

## Attachment 3. – Probe Calibration Data

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



**S** Schweizerischer Kalibrierdienst  
**C** Service suisse d'étalonnage  
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**S** Swiss Calibration Service

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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 ± 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. 217-02126)	Mar-16
Power sensor E4412A	MY41498067	01-Apr-15 (No. 217-02126)	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 E530V2	SN: 3013	30-Dec-14 (No. ES3-3013_Dec14)	Dec-15
DAE4	SN: 660	14-Jan-15 (No. DAE4-660_Jan15)	Jan-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

	Name	Function	Signature
Calibrated by:	Jeton Kasrati	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.

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**Glossary:**

TSL	tissue simulating liquid
NORM <sub>x,y,z</sub>	sensitivity in free space
ConvF	sensitivity in TSL / NORM <sub>x,y,z</sub>
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization $\varphi$	$\varphi$ rotation around probe axis
Polarization $\theta$	$\theta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), 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:**

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

**Methods Applied and Interpretation of Parameters:**

- NORM<sub>x,y,z</sub>: Assessed for E-field polarization  $\theta = 0$  ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide). NORM<sub>x,y,z</sub> are only intermediate values, i.e., the uncertainties of NORM<sub>x,y,z</sub> does not affect the E<sup>2</sup>-field uncertainty inside TSL (see below ConvF).
- NORM(f)<sub>x,y,z</sub> = NORM<sub>x,y,z</sub> \* frequency\_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- 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 ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <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 dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>C</sup> (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>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: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>g</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>f</sup>	Conductivity (S/m) <sup>f</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>g</sup>	Depth <sup>g</sup> (mm)	Unc (k=2)
750	55.5	0.96	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.

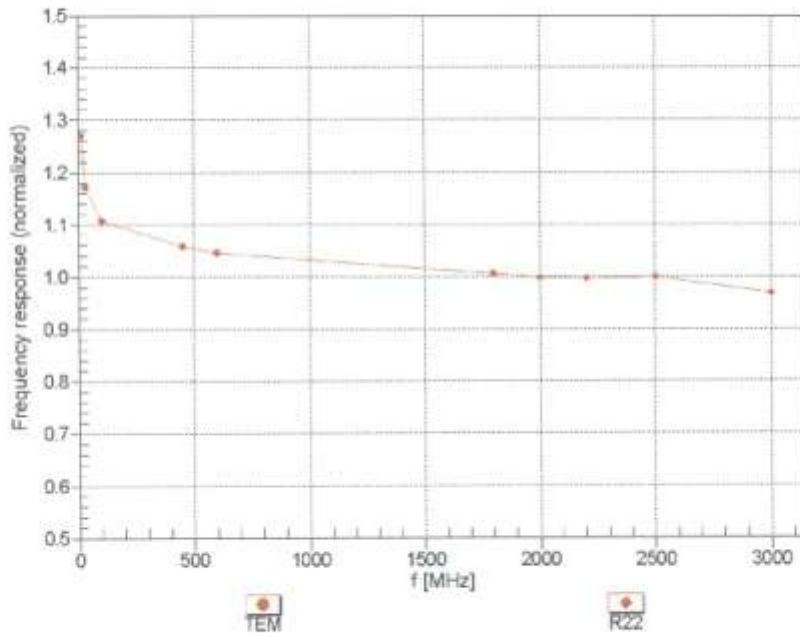
<sup>f</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

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



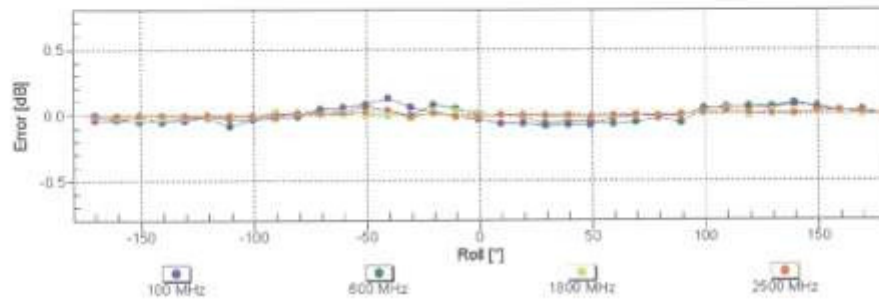
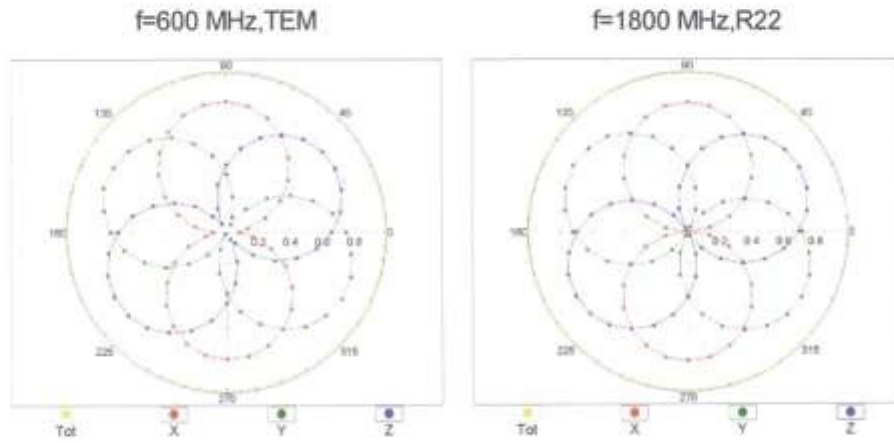
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)



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December 16, 2015

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

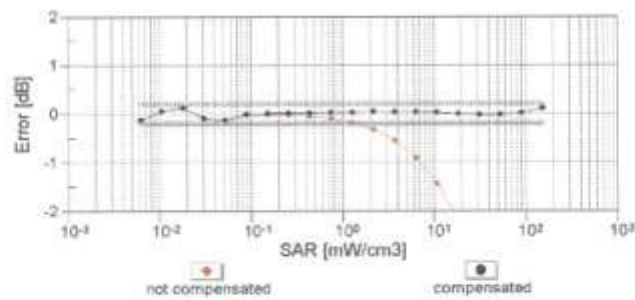
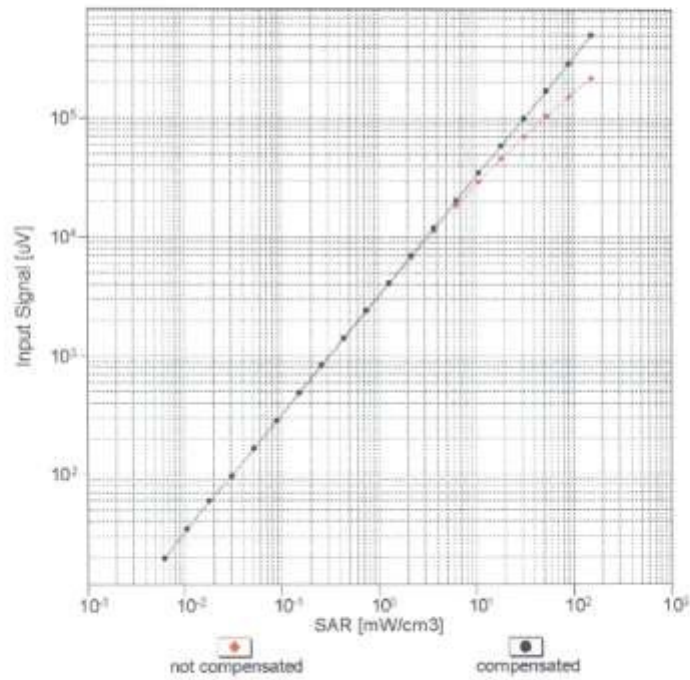


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

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December 16, 2015

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

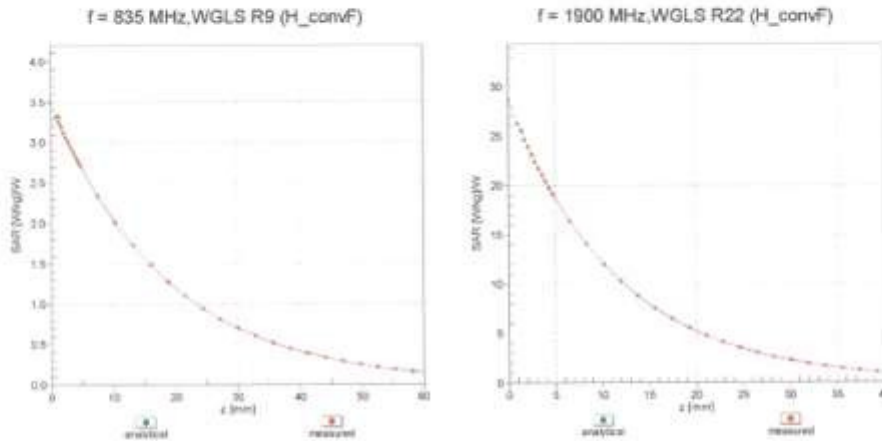


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

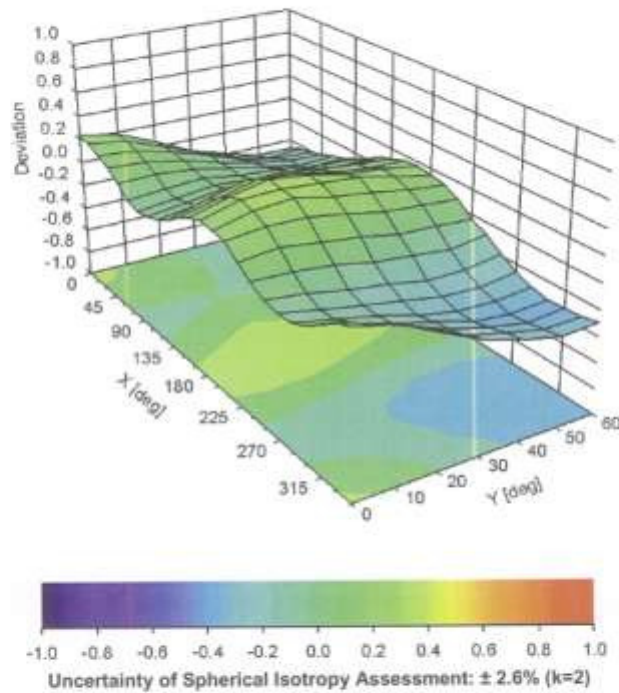
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December 16, 2015

### Conversion Factor Assessment



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

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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.

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Calibrated by:	Name <b>Jeton Kastrati</b>	Function <b>Laboratory Technician</b>	Signature 
Approved by:	Name <b>Katja Pokovic</b>	Function <b>Technical Manager</b>	Signature 

Issued: August 29, 2015.

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A, B, C, D	modulation dependent linearization parameters
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Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

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- b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

**Methods Applied and Interpretation of Parameters:**

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- **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 ≤ 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 ± 50 MHz to ± 100 MHz.
- **Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- **Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- **Connector Angle**: The angle is assessed using the information gained by determining the NORM<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 ( $\mu\text{V}/(\text{V}/\text{m})^{-2}$ ) <sup>4</sup>	0.37	0.35	0.45	± 10.1 %
DCP (mV) <sup>5</sup>	101.9	103.9	98.9	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>6</sup> (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>4</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>5</sup> Numerical linearization parameter: uncertainty not required.

