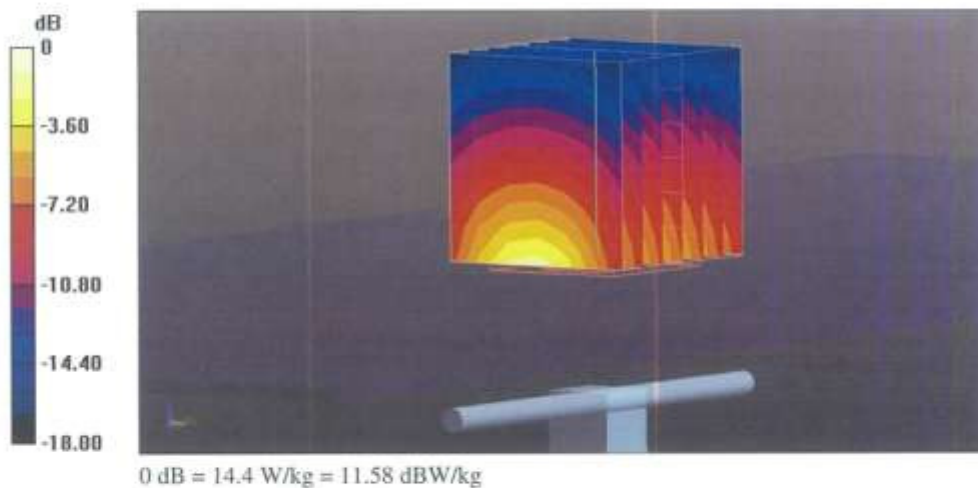
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 102.4 V/m; Power Drift = -0.01 dB

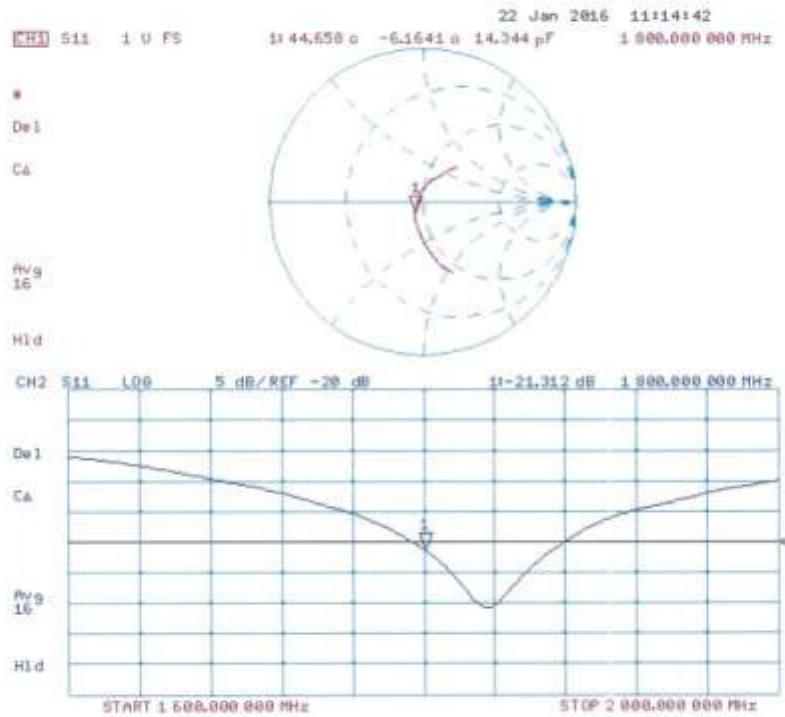
Peak SAR (extrapolated) = 16.8 W/kg

SAR(1 g) = 9.57 W/kg; SAR(10 g) = 5.05 W/kg

Maximum value of SAR (measured) = 14.4 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D1900V2-5d032\_May15**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN: 5d032**

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

Calibration date: **May 20, 2015**

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

All calibrations have been conducted in the closed laboratory facility, environment temperature  $(22 \pm 3)^{\circ}\text{C}$  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       | MY41082317         | 07-Oct-14 (No. 217-02021)      | Oct-15                |
| Reference 20 dB Attenuator  | SN: 5058 (20k)     | 01-Apr-15 (No. 217-02131)      | Mar-16                |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134)      | Mar-16                |
| Reference Probe ESSDV3      | 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 |

|                |               |                       |           |
|----------------|---------------|-----------------------|-----------|
|                | Name          | Function              | Signature |
| Calibrated by: | Leif Klynsner | Laboratory Technician |           |
| Approved by:   | Katja Pokovic | Technical Manager     |           |

