

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.2 $\Omega$ - 2.7 $j\Omega$
Return Loss	- 30.6 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.6 $\Omega$ - 4.1 $j\Omega$
Return Loss	- 26.2 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.399 ns
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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	May 26, 2010

## Measurement Conditions

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

DASY Version	DASY5	V52.8.7
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

Nominal and measured parameters and calculations were applied.			
	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	41.5	0.90 mho/m
<b>Measured Head TSL parameters</b>	(22.0 ± 0.2) °C	41.8 ± 6 %	0.92 mho/m ± 6 %
<b>Head TSL temperature change during test</b>	< 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	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.58 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	1.58 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.24 W/kg $\pm$ 16.5 % (k=2)

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	55.2	0.97 mho/m
<b>Measured Body TSL parameters</b>	(22.0 ± 0.2) °C	54.9 ± 6 %	1.00 mho/m ± 6 %
<b>Body TSL temperature change during test</b>	< 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	2.45 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.57 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	1.61 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.32 W/kg $\pm$ 16.5 % (k=2)



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

#### **Glossary:**

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

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

- a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- 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) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

#### **Additional Documentation:**

- d) DASY4/5 System Handbook

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

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

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 108**

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 Multilateral Agreement for the recognition of calibration certificates

Client **MET Laboratories**

Certificate No: **IndexSAR-1S2572\_Jul13**

## CALIBRATION CERTIFICATE

Object **IndexSAR - SN: 1S2572**

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

Calibration date: **July 18, 2013**

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	01-Nov-12 (No. 217-01640)	Oct-13
Power sensor HP 8481A	US37292783	01-Nov-12 (No. 217-01640)	Oct-13
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-13 (No. 217-01736)	Apr-14
Type-N mismatch combination	SN: 5047.3 / 06327	04-Apr-13 (No. 217-01739)	Apr-14
Reference Probe ES3DV3	SN: 3205	28-Dec-12 (No. ES3-3205_Dec12)	Dec-13
DAE4	SN: 601	25-Apr-13 (No. DAE4-601_Apr13)	Apr-14
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor HP 8481A	MY41092317	18-Oct-02 (in house check Oct-11)	In house check: Oct-13
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-11)	In house check: Oct-13
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

Calibrated by:

Name: **Jeton Kastrati**  
 Function: **Laboratory Technician**

Signature:

Approved by:

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

Signature:

Issued: July 19, 2013

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



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

Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 108**

### **Glossary:**

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

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

- a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
- 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) Federal Communications Commission Office of Engineering & Technology (FCC OET), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields; Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", Supplement C (Edition 01-01) to Bulletin 65

### **Additional Documentation:**

- d) DASY4/5 System Handbook

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

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TS:* 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 TS parameters:* The measured TS parameters are used to calculate the nominal SAR result.

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

## Measurement Conditions

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

<b>DASY Version</b>	DASY5	V52.8.7
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	Modular Flat Phantom	
<b>Distance Dipole Center - TSL</b>	10 mm	with Spacer
<b>Zoom Scan Resolution</b>	dx, dy, dz = 5 mm	
<b>Frequency</b>	1800 MHz $\pm$ 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Head TSL parameters</b>	22.0 °C	40.0	1.40 mho/m
<b>Measured Head TSL parameters</b>	(22.0 $\pm$ 0.2) °C	38.7 $\pm$ 6 %	1.37 mho/m $\pm$ 6 %
<b>Head TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Head TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	9.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.8 W/kg $\pm$ 17.0 % (k=2)

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b>	Condition	
SAR measured	250 mW input power	4.80 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.3 W/kg $\pm$ 16.5 % (k=2)

## Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
<b>Nominal Body TSL parameters</b>	22.0 °C	53.3	1.52 mho/m
<b>Measured Body TSL parameters</b>	(22.0 $\pm$ 0.2) °C	51.4 $\pm$ 6 %	1.53 mho/m $\pm$ 6 %
<b>Body TSL temperature change during test</b>	< 0.5 °C	----	----

## SAR result with Body TSL

<b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	9.52 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	37.6 W/kg $\pm$ 17.0 % (k=2)

<b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Body TSL</b>	Condition	
SAR measured	250 mW input power	4.99 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	19.8 W/kg $\pm$ 16.5 % (k=2)