<sup>6</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>f</sup>	Conductivity (S/m) <sup>f</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>g</sup>	Depth (mm) <sup>g</sup>	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>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

## 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>D</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, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

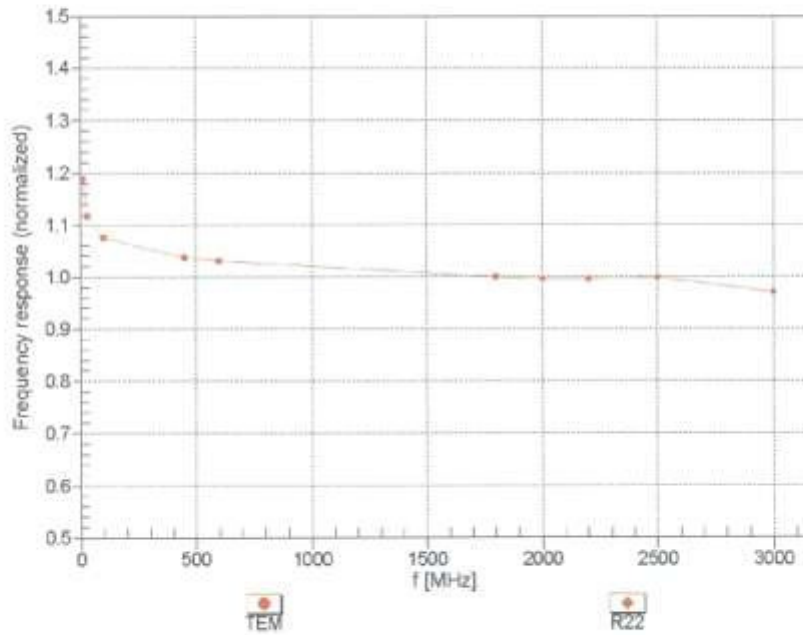
<sup>F</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

<sup>D</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.

EX30V4-- SN:3863

August 27, 2015

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

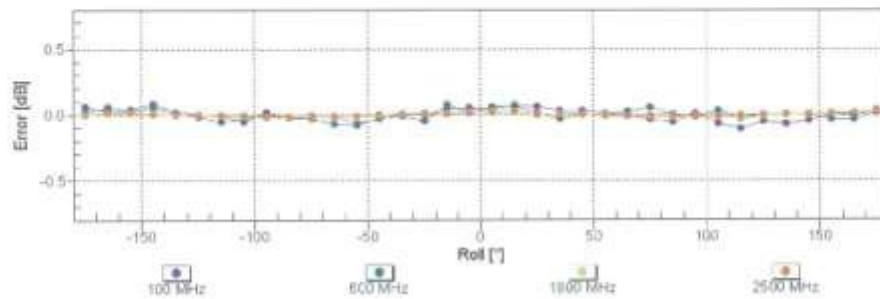
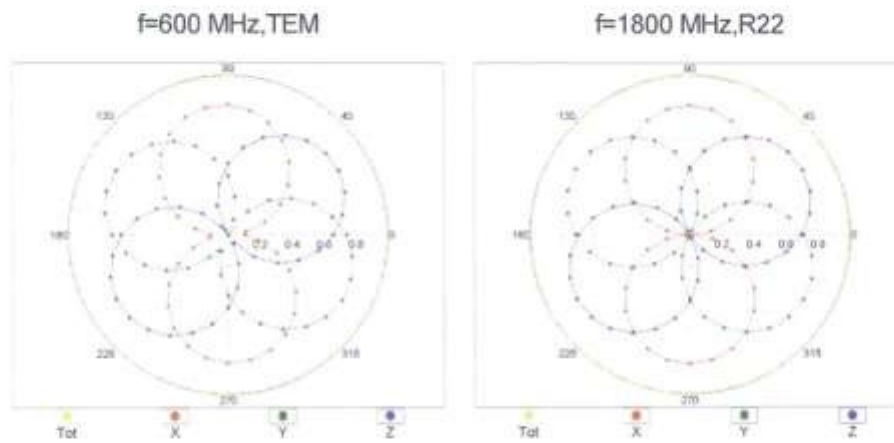


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

EX3DV4-SN:3863

August 27, 2015

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

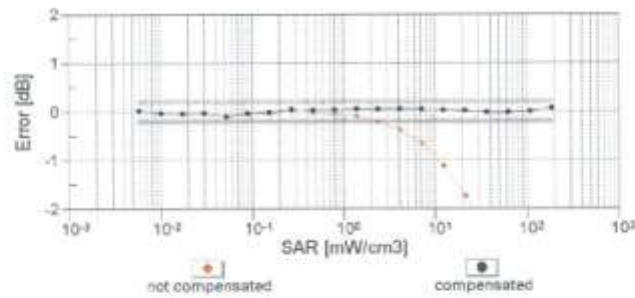
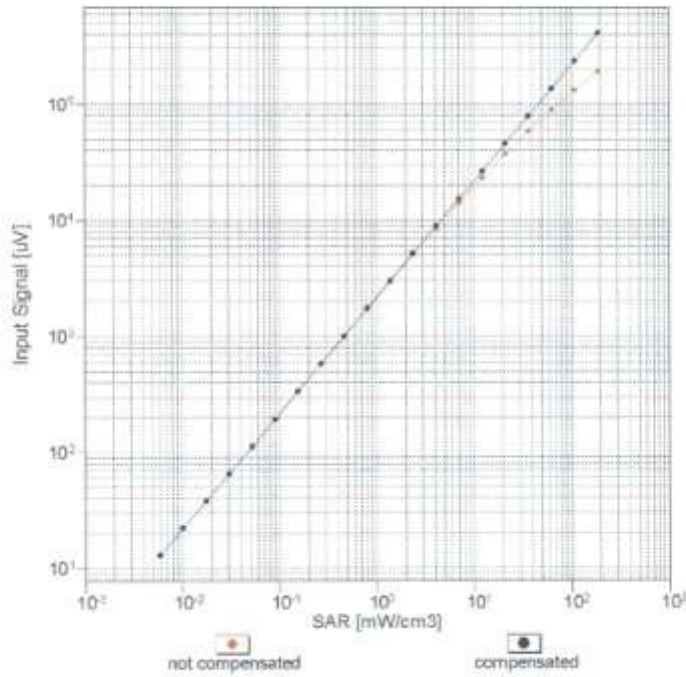


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

EX3DV4- SN:3863

August 27, 2015

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

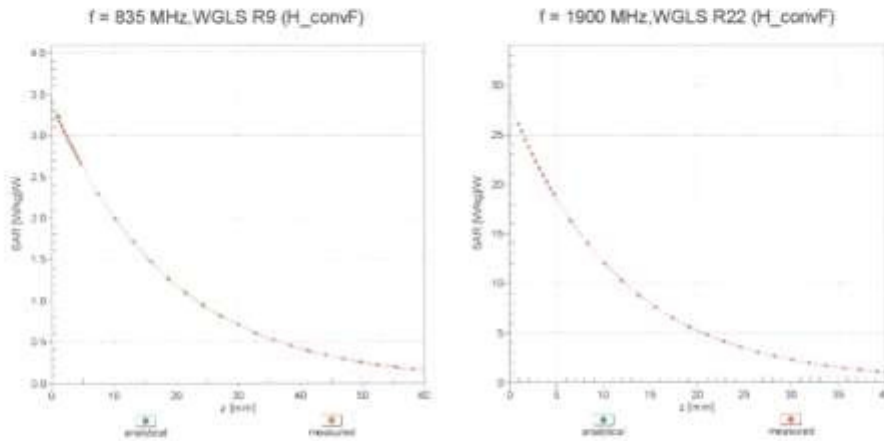


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

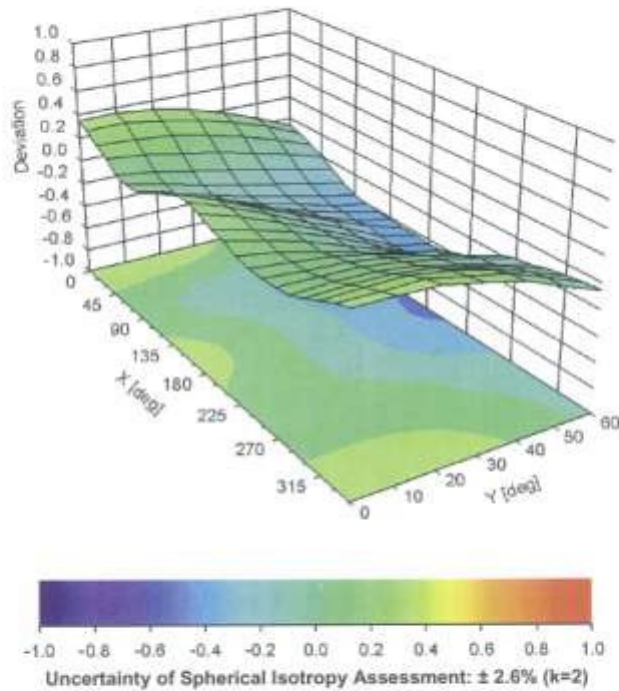
EX3DV4-SN:3863

August 27, 2015

### Conversion Factor Assessment



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

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



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

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

Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **ET3-1609\_Mar16**

**CALIBRATION CERTIFICATE**

Object **ET3DV6 - SN:1609**

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

Calibration date: **March 18, 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 ± 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 E53DV2	SN: 3013	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Issued: March 21, 2016

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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 $\beta$	$\beta$ rotation around an axis that is in the plane normal to probe axis (at measurement center), 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:**

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

**Methods Applied and Interpretation of Parameters:**

- **NORM<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).

ET3DV6 – SN:1609

March 18, 2016

# Probe ET3DV6

## SN:1609

Manufactured: July 27, 2001  
Calibrated: March 18, 2016

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

ET3DV6- SN:1609

March 18, 2016

## DASY/EASY - Parameters of Probe: ET3DV6 - SN:1609

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) <sup>A</sup>	2.00	1.81	1.82	± 10.1 %
DCP (mV) <sup>B</sup>	102.0	100.5	101.5	

### Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc <sup>C</sup> (k=2)
0	CW	X	0.0	0.0	1.0	0.00	266.0	±3.3 %
		Y	0.0	0.0	1.0		266.9	
		Z	0.0	0.0	1.0		259.2	

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>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.