Issued: May 20, 2015

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Certificate No: D1900V2-5d032\_May15

Page 1 of 8

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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.

|                              |                        |             |
|------------------------------|------------------------|-------------|
| 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 | 38.9 $\pm$ 6 % | 1.37 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 | 10.2 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 41.1 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 | 5.33 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 21.4 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 | 52.7 $\pm$ 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 | 10.2 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 40.9 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 | 5.41 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 21.7 W/kg $\pm$ 16.5 % (k=2) |

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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 51.3 $\Omega$ + 5.2 j $\Omega$ |
| Return Loss                          | - 25.5 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 47.4 $\Omega$ + 5.5 j $\Omega$ |
| Return Loss                          | - 24.2 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.195 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 17, 2003 |

## DASY5 Validation Report for Head TSL

Date: 20.05.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d032**

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

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.37$  S/m;  $\epsilon_r = 38.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5, 5, 5); 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/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

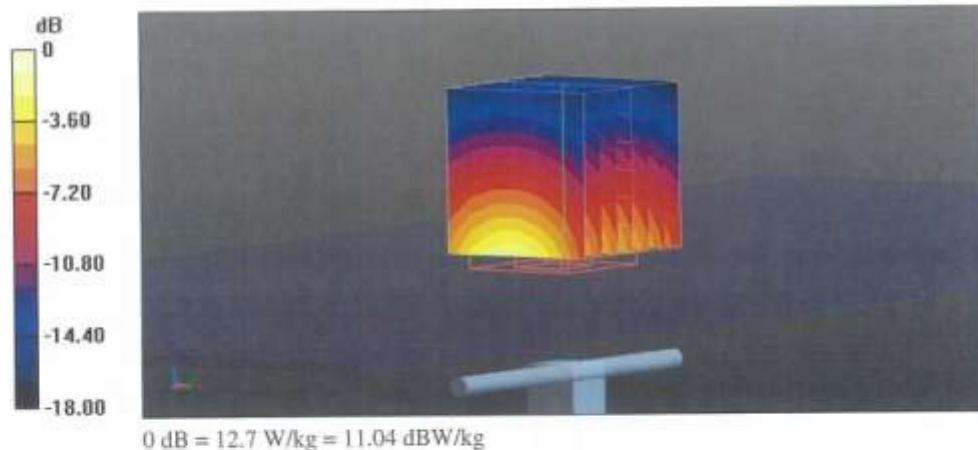
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 99.00 V/m; Power Drift = 0.04 dB

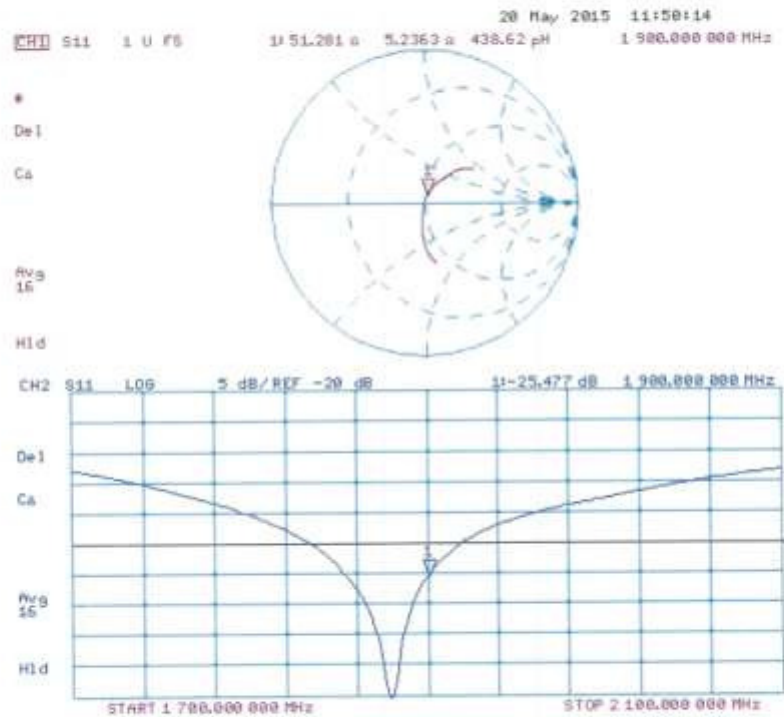
Peak SAR (extrapolated) = 18.6 W/kg

**SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.33 W/kg**

Maximum value of SAR (measured) = 12.7 W/kg



Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 20.05.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d032**