## Appendix

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	47.2 $\Omega$ - 5.8 $j\Omega$
Return Loss	- 23.5 dB

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	44.7 $\Omega$ - 4.6 $j\Omega$
Return Loss	- 22.6 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	0.960 ns
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Dipole designed and manufactured by IndexSAR. Please see details on <http://www.indexsar.com/balanced.htm>

### Additional EUT Data

Manufactured by	IndexSAR
Manufactured on	unknown

# DASY5 Validation Report for Head TSL

Date: 18.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1800 MHz; Type: IndexSAR; Serial: IndexSAR - SN:1S2572**

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

Medium parameters used:  $f = 1800 \text{ MHz}$ ;  $\sigma = 1.37 \text{ S/m}$ ;  $\epsilon_r = 38.7$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5.04, 5.04, 5.04); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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

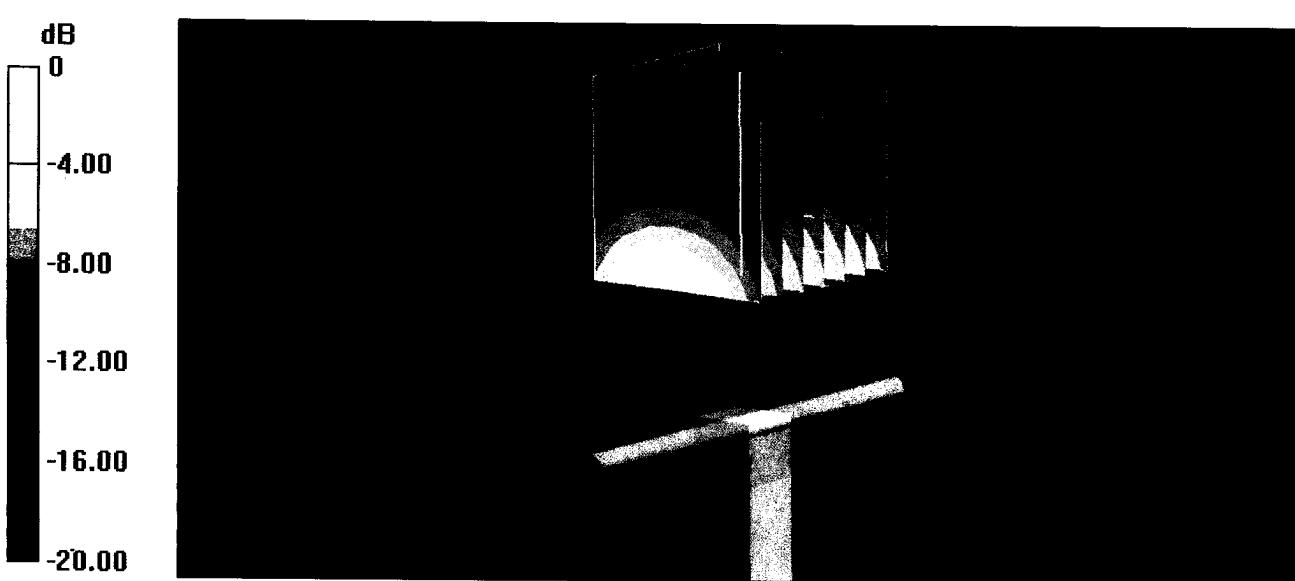
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 94.589 V/m; Power Drift = 0.01 dB