ET3DV6- SN:1609

March 18, 2016

## DASY/EASY - Parameters of Probe: ET3DV6 - SN:1609

### Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) <sup>c</sup>	Relative Permittivity <sup>f</sup>	Conductivity (S/m) <sup>f</sup>	ConvF X	ConvF Y	ConvF Z	Alpha <sup>g</sup>	Depth <sup>g</sup> (mm)	Unc (k=2)
750	41.9	0.89	6.81	6.81	6.81	0.42	2.32	± 12.0 %
835	41.5	0.90	6.48	6.48	6.48	0.45	2.22	± 12.0 %
900	41.5	0.97	6.33	6.33	6.33	0.34	2.61	± 12.0 %
1450	40.5	1.20	5.61	5.61	5.61	0.53	2.34	± 12.0 %
1750	40.1	1.37	5.40	5.40	5.40	0.68	2.25	± 12.0 %
1900	40.0	1.40	5.20	5.20	5.20	0.79	2.05	± 12.0 %
1950	40.0	1.40	5.04	5.04	5.04	0.80	2.16	± 12.0 %
2300	39.5	1.67	4.88	4.88	4.88	0.80	1.94	± 12.0 %

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

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

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

ET3DV6- SN:1609

March 18, 2016

## DASY/EASY - Parameters of Probe: ET3DV6 - SN:1609

### Calibration Parameter Determined in Body 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>d</sup> (mm)	Unc (k=2)
750	55.5	0.96	6.25	6.25	6.25	0.31	2.75	± 12.0 %
835	55.2	0.97	6.16	6.16	6.16	0.32	2.73	± 12.0 %
1750	53.4	1.49	4.86	4.86	4.86	0.80	2.45	± 12.0 %
1900	53.3	1.52	4.68	4.68	4.68	0.80	2.31	± 12.0 %

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

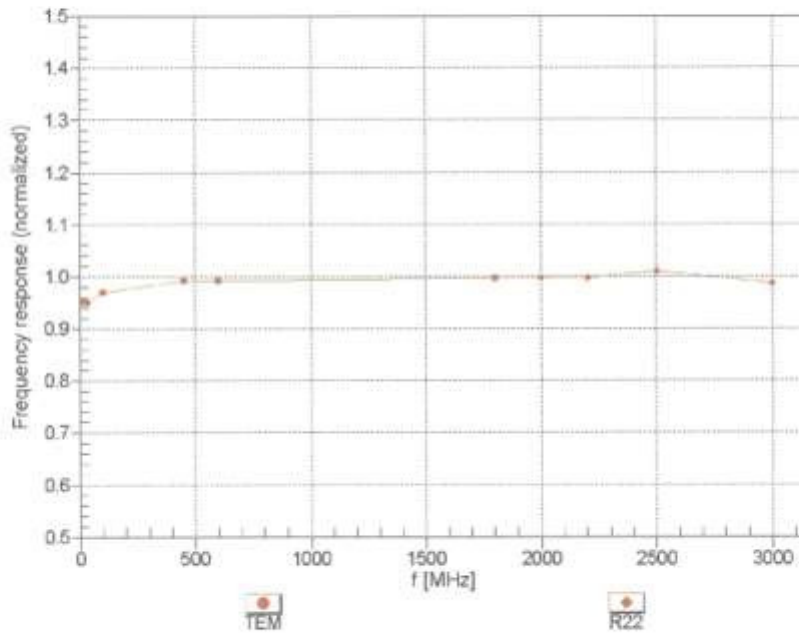
<sup>e</sup> At frequencies below 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters ( $\epsilon$  and  $\sigma$ ) is restricted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

ET3DV6-SN:1609

March 18, 2016

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

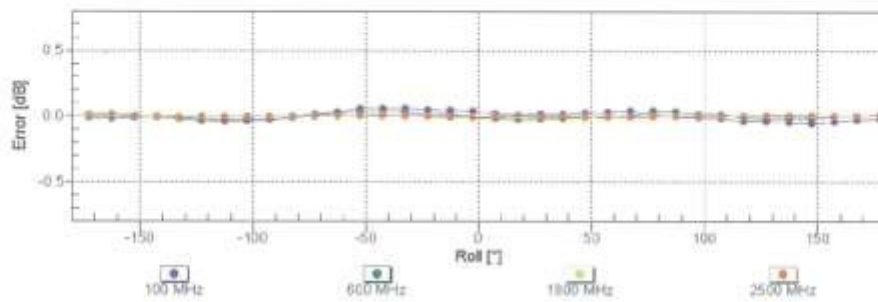
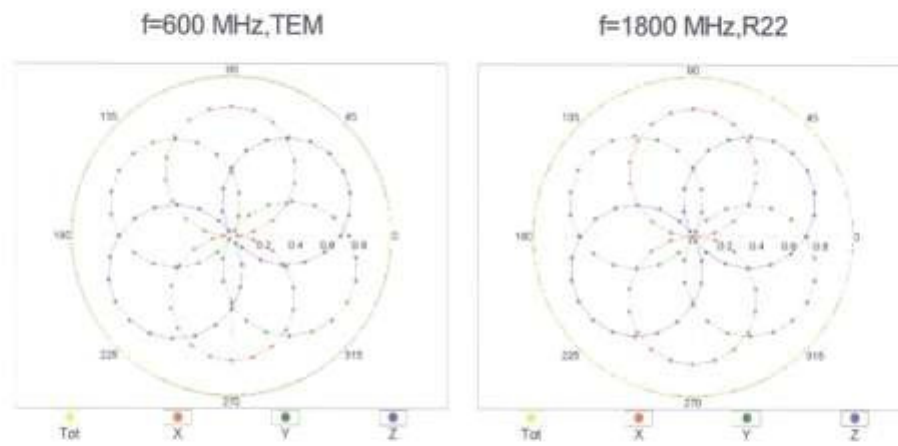


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

ET3DV6- SN:1609

March 18, 2016

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

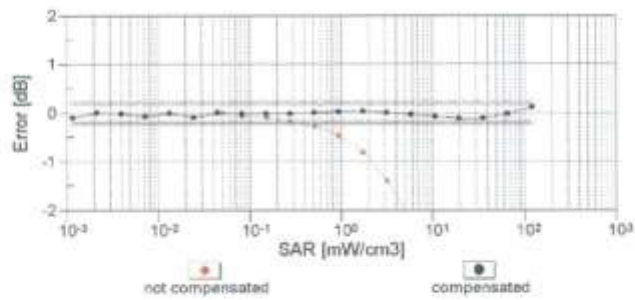
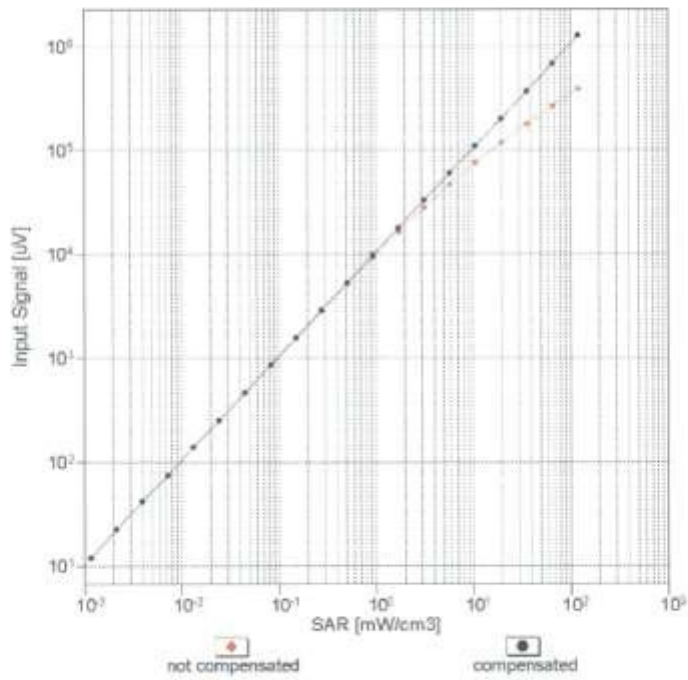


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)

ET3DV6- SN:1609

March 18, 2016

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



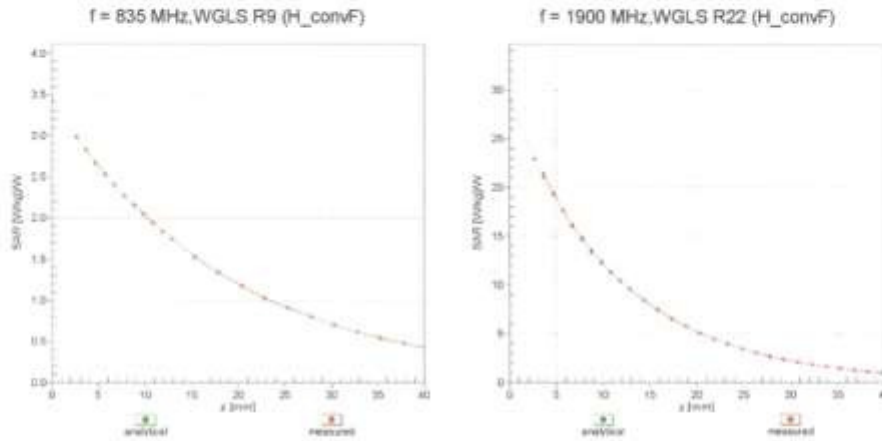
Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)



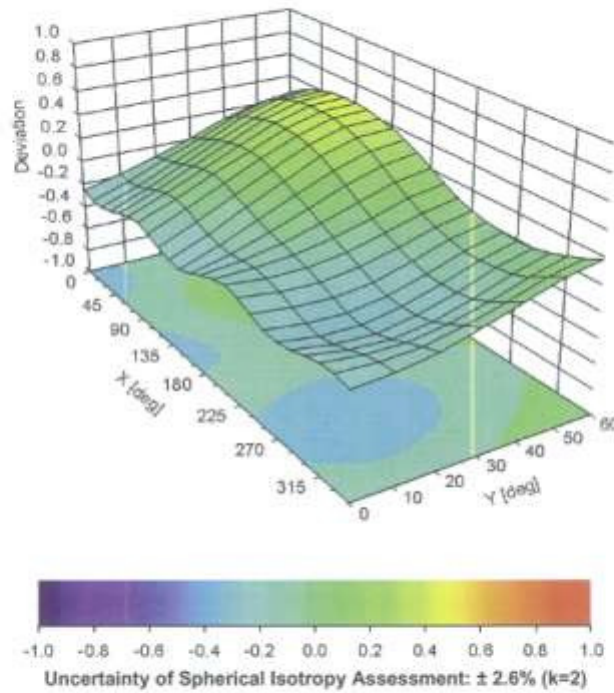
ET3DV6-- SN:1609

March 18, 2016

### Conversion Factor Assessment



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



ET3DV6- SN:1609

March 18, 2016

## DASY/EASY - Parameters of Probe: ET3DV6 - SN:1609

### Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	77.4
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	6.8 mm
Probe Tip to Sensor X Calibration Point	2.7 mm
Probe Tip to Sensor Y Calibration Point	2.7 mm
Probe Tip to Sensor Z Calibration Point	2.7 mm
Recommended Measurement Distance from Surface	4 mm

## Attachment 4. – Dipole Calibration Data

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**S** Swiss Calibration Service

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

Accreditation No.: **SCS 0108**

Client **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 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292763	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-05	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 54206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

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

Issued: July 23, 2015

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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)  
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:**

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

**Additional Documentation:**

- e) 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 ± 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 ± 0.2) °C	42.5 ± 6 %	0.90 mho/m ± 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	<b>8.15 W/kg ± 17.0 % (k=2)</b>
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	<b>5.33 W/kg ± 16.5 % (k=2)</b>

**Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	55.5	0.98 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	55.1 ± 6 %	0.98 mho/m ± 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	<b>8.49 W/kg ± 17.0 % (k=2)</b>
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	<b>5.60 W/kg ± 16.5 % (k=2)</b>