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

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.5$  S/m;  $\epsilon_r = 52.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.65, 4.65, 4.65); 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/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

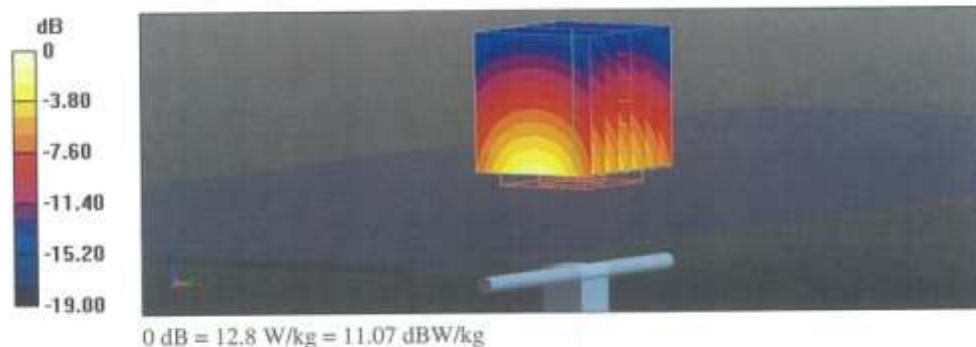
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 96.54 V/m; Power Drift = 0.01 dB

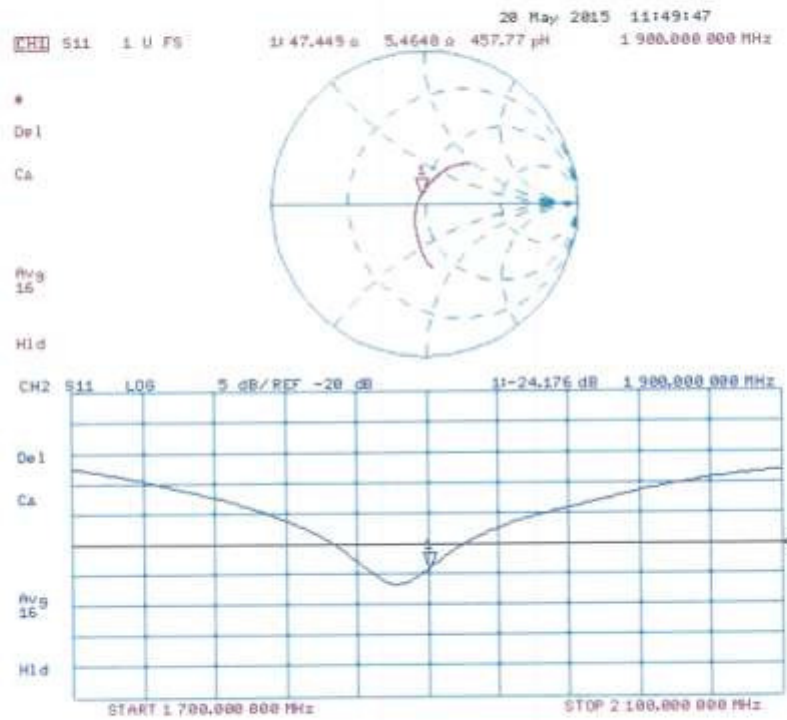
Peak SAR (extrapolated) = 17.3 W/kg

**SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.41 W/kg**

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



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D2450V2-743\_May15**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 743**

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

Calibration date: **May 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 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&E 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)     | 01-Apr-15 (No. 217-02131)         | Mar-16                 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 01-Apr-15 (No. 217-02134)         | Mar-16                 |
| 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   | US57390585 S4206   | 18-Oct-01 (in house check Oct-14) | In house check: Oct-15 |

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

Issued: May 20, 2015

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Certificate No: D2450V2-743\_May15

Page 1 of 8

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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.

|                              |                        |             |
|------------------------------|------------------------|-------------|
| 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                    | 2450 MHz $\pm$ 1 MHz   |             |

### Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 39.2           | 1.80 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 37.9 $\pm$ 6 % | 1.84 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 | 13.6 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 53.4 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 | 6.32 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 25.0 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             | 52.7           | 1.95 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 50.7 $\pm$ 6 % | 2.03 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 | 13.4 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 52.1 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 | 6.20 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 24.4 W/kg $\pm$ 16.5 % (k=2) |

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

### Antenna Parameters with Head TSL

|                                      |                             |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $54.2 \Omega + 4.4 j\Omega$ |
| Return Loss                          | - 24.6 dB                   |

### Antenna Parameters with Body TSL

|                                      |                             |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $51.4 \Omega + 6.1 j\Omega$ |
| Return Loss                          | - 24.2 dB                   |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1,160 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 | December 01, 2003 |

**DASY5 Validation Report for Head TSL**

Date: 19.05.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 743**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.84$  S/m;  $\epsilon_r = 37.9$ ;  $\rho = 1000$  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/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**

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

Reference Value = 101.4 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 28.0 W/kg

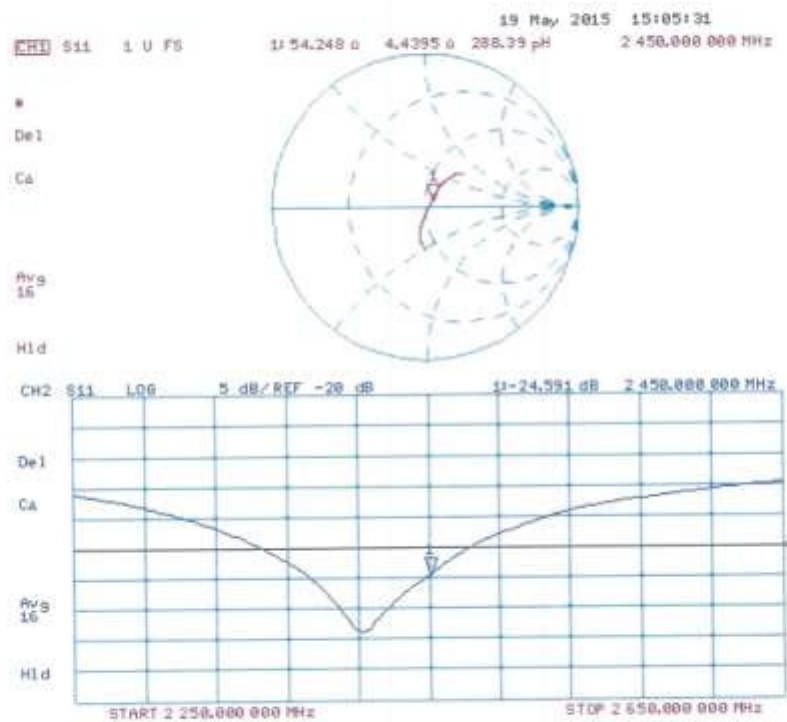
**SAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.32 W/kg**

Maximum value of SAR (measured) = 17.7 W/kg



0 dB = 17.7 W/kg = 12.48 dBW/kg

# Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 19.05.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 743**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 2.03$  S/m;  $\epsilon_r = 50.7$ ;  $\rho = 1000$  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/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

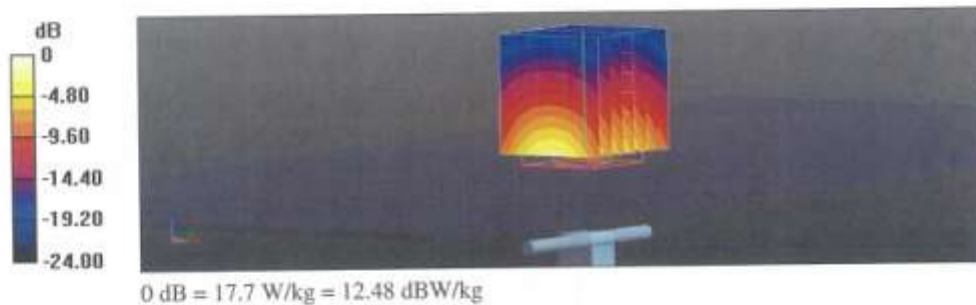
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 96.12 V/m; Power Drift = -0.02 dB