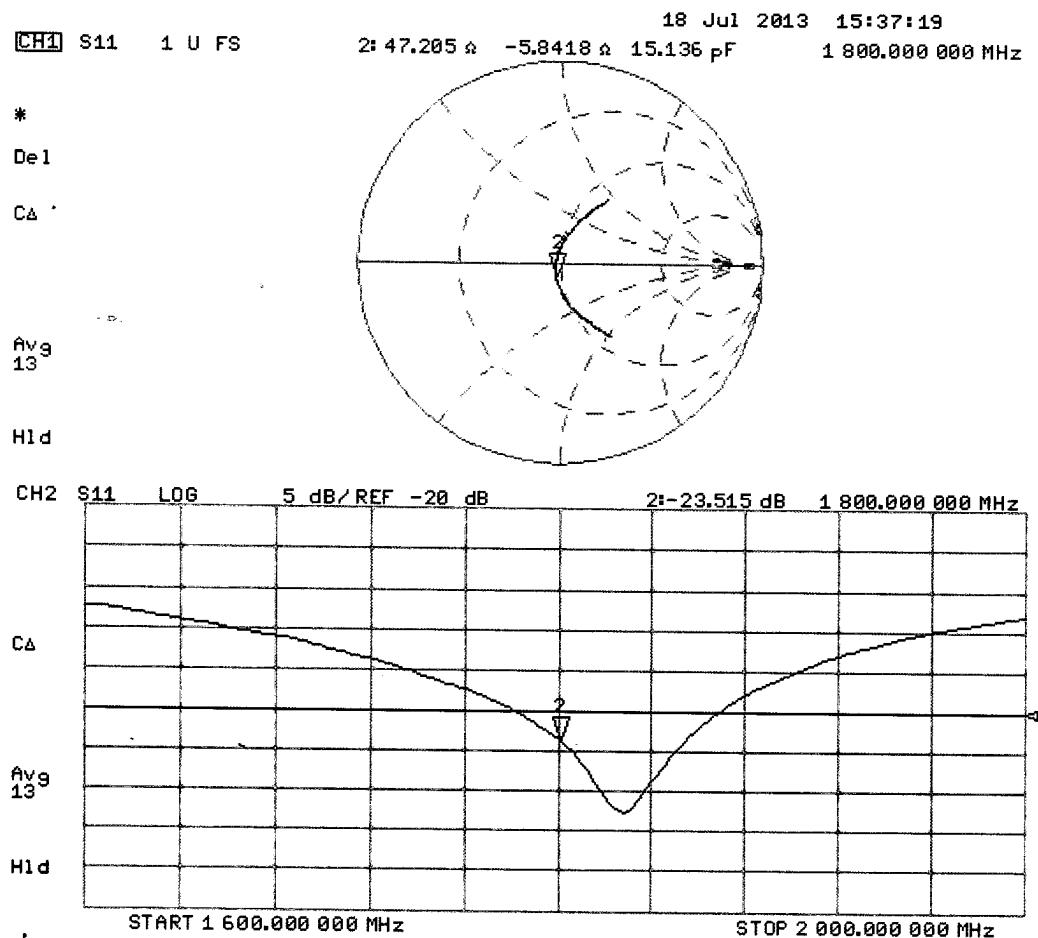
Peak SAR (extrapolated) = 16.7 W/kg

**SAR(1 g) = 9.16 W/kg; SAR(10 g) = 4.8 W/kg**

Maximum value of SAR (measured) = 11.5 W/kg



# Impedance Measurement Plot for Head TSL



# DASY5 Validation Report for Body TSL

Date: 18.07.2013

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1800 MHz; Type: IndexSAR; Serial: IndexSAR - SN:1S2572**

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

Medium parameters used:  $f = 1800$  MHz;  $\sigma = 1.53$  S/m;  $\epsilon_r = 51.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.73, 4.73, 4.73); Calibrated: 28.12.2012;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 25.04.2013
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.7(1137); SEMCAD X 14.6.10(7164)