**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**

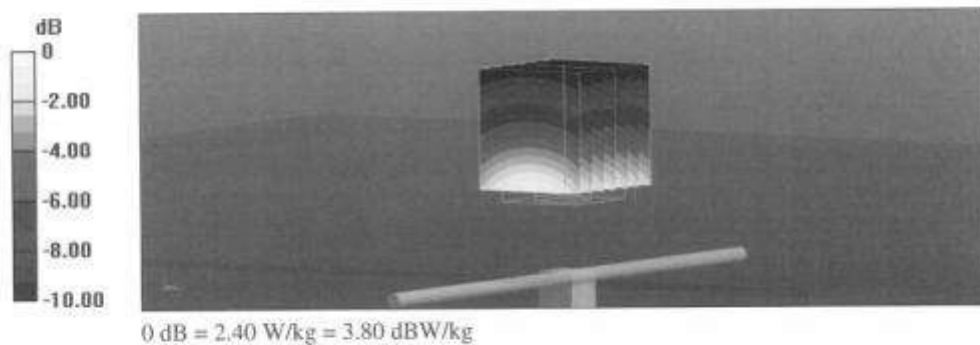
Communication System: UID 0 - CW; Frequency: 750 MHz  
Medium parameters used:  $f = 750 \text{ MHz}$ ;  $\sigma = 0.9 \text{ S/m}$ ;  $\epsilon_r = 42.5$ ;  $\rho = 1000 \text{ kg/m}^3$   
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(6.44, 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)

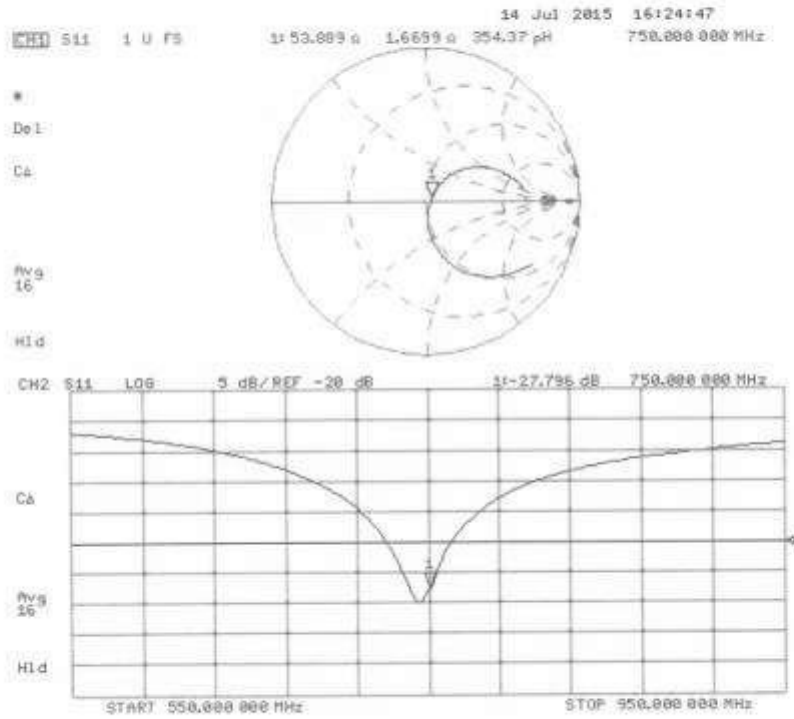
**Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**

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





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**

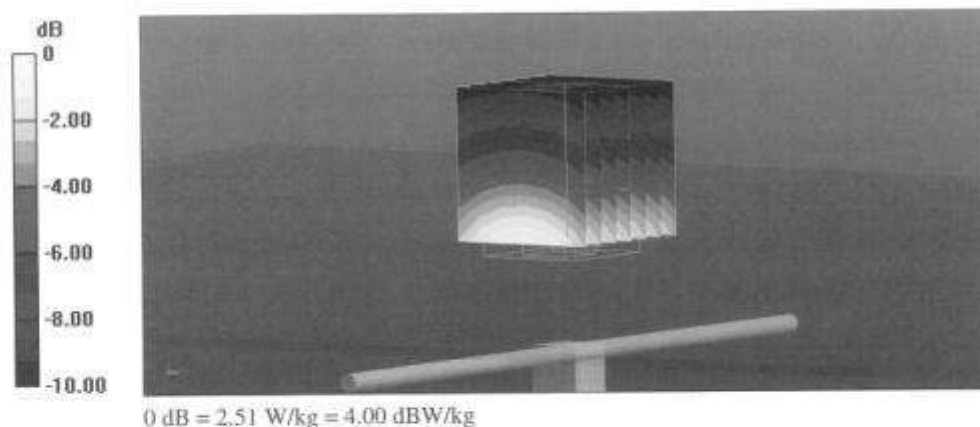
Communication System: UID 0 - CW; Frequency: 750 MHz  
Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.98$  S/m;  $\epsilon_r = 55.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

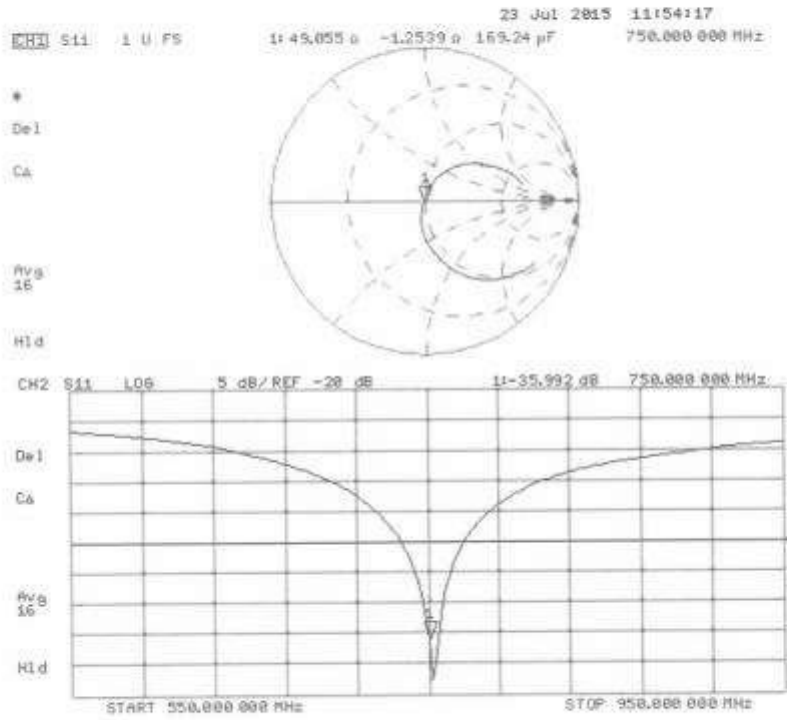
- Probe: ES3DV3 - SN3205; ConvF(6.21, 6.21, 6.21); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**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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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																																														
<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity &lt; 70%.</p> <p>Calibration Equipment used (M&amp;TE critical for calibration)</p> <table border="1"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date (Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power meter EPM-442A</td> <td>GB37480704</td> <td>07-Oct-15 (No. 217-02222)</td> <td>Oct-16</td> </tr> <tr> <td>Power sensor HP 8481A</td> <td>US37292783</td> <td>07-Oct-15 (No. 217-02222)</td> <td>Oct-16</td> </tr> <tr> <td>Power sensor HP 8481A</td> <td>MY41092317</td> <td>07-Oct-15 (No. 217-02223)</td> <td>Oct-16</td> </tr> <tr> <td>Reference 20 dB Attenuator</td> <td>SN: 5058 (20k)</td> <td>01-Apr-15 (No. 217-02131)</td> <td>Mar-16</td> </tr> <tr> <td>Type-N mismatch combination</td> <td>SN: 5047.2 / 06327</td> <td>01-Apr-15 (No. 217-02134)</td> <td>Mar-16</td> </tr> <tr> <td>Reference Probe EX3DV4</td> <td>SN: 7349</td> <td>30-Dec-14 (No. EX3-7349_Dec14)</td> <td>Dec-15</td> </tr> <tr> <td>DAE4</td> <td>SN: 601</td> <td>17-Aug-15 (No. DAE4-601_Aug15)</td> <td>Aug-16</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Secondary Standards</th> <th>ID #</th> <th>Check Date (in house)</th> <th>Scheduled Check</th> </tr> </thead> <tbody> <tr> <td>RF generator R&amp;S SMT-06</td> <td>100972</td> <td>15-Jun-15 (in house check Jun-15)</td> <td>In house check: Jun-16</td> </tr> <tr> <td>Network Analyzer HP 8753E</td> <td>US37390585 S4206</td> <td>18-Oct-01 (in house check Oct-15)</td> <td>In house check: Oct-16</td> </tr> </tbody> </table>				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
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Calibrated by:	Name Michael Weber	Function Laboratory Technician	Signature 																																												
Approved by:	Name Katja Pokovic	Function Technical Manager	Signature 																																												
			Issued: November 24, 2015																																												
This calibration certificate shall not be reproduced except in full without written approval of the laboratory.																																															

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**Glossary:**

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

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

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

**Additional Documentation:**

- e) 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 ± 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 ± 0.2) °C	42.6 ± 6 %	0.92 mho/m ± 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 ± 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 ± 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 ± 0.2) °C	55.6 ± 6 %	0.99 mho/m ± 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 ± 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 ± 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**

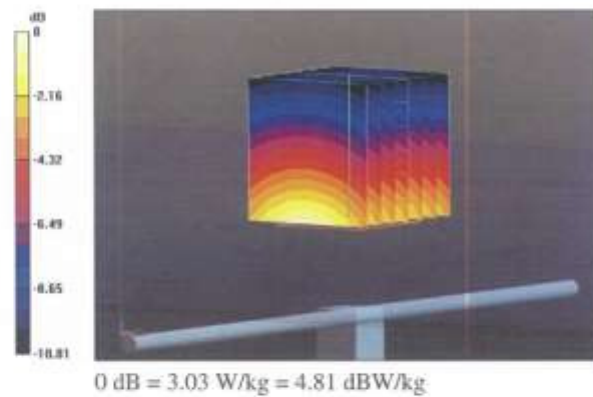
Communication System: UID 0 - CW; Frequency: 835 MHz  
Medium parameters used:  $f = 835$  MHz;  $\sigma = 0.92$  S/m;  $\epsilon_r = 42.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

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)