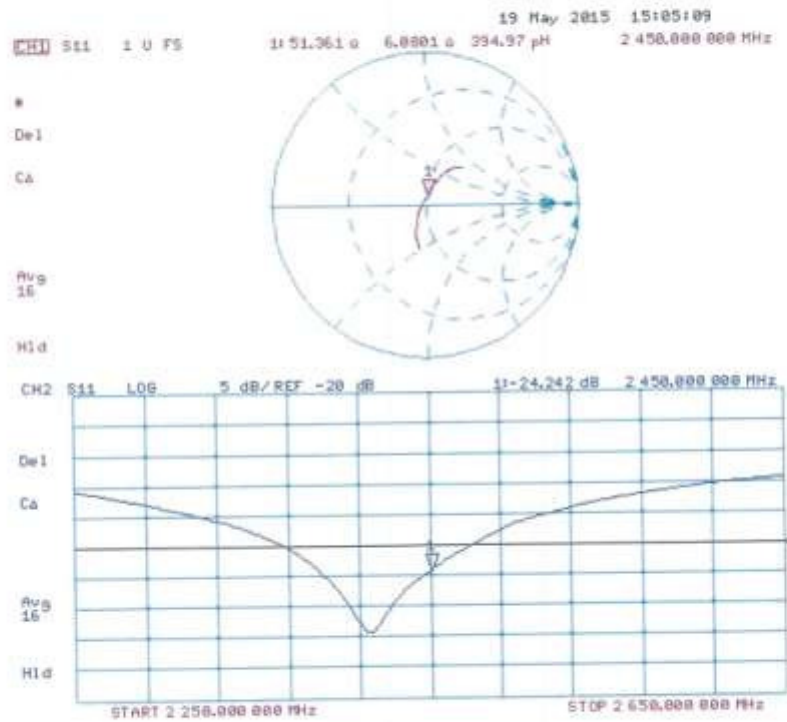
Peak SAR (extrapolated) = 27.9 W/kg

**SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.2 W/kg**

Maximum value of SAR (measured) = 17.7 W/kg



### Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D2600V2-1015\_Mar15**

## CALIBRATION CERTIFICATE

Object **D2600V2 - SN: 1015**

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

Calibration date: **March 25, 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 / 05327 | 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 |

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

Issued: March 25, 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.

|                              |                        |             |
|------------------------------|------------------------|-------------|
| 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 | 37.2 $\pm$ 6 % | 2.00 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 | 14.4 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 56.5 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 | 6.40 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 25.3 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 | 50.3 $\pm$ 6 % | 2.20 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 | 14.1 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 55.4 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 | 6.27 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 24.8 W/kg $\pm$ 16.5 % (k=2) |

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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 50.0 $\Omega$ - 2.1 j $\Omega$ |
| Return Loss                          | - 33.5 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 46.6 $\Omega$ - 1.9 j $\Omega$ |
| Return Loss                          | - 27.6 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.150 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 30, 2007 |

**DASY5 Validation Report for Head TSL**

Date: 20.03.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1015**

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

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2$  S/m;  $\epsilon_r = 37.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.49, 4.49, 4.49); 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/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**

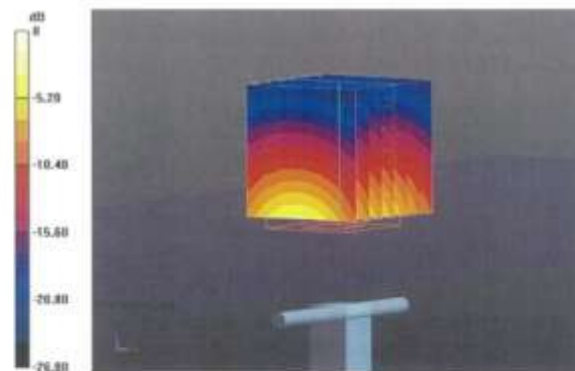
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 102.2 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 30.4 W/kg