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

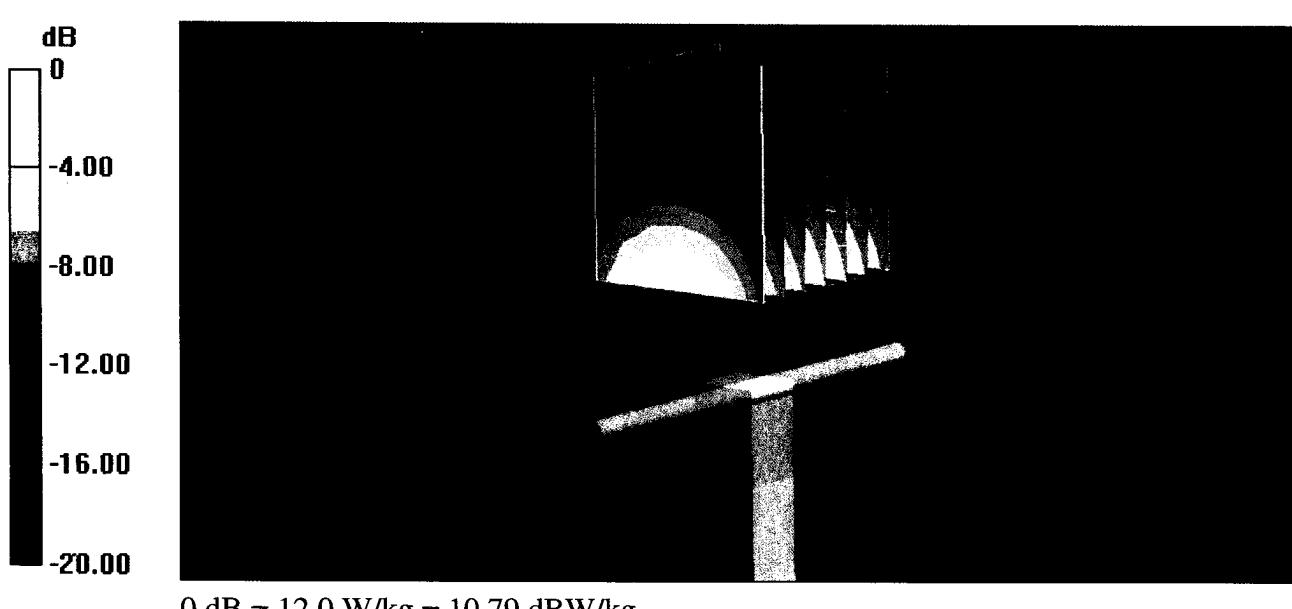
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.589 V/m; Power Drift = 0.01 dB