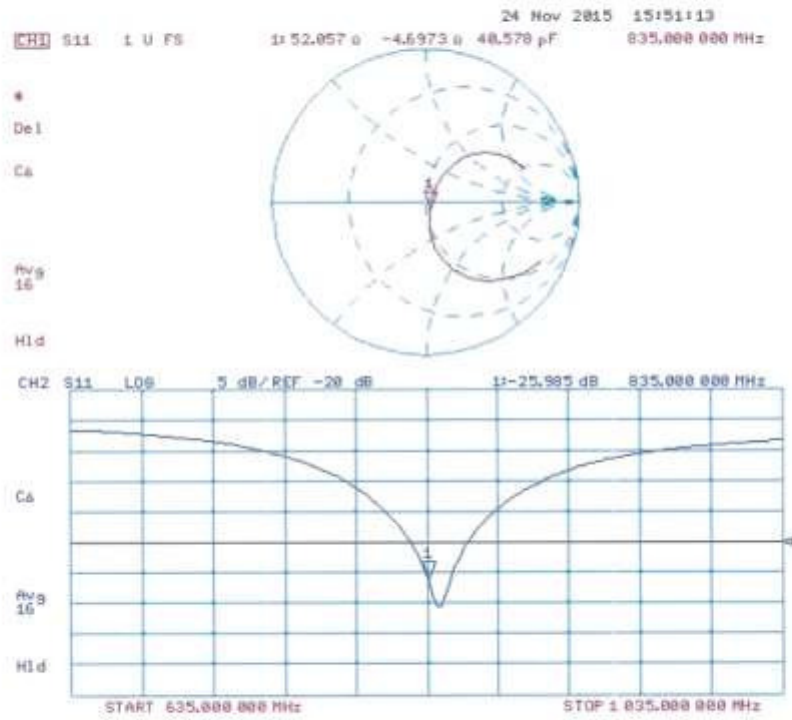
**Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:**

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**

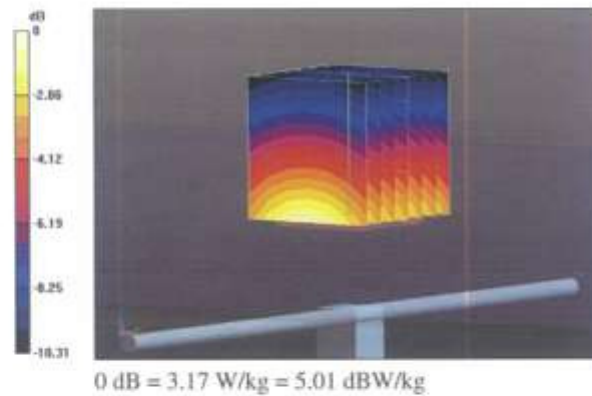
Communication System: UID 0 - CW; Frequency: 835 MHz  
Medium parameters used:  $f = 835$  MHz;  $\sigma = 0.99$  S/m;  $\epsilon_r = 55.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

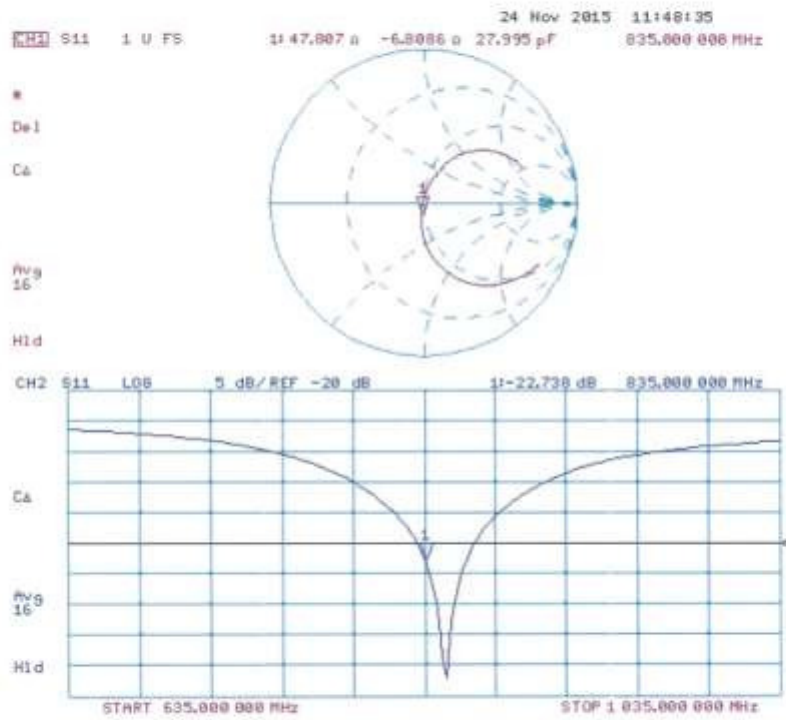
- Probe: EX3DV4 - SN7349; ConvF(9.72, 9.72, 9.72); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 17.08.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

**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 ± 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	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-18
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

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

Approved by: **Katja Pokovic** (Name), **Technical Manager** (Function), *K. Pokovic* (Signature)

Issued: January 25, 2016

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**S** Servizio svizzero di taratura  
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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:**

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

**Additional Documentation:**

- e) 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 ± 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 ± 0.2) °C	40.1 ± 6 %	1.39 mho/m ± 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	<b>38.5 W/kg ± 17.0 % (k=2)</b>

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	<b>20.2 W/kg ± 16.5 % (k=2)</b>

**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 ± 0.2) °C	53.7 ± 6 %	1.52 mho/m ± 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	<b>38.3 W/kg ± 17.0 % (k=2)</b>

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	<b>20.2 W/kg ± 16.5 % (k=2)</b>

**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**

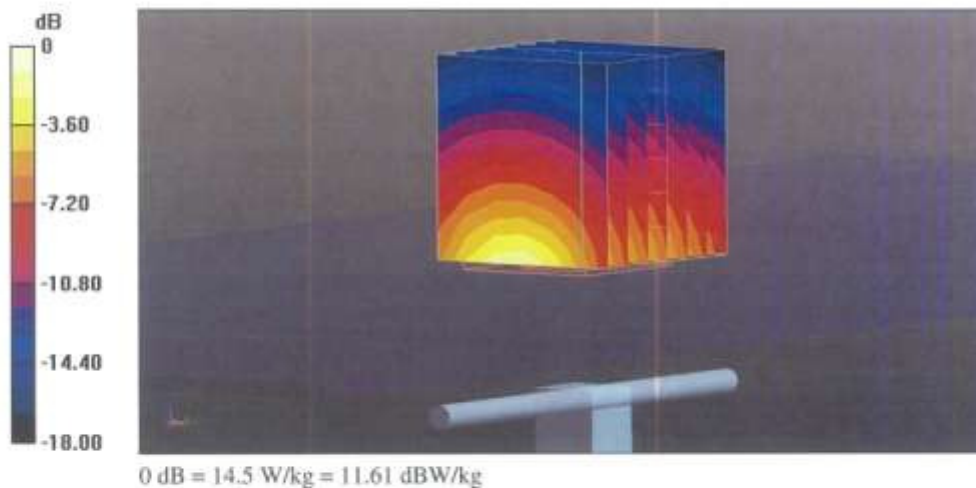
Communication System: UID 0 - CW; Frequency: 1800 MHz  
Medium parameters used:  $f = 1800$  MHz;  $\sigma = 1.39$  S/m;  $\epsilon_r = 40.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - 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)

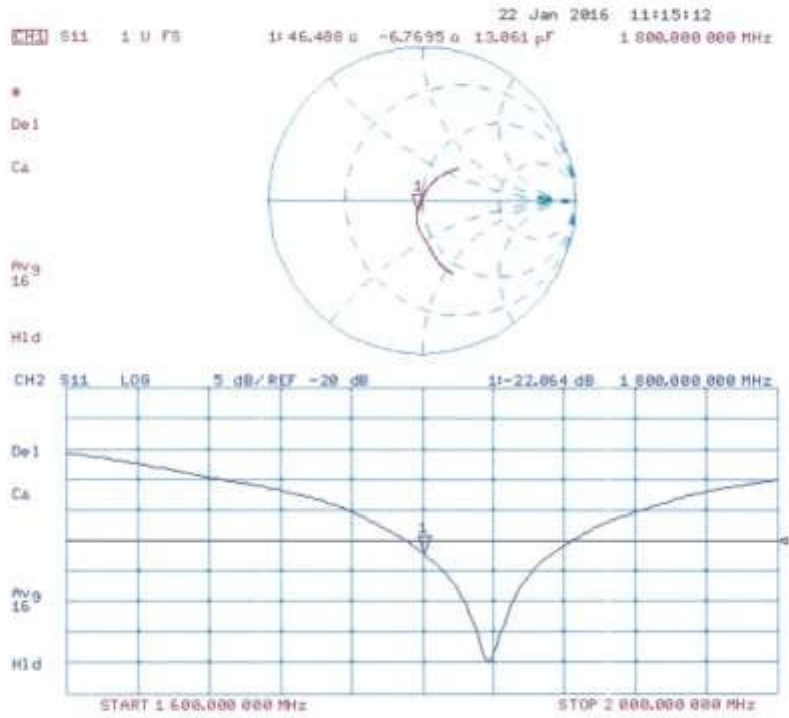
**Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**

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

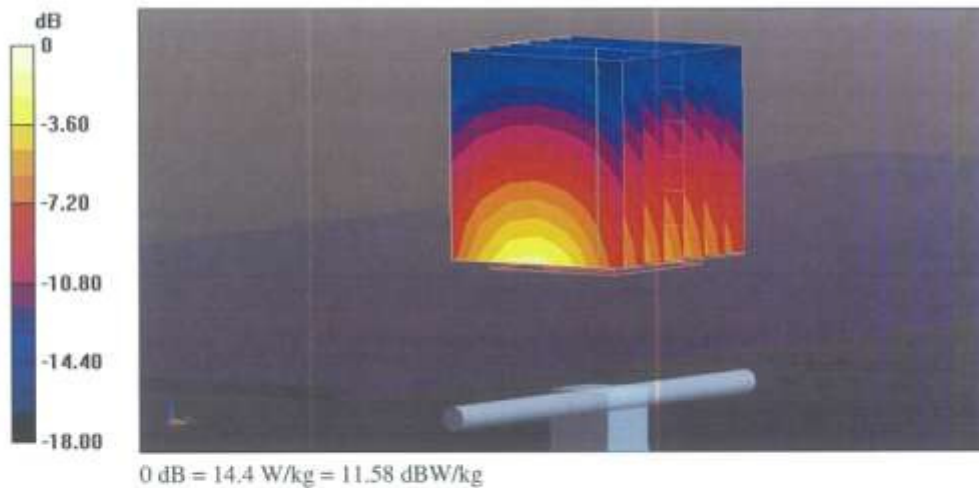
Communication System: UID 0 - CW; Frequency: 1800 MHz  
Medium parameters used:  $f = 1800$  MHz;  $\sigma = 1.52$  S/m;  $\epsilon_r = 53.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

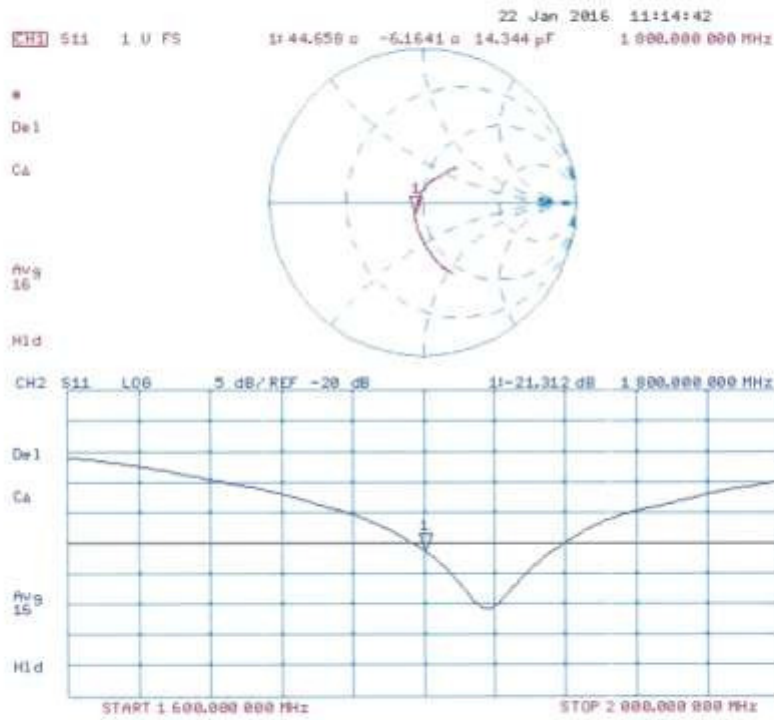
- Probe: EX3DV4 - SN7349; ConvF(8.17, 8.17, 8.17); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm  
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: **D1900V2-5d061\_Apr16**