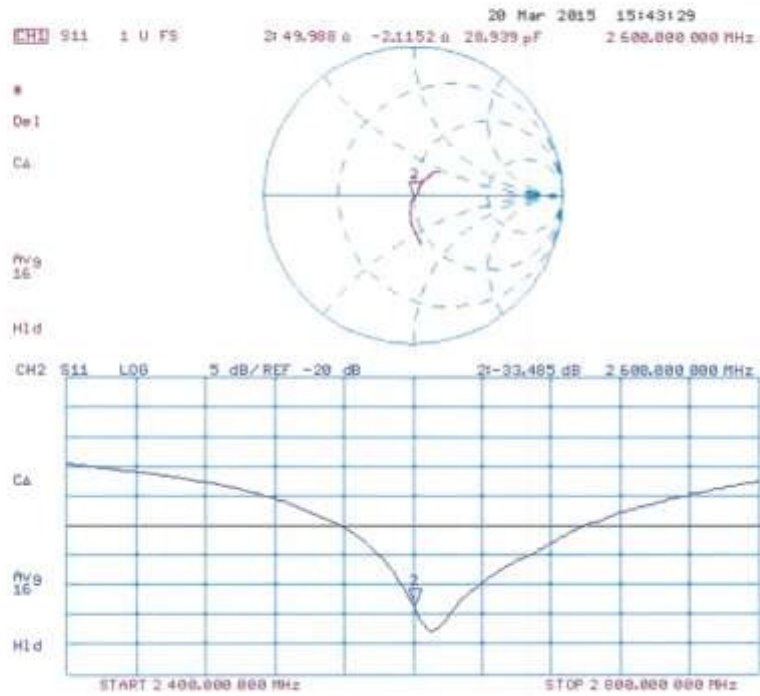
**SAR(1 g) = 14.4 W/kg; SAR(10 g) = 6.4 W/kg**

Maximum value of SAR (measured) = 18.9 W/kg



0 dB = 18.9 W/kg = 12.76 dBW/kg

Impedance Measurement Plot for Head TSL



## DASY5 Validation Report for Body TSL

Date: 25.03.2015

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1015**

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

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.2$  S/m;  $\epsilon_r = 50.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.13, 4.13, 4.13); 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/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

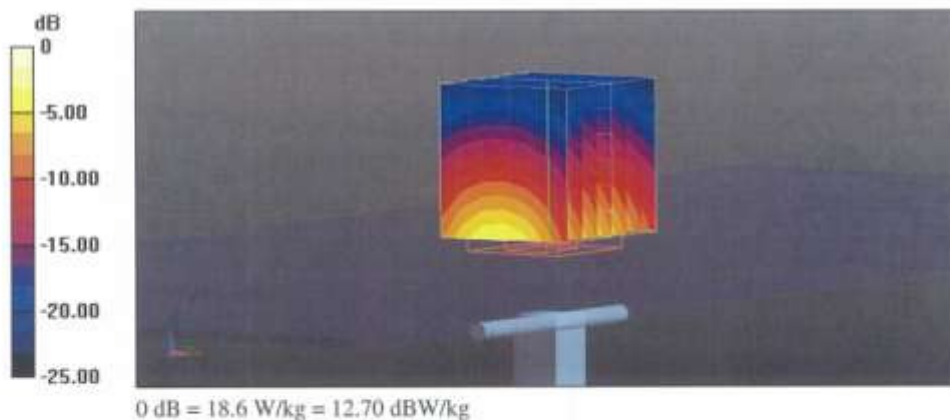
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 96.03 V/m; Power Drift = 0.03 dB