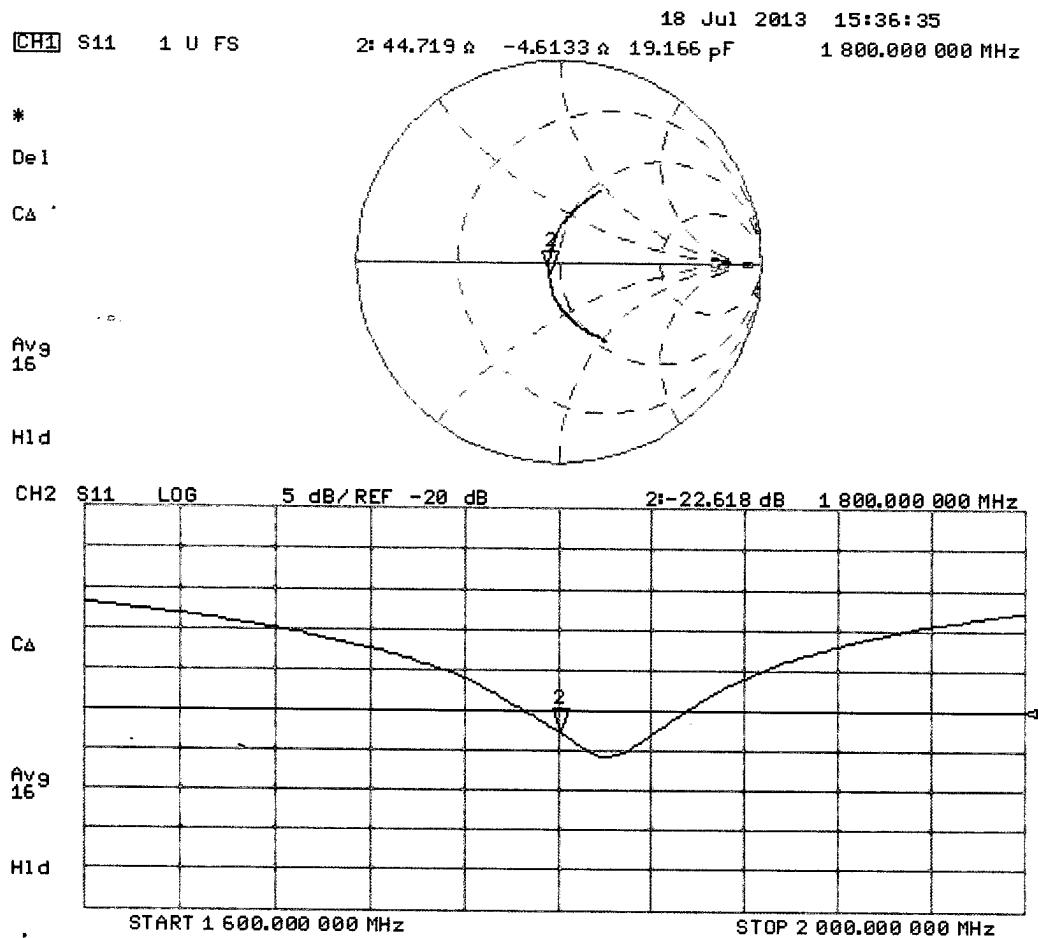
Peak SAR (extrapolated) = 17.1 W/kg

**SAR(1 g) = 9.52 W/kg; SAR(10 g) = 4.99 W/kg**

Maximum value of SAR (measured) = 12.0 W/kg



## Impedance Measurement Plot for Body TSL





## APPENDIX E - MEASURED FLUID DIELECTRIC PARAMETERS

# Title

## SubTitle

January 9, 2015 01:23 PM

Frequency	e'	e''
800.000000 MI	54.788	21.5324
802.000000 MI	54.751	21.5312
804.000000 MI	54.649	21.5220
806.000000 MI	54.624	21.5094
808.000000 MI	54.546	21.5004
810.000000 MI	54.526	21.4970
812.000000 MI	54.504	21.4943
814.000000 MI	54.488	21.4874
816.000000 MI	54.476	21.4819
818.000000 MI	54.462	21.4738
820.000000 MI	54.453	21.4702
822.000000 MI	54.432	21.4690
824.000000 MI	54.390	21.4610
826.000000 MI	54.386	21.4557
828.000000 MI	54.374	21.4502
830.000000 MI	54.361	21.4489
832.000000 MI	54.316	21.4465
834.000000 MI	54.380	21.4432
836.000000 MI	54.361	21.4421
838.000000 MI	54.323	21.4394
840.000000 MI	54.303	21.4382
842.000000 MI	54.273	21.4364
844.000000 MI	54.237	21.4321
846.000000 MI	54.174	21.4301
848.000000 MI	54.163	21.4223
850.000000 MI	54.101	21.4212
852.000000 MI	54.058	21.4234
854.000000 MI	54.089	21.4170
856.000000 MI	53.985	21.4101
858.000000 MI	53.909	21.4086
860.000000 MI	53.875	21.3996
862.000000 MI	53.854	21.3906
864.000000 MI	53.810	21.3885
866.000000 MI	53.796	21.3823
868.000000 MI	53.780	21.3730

870.000000 MI	53.708	21.3540
872.000000 MI	53.691	21.3430
874.000000 MI	53.659	21.3385
876.000000 MI	53.639	21.3313
878.000000 MI	53.626	21.3270
880.000000 MI	53.617	21.3180
882.000000 MI	53.607	21.3043
884.000000 MI	53.582	21.2960
886.000000 MI	53.574	21.2834
888.000000 MI	53.563	21.2795
890.000000 MI	53.549	21.2713
892.000000 MI	53.532	21.2663
894.000000 MI	53.523	21.2601
896.000000 MI	53.509	21.2530
898.000000 MI	53.498	21.2491
900.000000 MI	53.487	21.2432

# Title

## SubTitle

November 21, 2014 11:19 AM

Frequency	e'	e"
1.800000000 GI	52.654	14.5178
1.802000000 GI	52.654	14.5185
1.804000000 GI	52.650	14.5328
1.806000000 GI	52.648	14.5312
1.808000000 GI	52.643	14.5510
1.810000000 GI	52.632	14.5547
1.812000000 GI	52.619	14.5482
1.814000000 GI	52.626	14.5411
1.816000000 GI	52.638	14.5376
1.818000000 GI	52.619	14.5611
1.820000000 GI	52.588	14.5566
1.822000000 GI	52.580	14.5642
1.824000000 GI	52.612	14.5730
1.826000000 GI	52.585	14.5754
1.828000000 GI	52.595	14.5861
1.830000000 GI	52.581	14.5811
1.832000000 GI	52.560	14.5741
1.834000000 GI	52.563	14.5732
1.836000000 GI	52.576	14.5885
1.838000000 GI	52.539	14.5882
1.840000000 GI	52.525	14.5865
1.842000000 GI	52.518	14.5711
1.844000000 GI	52.513	14.5058
1.846000000 GI	52.587	14.5013
1.848000000 GI	52.578	14.4888
1.850000000 GI	52.567	14.5476
1.852000000 GI	52.556	14.5011
1.854000000 GI	52.547	14.5184
1.856000000 GI	52.546	14.5117
1.858000000 GI	52.538	14.5201
1.860000000 GI	52.534	14.5181
1.862000000 GI	52.521	14.5152
1.864000000 GI	52.432	14.5211
1.866000000 GI	52.429	14.5166
1.868000000 GI	52.422	14.5352