CALIBRATION CERTIFICATE																																																																							
Object	D1900V2 - SN: 5d061																																																																						
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz																																																																						
Calibration date:	April 25, 2016																																																																						
<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility, environment temperature (22 ± 3)°C and humidity &lt; 70%.</p> <p>Calibration Equipment used (M&amp;TE critical for calibration)</p> <table border="1"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date (Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power meter NRP</td> <td>SN: 104778</td> <td>06-Apr-16 (No. 217-02288/02289)</td> <td>Apr-17</td> </tr> <tr> <td>Power sensor NRP-Z91</td> <td>SN: 103244</td> <td>06-Apr-16 (No. 217-02288)</td> <td>Apr-17</td> </tr> <tr> <td>Power sensor NRP-Z91</td> <td>SN: 103245</td> <td>06-Apr-16 (No. 217-02289)</td> <td>Apr-17</td> </tr> <tr> <td>Reference 20 dB Attenuator</td> <td>SN: 5058 (20k)</td> <td>05-Apr-16 (No. 217-02292)</td> <td>Apr-17</td> </tr> <tr> <td>Type-N mismatch combination</td> <td>SN: 5047.2 / 06327</td> <td>05-Apr-16 (No. 217-02295)</td> <td>Apr-17</td> </tr> <tr> <td>Reference Probe EX30V4</td> <td>SN: 7349</td> <td>31-Dec-15 (No. EX3-7349_Dec15)</td> <td>Dec-16</td> </tr> <tr> <td>DAE4</td> <td>SN: 601</td> <td>30-Dec-15 (No. DAE4-601_Dec15)</td> <td>Dec-16</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Secondary Standards</th> <th>ID #</th> <th>Check Date (in house)</th> <th>Scheduled Check</th> </tr> </thead> <tbody> <tr> <td>Power meter EPM-442A</td> <td>SN: GB37480704</td> <td>07-Oct-15 (No. 217-02222)</td> <td>In house check: Oct-16</td> </tr> <tr> <td>Power sensor HP 8481A</td> <td>SN: US37292783</td> <td>07-Oct-15 (No. 217-02222)</td> <td>In house check: Oct-16</td> </tr> <tr> <td>Power sensor HP 8481A</td> <td>SN: MY41092317</td> <td>07-Oct-15 (No. 217-02223)</td> <td>In house check: Oct-16</td> </tr> <tr> <td>RF generator R&amp;S SMT-06</td> <td>SN: 100972</td> <td>15-Jun-15 (in house check Jun-15)</td> <td>In house check: Oct-16</td> </tr> <tr> <td>Network Analyzer HP 8753E</td> <td>SN: US37390585</td> <td>18-Oct-01 (in house check Oct-15)</td> <td>In house check: Oct-16</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Calibrated by:</th> <th>Name</th> <th>Function</th> <th>Signature</th> </tr> </thead> <tbody> <tr> <td></td> <td>Michael Weber</td> <td>Laboratory Technician</td> <td></td> </tr> <tr> <td>Approved by:</td> <td>Katja Pokovic</td> <td>Technical Manager</td> <td></td> </tr> </tbody> </table> <p>Issued: April 26, 2016</p> <p>This calibration certificate shall not be reproduced except in full without written approval of the laboratory.</p>				Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration	Power meter NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17	Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17	Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17	Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17	Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17	Reference Probe EX30V4	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	Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16	Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16	Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16	RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16	Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16	Calibrated by:	Name	Function	Signature		Michael Weber	Laboratory Technician		Approved by:	Katja Pokovic	Technical Manager	
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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:**

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

**Additional Documentation:**

- e) 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 ± 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 ± 0.2) °C	40.0 ± 6 %	1.37 mho/m ± 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	9.53 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>38.6 W/kg ± 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.01 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>20.2 W/kg ± 16.5 % (k=2)</b>

**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 ± 0.2) °C	52.9 ± 6 %	1.49 mho/m ± 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	9.82 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>39.7 W/kg ± 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.20 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>20.9 W/kg ± 16.5 % (k=2)</b>

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

Impedance, transformed to feed point	52.5 $\Omega$ + 7.7 j $\Omega$
Return Loss	- 22.1 dB

**Antenna Parameters with Body TSL**

Impedance, transformed to feed point	47.9 $\Omega$ + 8.5 j $\Omega$
Return Loss	- 21.0 dB

**General Antenna Parameters and Design**

Electrical Delay (one direction)	1.192 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 10, 2004

**DASY5 Validation Report for Head TSL**

Date: 25.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d061**

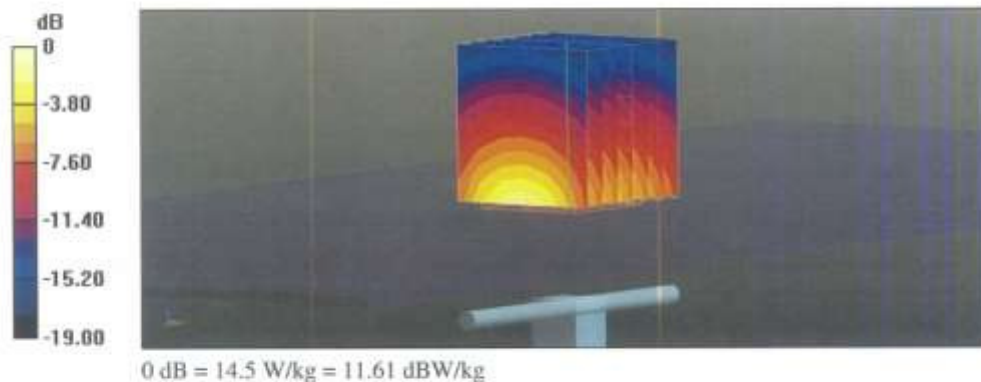
Communication System: UID 0 - CW; Frequency: 1900 MHz  
Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.37$  S/m;  $\epsilon_r = 40$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.2, 8.2, 8.2); 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)

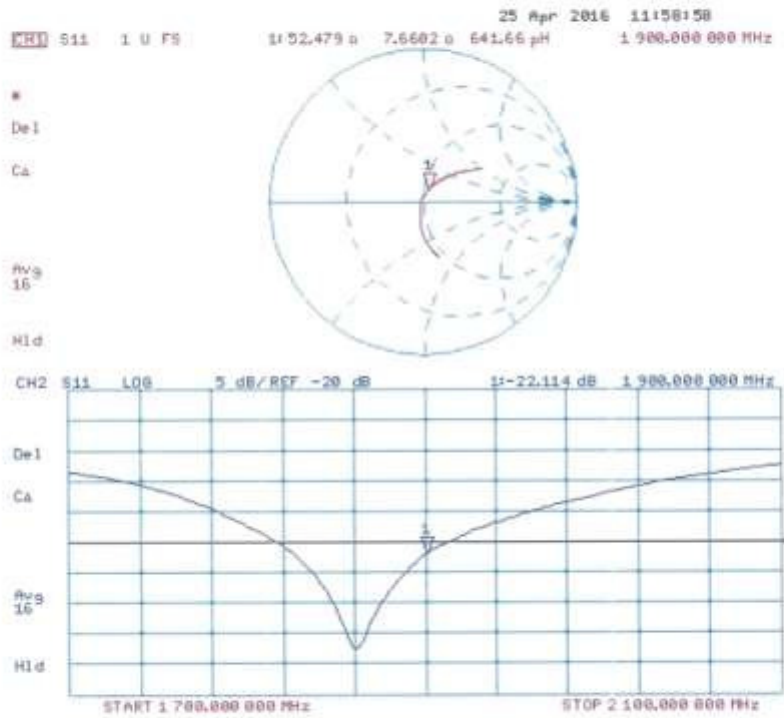
**Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:**

Measurement grid: dx=5mm, dy=5mm, dz=5mm  
Reference Value = 107.4 V/m; Power Drift = 0.03 dB  
Peak SAR (extrapolated) = 17.2 W/kg  
**SAR(1 g) = 9.53 W/kg; SAR(10 g) = 5.01 W/kg**  
Maximum value of SAR (measured) = 14.5 W/kg





Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 25.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN: 5d061**

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

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.49$  S/m;  $\epsilon_r = 52.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.03, 8.03, 8.03); 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:**

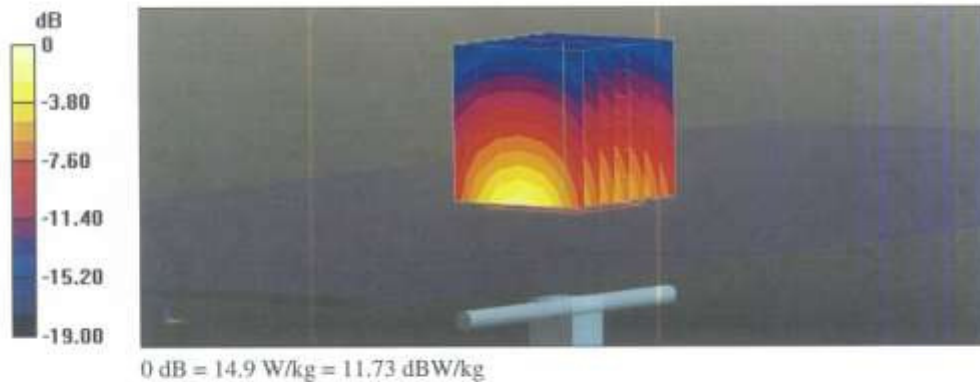
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 104.3 V/m; Power Drift = -0.03 dB