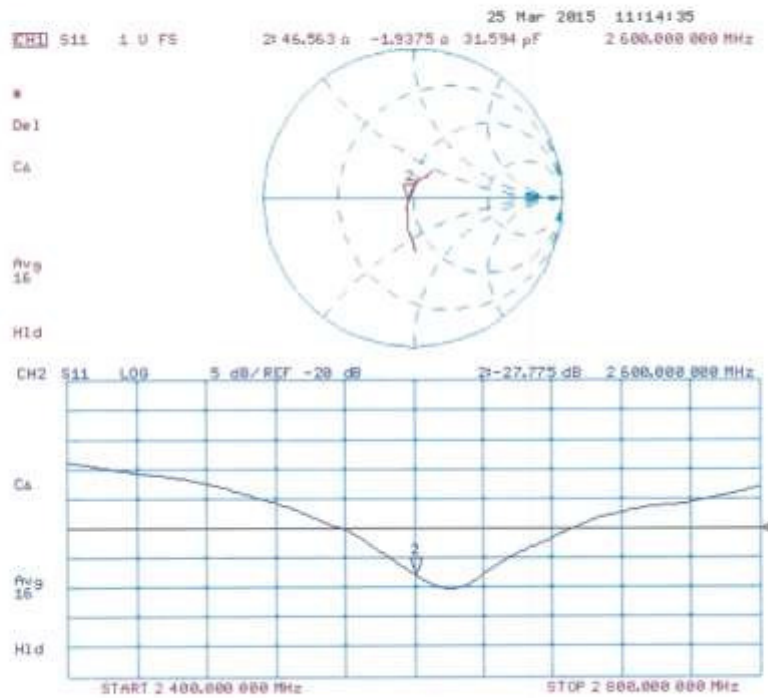
Peak SAR (extrapolated) = 29.2 W/kg

**SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.27 W/kg**

Maximum value of SAR (measured) = 18.6 W/kg



### Impedance Measurement Plot for Body TSL



## Attachment 5. – SAR Tissue Characterization

The brain and muscle mixtures consist of a viscous gel using hydrox-ethyl cellulose (HEC) gelling agent and saline solution (see Table 3.1). Preservation with a bactericide is added and visual inspection is made to make sure air bubbles are not trapped during the mixing process. The mixture is calibrated to obtain proper dielectric constant (permittivity) and conductivity of the desired tissue. The mixture characterizations used for the brain and muscle tissue simulating liquids are according to the data by C. Gabriel and G. Hartsgrove.

| Ingredients<br>(% by weight)  | Frequency (MHz) |       |       |       |               |      |               |       |
|-------------------------------|-----------------|-------|-------|-------|---------------|------|---------------|-------|
|                               | 835             |       | 1 900 |       | 2 450 – 2 700 |      | 5 200 - 5 800 |       |
| Tissue Type                   | Head            | Body  | Head  | Body  | Head          | Body | Head          | Body  |
| Water                         | 40.45           | 53.06 | 54.9  | 70.17 | 71.88         | 73.2 | 65.52         | 78.66 |
| Salt (NaCl)                   | 1.45            | 0.94  | 0.18  | 0.39  | 0.16          | 0.1  | 0.0           | 0.0   |
| Sugar                         | 57.0            | 44.9  | 0.0   | 0     | 0.0           | 0.0  | 0.0           | 0.0   |
| HEC                           | 1.0             | 1.0   | 0.0   | 0     | 0.0           | 0.0  | 0.0           | 0.0   |
| Bactericide                   | 0.1             | 0.1   | 0.0   | 0     | 0.0           | 0.0  | 0.0           | 0.0   |
| Triton X-100                  | 0.0             | 0.0   | 0.0   | 0.0   | 19.97         | 0.0  | 17.24         | 10.67 |
| DGBE                          | 0.0             | 0.0   | 44.92 | 29.44 | 7.99          | 26.7 | 0.0           | 0.0   |
| Diethylene glycol hexyl ether | -               | -     | -     | -     | -             | -    | 17.24         | 10.67 |

|                           |                                                                    |        |                        |
|---------------------------|--------------------------------------------------------------------|--------|------------------------|
| Salt:                     | 99 % Pure Sodium Chloride                                          | Sugar: | 98 % Pure Sucrose      |
| Water:                    | De-ionized, 16M resistivity                                        | HEC:   | Hydroxyethyl Cellulose |
| DGBE:                     | 99 % Di(ethylene glycol) butyl ether,[2-(2-butoxyethoxy) ethanol]  |        |                        |
| Triton X-100(ultra pure): | Polyethylene glycol mono[4-(1,1,3,3-tetramethylbutyl)phenyl] ether |        |                        |

### Composition of the Tissue Equivalent Matter

## Attachment 6. – SAR SYSTEM VALIDATION

Per FCC KCB 865664 D02v01r02, SAR system validation status should be document 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 IEEE 1528-2013 and FCC KDB 865664 D01v01r04. 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.