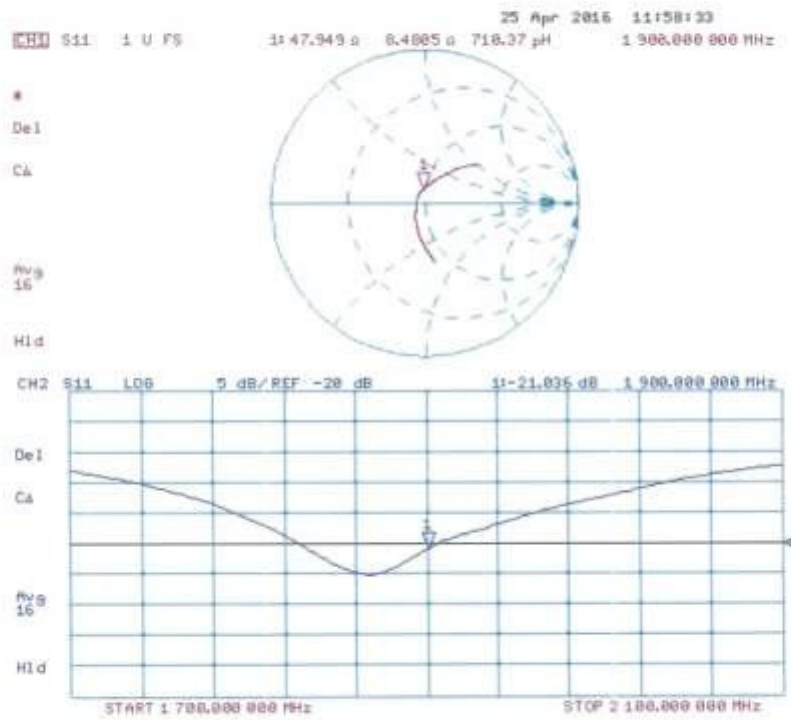
Peak SAR (extrapolated) = 17.3 W/kg

**SAR(1 g) = 9.82 W/kg; SAR(10 g) = 5.2 W/kg**

Maximum value of SAR (measured) = 14.9 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D2450V2-965\_Apr16**

CALIBRATION CERTIFICATE			
Object	D2450V2 - SN: 965		
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz		
Calibration date:	April 19, 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 ± 3)°C and humidity < 70%.			
Calibration Equipment used (M&TE critical for calibration)			
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: 5058 (20k)	05-Apr-16 (No. 217-02292)	Apr-17
Type-N mismatch combination	SN: 5047.2 / 06327	05-Apr-16 (No. 217-02295)	Apr-17
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
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (No. 217-02222)	In house check: Oct-16
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (No. 217-02223)	In house check: Oct-16
RF generator R&S SMT-08	SN: 100972	15-Jun-15 (in house check Jun-15)	In house check: Oct-16
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16
Calibrated by:	Name Michael Weber	Function Laboratory Technician	Signature 
Approved by:	Name Katja Pokovic	Technical Manager	
			Issued: April 20, 2016
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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:**

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

**Additional Documentation:**

- e) 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 ± 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 ± 0.2) °C	40.0 ± 6 %	1.83 mho/m ± 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	12.7 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	50.6 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.89 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.5 W/kg ± 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 ± 0.2) °C	52.7 ± 6 %	1.98 mho/m ± 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	12.4 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.2 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.78 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.0 W/kg ± 16.5 % (k=2)

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

**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	54.6 $\Omega$ + 3.8 j $\Omega$
Return Loss	- 24.8 dB

**Antenna Parameters with Body TSL**

Impedance, transformed to feed point	51.0 $\Omega$ + 5.9 j $\Omega$
Return Loss	- 24.5 dB

**General Antenna Parameters and Design**

Electrical Delay (one direction)	1.162 ns
----------------------------------	----------

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

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

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

**Additional EUT Data**

Manufactured by	SPEAG
Manufactured on	November 19, 2014

**DASY5 Validation Report for Head TSL**

Date: 19.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 965**

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.83$  S/m;  $\epsilon_r = 40$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.76, 7.76, 7.76); 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:**

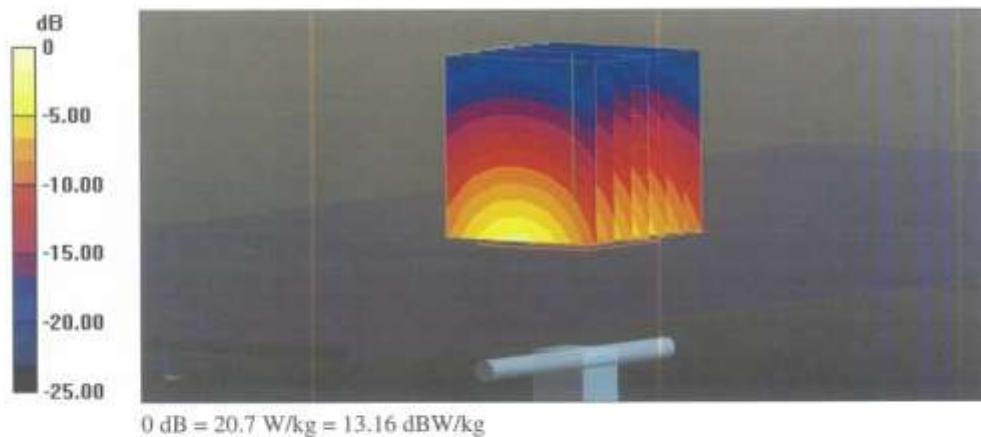
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 112.4 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 25.6 W/kg

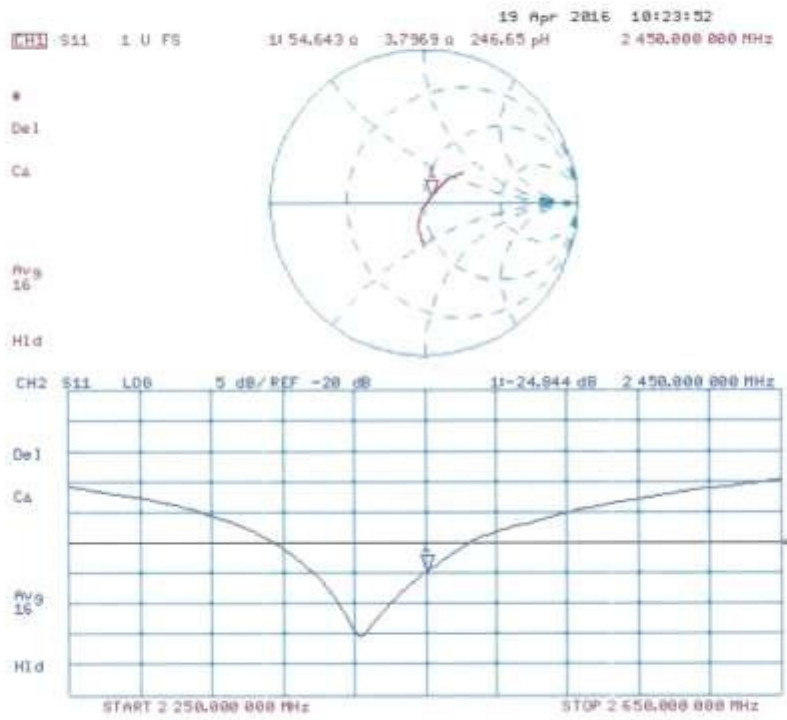
**SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.89 W/kg**

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





Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 19.04.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 965**

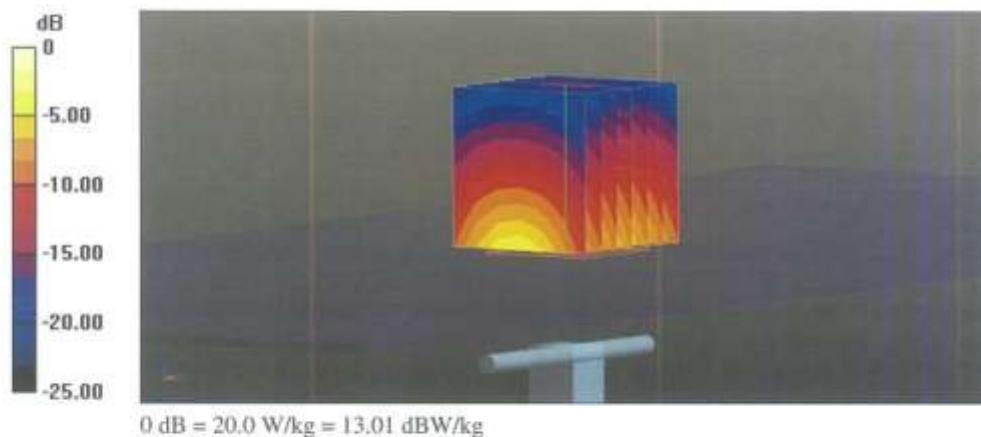
Communication System: UID 0 - CW; Frequency: 2450 MHz  
Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.98$  S/m;  $\epsilon_r = 52.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

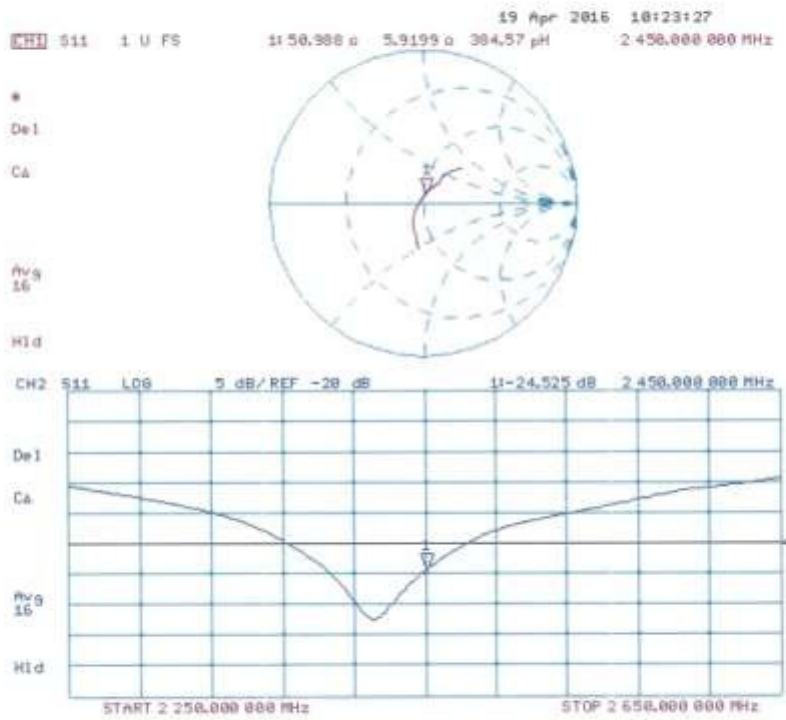
- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm  
Reference Value = 104.7 V/m; Power Drift = 0.01 dB  
Peak SAR (extrapolated) = 24.7 W/kg  
SAR(1 g) = 12.4 W/kg; SAR(10 g) = 5.78 W/kg  
Maximum value of SAR (measured) = 20.0 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **HCT (Dymstec)**

Certificate No: **D2600V2-1106\_Feb16**

**CALIBRATION CERTIFICATE**

Object: **D2600V2 - SN: 1106**

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

Calibration date: **February 18, 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 ± 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	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	16-Oct-01 (in house check Oct-15)	in house check: Oct-16

Calibrated by: **Name: Claudio Leubler, Function: Laboratory Technician, Signature: [Signature]**

Approved by: **Name: Katja Pokovic, Function: Technical Manager, Signature: [Signature]**

Issued: February 18, 2016

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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	2600 MHz ± 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 ± 0.2) °C	38.1 ± 6 %	2.01 mho/m ± 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	14.0 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>55.1 W/kg ± 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.19 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	<b>24.5 W/kg ± 16.5 % (k=2)</b>

**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 ± 0.2) °C	52.5 ± 6 %	2.18 mho/m ± 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	<b>53.4 W/kg ± 17.0 % (k=2)</b>

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.94 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	<b>23.7 W/kg ± 16.5 % (k=2)</b>

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

**Antenna Parameters with Head TSL**

Impedance, transformed to feed point	49.5 $\Omega$ - 7.3 $j\Omega$
Return Loss	- 22.7 dB

**Antenna Parameters with Body TSL**

Impedance, transformed to feed point	44.8 $\Omega$ - 6.0 $j\Omega$
Return Loss	- 21.5 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	February 18, 2015

**DASY5 Validation Report for Head TSL**

Date: 18.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1106**

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

Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.01$  S/m;  $\epsilon_r = 38.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.49, 7.49, 7.49); 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:**

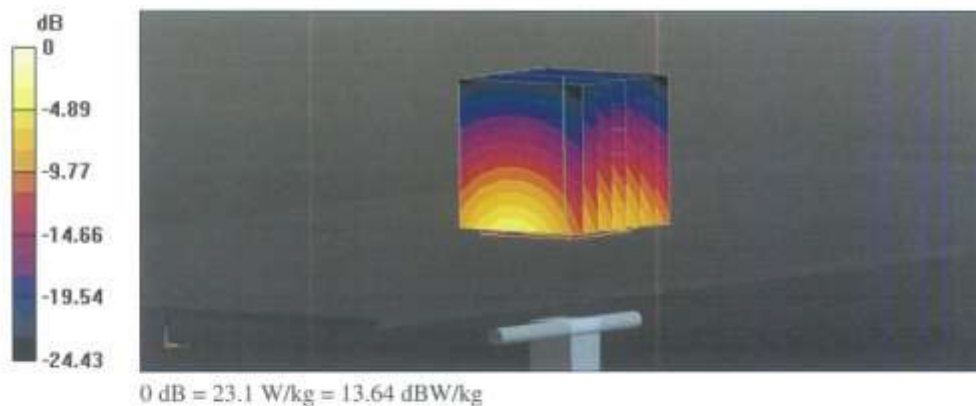
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 113.4 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 29.4 W/kg

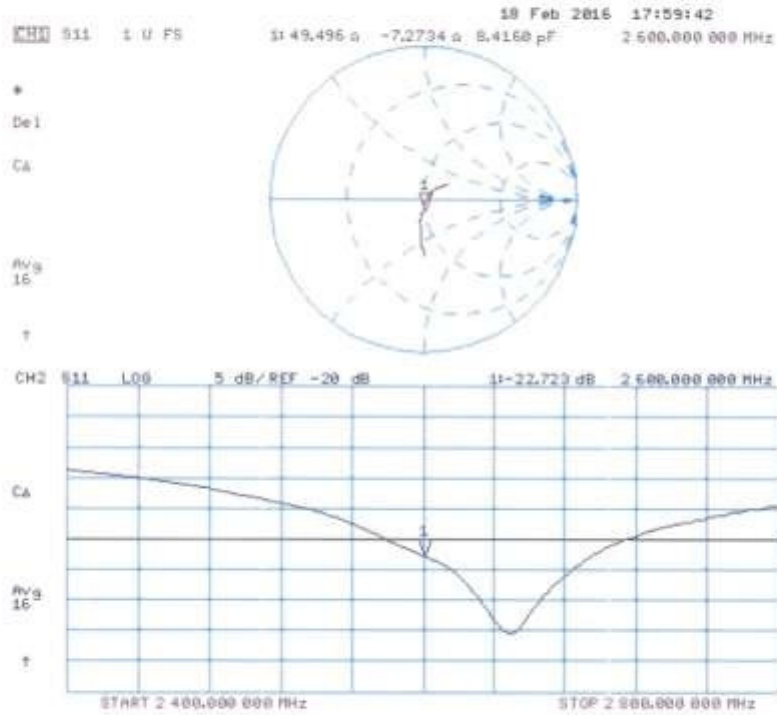
SAR(1 g) = 14 W/kg; SAR(10 g) = 6.19 W/kg

Maximum value of SAR (measured) = 23.1 W/kg





Impedance Measurement Plot for Head TSL



**DASY5 Validation Report for Body TSL**

Date: 18.02.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1106**

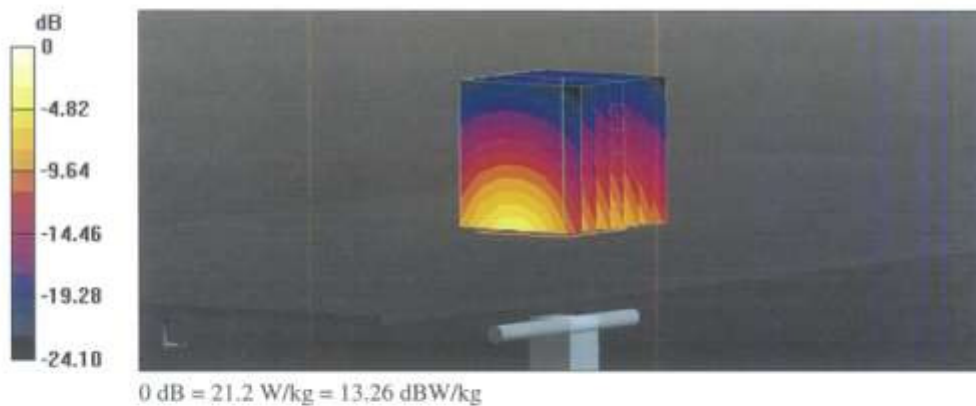
Communication System: UID 0 - CW; Frequency: 2600 MHz  
Medium parameters used:  $f = 2600$  MHz;  $\sigma = 2.18$  S/m;  $\epsilon_r = 52.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

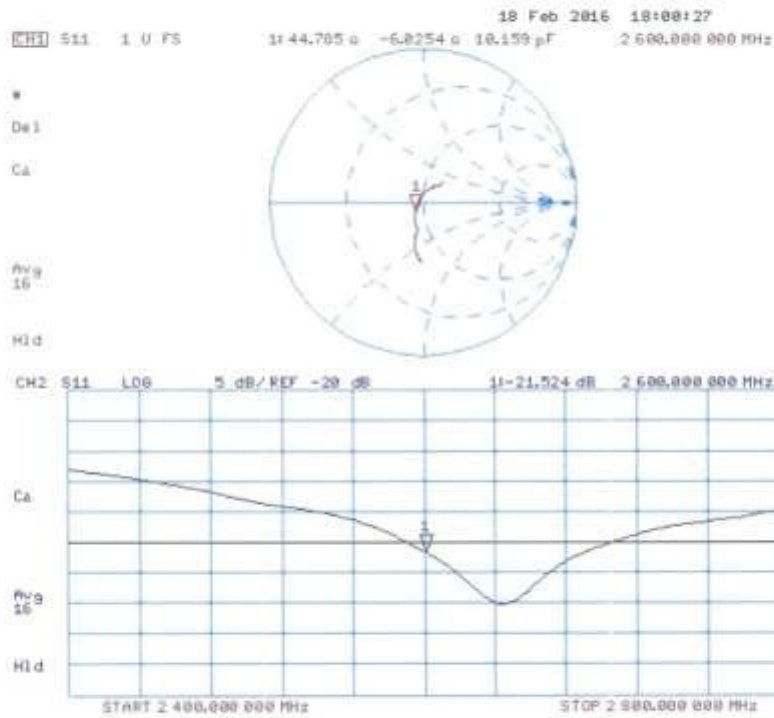
- Probe: EX3DV4 - SN7349; ConvF(7.6, 7.6, 7.6); Calibrated: 31.12.2015;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

Measurement grid: dx=5mm, dy=5mm, dz=5mm  
Reference Value = 104.1 V/m; Power Drift = 0.05 dB  
Peak SAR (extrapolated) = 27.7 W/kg  
SAR(1 g) = 13.4 W/kg; SAR(10 g) = 5.94 W/kg  
Maximum value of SAR (measured) = 21.2 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 (% by weight)	Frequency (MHz)							
	750		835		1 900		2 450 – 2 700	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body
Water	41.1	51.7	40.45	53.06	54.9	70.17	71.88	73.2
Salt (NaCl)	1.4	0.9	1.45	0.94	0.18	0.39	0.16	0.1
Sugar	57.0	47.2	57.0	44.9	0.0	0	0.0	0.0
HEC	0.2	0	1.0	1.0	0.0	0	0.0	0.0
Bactericide	0.2	0.1	0.1	0.1	0.0	0	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	19.97	0.0
DGBE	0.0	0.0	0.0	0.0	44.92	29.44	7.99	26.7
Diethylene glycol hexyl ether	-	-	-	-	-	-	-	-

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
8	3967	EX3DV4	Head	750	1014	2015.12.28	41.8	0.91	PASS	PASS	PASS	N/A	N/A	N/A
8	3967	EX3DV4	Body	750	1014	2015.12.30	55.3	0.97	PASS	PASS	PASS	N/A	N/A	N/A
8	3967	EX3DV4	Head	835	4d165	2015.12.28	41.2	0.9	PASS	PASS	PASS	GMSK	PASS	N/A
8	3967	EX3DV4	Head	835	4d165	2015.12.28	41.2	0.9	PASS	PASS	PASS	N/A	N/A	N/A
8	3967	EX3DV4	Body	835	4d165	2015.12.30	55.1	0.98	PASS	PASS	PASS	GMSK	PASS	N/A
8	3967	EX3DV4	Body	835	4d165	2015.12.30	55.1	0.98	PASS	PASS	PASS	N/A	N/A	N/A
1	3863	EX3DV4	Head	1800	2d006	2016.02.05	40.2	1.38	PASS	PASS	PASS	N/A	N/A	N/A
1	3863	EX3DV4	Head	1800	2d006	2016.02.05	40.2	1.38	PASS	PASS	PASS	GMSK	PASS	N/A
8	3967	EX3DV4	Body	1800	2d006	2016.02.08	53.1	1.5	PASS	PASS	PASS	GMSK	PASS	N/A
8	3967	EX3DV4	Body	1800	2d006	2016.02.08	53.1	1.5	PASS	PASS	PASS	N/A	N/A	N/A
2	1609	ET3DV6	Head	1900	5d061	2016.05.09	39.9	1.41	PASS	PASS	PASS	GMSK	PASS	N/A
1	3863	EX3DV4	Head	1900	5d061	2016.05.09	39.9	1.41	PASS	PASS	PASS	N/A	N/A	N/A
1	3863	EX3DV4	Head	1900	5d061	2016.05.09	39.9	1.41	PASS	PASS	PASS	GMSK	PASS	N/A
8	3967	EX3DV4	Body	1900	5d061	2016.05.10	53.1	1.51	PASS	PASS	PASS	GMSK	PASS	N/A
8	3967	EX3DV4	Body	1900	5d061	2016.05.10	53.1	1.51	PASS	PASS	PASS	N/A	N/A	N/A
8	3967	EX3DV4	Head	2450	965	2016.05.02	39.1	1.78	PASS	PASS	PASS	OFDM	N/A	PASS
8	3967	EX3DV4	Body	2450	965	2016.05.03	52.4	1.96	PASS	PASS	PASS	OFDM	N/A	PASS
8	3967	EX3DV4	Head	2600	1106	2016.03.07	39.2	1.94	PASS	PASS	PASS	NA	N/A	NA
9	3967	EX3DV4	Body	2600	1106	2016.03.08	52.1	2.12	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.