| SAR System No. | Probe | Probe Type | Probe Calibration Point |      | Dipole | Date       | Dielectric Parameters |                       | CW Validation |                 |                | Modulation Validation |             |      |
|----------------|-------|------------|-------------------------|------|--------|------------|-----------------------|-----------------------|---------------|-----------------|----------------|-----------------------|-------------|------|
|                |       |            |                         |      |        |            | Measured Permittivity | Measured Conductivity | Sensitivity   | Probe Linearity | Probe Isotropy | MOD. Type             | Duty Factor | PAR  |
| 1              | 3863  | EX3DV4     | Head                    | 750  | 1014   | 2015.09.14 | 41.8                  | 0.92                  | PASS          | PASS            | PASS           | N/A                   | N/A         | N/A  |
| 1              | 3863  | EX3DV4     | Body                    | 750  | 1014   | 2015.09.15 | 55.2                  | 0.96                  | PASS          | PASS            | PASS           | N/A                   | N/A         | N/A  |
| 1              | 3863  | EX3DV4     | Head                    | 835  | 4d165  | 2015.12.01 | 40.8                  | 0.89                  | PASS          | PASS            | PASS           | N/A                   | N/A         | N/A  |
| 1              | 3863  | EX3DV4     | Head                    | 835  | 4d165  | 2015.12.01 | 40.8                  | 0.89                  | PASS          | PASS            | PASS           | GMSK                  | PASS        | N/A  |
| 1              | 3863  | EX3DV4     | Body                    | 835  | 4d165  | 2015.12.02 | 54.8                  | 0.98                  | PASS          | PASS            | PASS           | N/A                   | N/A         | N/A  |
| 1              | 3863  | EX3DV4     | Body                    | 835  | 4d165  | 2015.12.02 | 54.8                  | 0.98                  | PASS          | PASS            | PASS           | GMSK                  | PASS        | N/A  |
| 12             | 7370  | EX3DV4     | Head                    | 1800 | 2d006  | 2016.02.05 | 40.2                  | 1.38                  | PASS          | PASS            | PASS           | GMSK                  | PASS        | N/A  |
| 9              | 3968  | EX3DV4     | Head                    | 1800 | 2d006  | 2016.02.05 | 40.2                  | 1.38                  | PASS          | PASS            | PASS           | N/A                   | N/A         | N/A  |
| 12             | 7370  | EX3DV4     | Body                    | 1800 | 2d006  | 2016.02.08 | 53.1                  | 1.5                   | PASS          | PASS            | PASS           | GMSK                  | PASS        | N/A  |
| 9              | 3968  | EX3DV4     | Body                    | 1800 | 2d006  | 2016.02.08 | 53.1                  | 1.5                   | PASS          | PASS            | PASS           | N/A                   | N/A         | N/A  |
| 9              | 3968  | EX3DV4     | Head                    | 1900 | 5d032  | 2015.06.29 | 40.1                  | 1.38                  | PASS          | PASS            | PASS           | GMSK                  | PASS        | N/A  |
| 9              | 3968  | EX3DV4     | Head                    | 1900 | 5d032  | 2015.06.29 | 40.1                  | 1.38                  | PASS          | PASS            | PASS           | N/A                   | N/A         | N/A  |
| 12             | 7370  | EX3DV4     | Head                    | 1900 | 5d032  | 2015.09.14 | 39.9                  | 1.41                  | PASS          | PASS            | PASS           | GMSK                  | PASS        | N/A  |
| 12             | 7370  | EX3DV4     | Body                    | 1900 | 5d032  | 2015.09.15 | 52.3                  | 1.52                  | PASS          | PASS            | PASS           | GMSK                  | PASS        | N/A  |
| 9              | 3968  | EX3DV4     | Body                    | 1900 | 5d032  | 2015.07.01 | 52.8                  | 1.53                  | PASS          | PASS            | PASS           | NA                    | N/A         | NA   |
| 8              | 3967  | EX3DV4     | Head                    | 2450 | 743    | 2015.12.28 | 39.3                  | 1.79                  | PASS          | PASS            | PASS           | OFDM                  | N/A         | PASS |
| 9              | 3968  | EX3DV4     | Body                    | 2450 | 743    | 2015.07.01 | 52.9                  | 1.98                  | PASS          | PASS            | PASS           | OFDM                  | N/A         | PASS |
| 8              | 3967  | EX3DV4     | Head                    | 2600 | 1015   | 2015.12.28 | 39.2                  | 1.95                  | PASS          | PASS            | PASS           | NA                    | N/A         | NA   |
| 9              | 3968  | EX3DV4     | Body                    | 2600 | 1015   | 2015.07.01 | 52.9                  | 2.18                  | PASS          | PASS            | PASS           | NA                    | N/A         | NA   |

**SAR System Validation Summary 1g**

### Note;

All measurement were performed using probes calibrated for CW signal only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01r04. SAR system 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 D01v01r04.