1.870000000 GI	<b>52.421</b>	<b>14.5383</b>
1.872000000 GI	<b>52.399</b>	<b>14.5411</b>
1.874000000 GI	<b>52.398</b>	<b>14.5456</b>
1.876000000 GI	<b>52.394</b>	<b>14.5481</b>
1.878000000 GI	<b>52.381</b>	<b>14.5421</b>
1.880000000 GI	<b>52.389</b>	<b>14.5527</b>
1.882000000 GI	<b>52.384</b>	<b>14.5416</b>
1.884000000 GI	<b>52.387</b>	<b>14.5682</b>
1.886000000 GI	<b>52.376</b>	<b>14.5553</b>
1.888000000 GI	<b>52.354</b>	<b>14.5731</b>
1.890000000 GI	<b>52.343</b>	<b>14.5867</b>
1.892000000 GI	<b>52.354</b>	<b>14.5882</b>
1.894000000 GI	<b>52.362</b>	<b>14.5810</b>
1.896000000 GI	<b>52.354</b>	<b>14.5160</b>
1.898000000 GI	<b>52.343</b>	<b>14.6127</b>
1.900000000 GI	<b>52.332</b>	<b>14.6236</b>



**APPENDIX F – PHANTOM CERTIFICATE OF CONFORMITY**

Zeughausstrasse 43, 8004 Zurich, Switzerland  
 Phone +41 1 245 9700, Fax +41 1 245 9779  
 info@speag.com, http://www.speag.com

## Certificate of conformity / First Article Inspection

Item	SAM Twin Phantom V4.0
Type No	QD 000 P40 C
Series No	TP-1150 and higher
Manufacturer / Origin	Untersee Composites Hauptstr. 69 CH-8559 Fruthwilen Switzerland

### Tests

The series production process used allows the limitation to test of first articles.

Complete tests were made on the pre-series Type No. QD 000 P40 AA, Serial No. TP-1001 and on the series first article Type No. QD 000 P40 BA, Serial No. TP-1006. Certain parameters have been retested using further series units (called samples).

Test	Requirement	Details	Units tested
Shape	Compliance with the geometry according to the CAD model.	IT'IS CAD File (*)	First article, Samples
Material thickness	Compliant with the requirements according to the standards	2mm +/- 0.2mm in specific areas; 6mm +/- 0.2mm at ERP	First article, Samples
Material parameters	Dielectric parameters for required frequencies	200 MHz – 3 GHz Relative permittivity < 5 Loss tangent < 0.05.	Material sample TP 104-5
Material resistivity	The material has been tested to be compatible with the liquids defined in the standards if handled and cleaned according to the instructions	DEGMBe based simulating liquids	Pre-series, First article, Samples

### Standards

- [1] CENELEC EN 50361
- [2] IEEE Std 1528-200x Draft CD 1.1 (Dec 02)
- [3] IEC 62209/CD (Nov 02)

(\*) The IT'IS CAD file is derived from [2] and is also within the tolerance requirements of the shapes of [1] and [3].

### Conformity

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of SAR measurements specified in standard [1] and draft standards [2] and [3].

Date 7.8.2003

### Signature / Stamp

**s p e a g**

Schmid & Partner Engineering AG  
 Zeughausstrasse 43, 8004 Zurich, Switzerland  
 Phone +41 1 245 9700, Fax +41 1 245 9779  
 info@speag.com, http://www.speag.com



Nielsen Audio

SAR Report

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## APPENDIX G - DAE CALIBRATION CERTIFICATE



**S** Schweizerischer Kalibrierdienst  
**C** Service suisse d'étalonnage  
**C** 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 108**

**Client MET Laboratories**

**Certificate No: DAE3-584\_Oct14**

## **CALIBRATION CERTIFICATE**

Object **DAE3 - SD 000 D03 AA - SN: 584**

Calibration procedure(s) **QA CAL-06.v28**  
 Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **October 14, 2014**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	03-Oct-14 (No:15573)	Oct-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	07-Jan-14 (in house check)	In house check: Jan-15
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-14 (in house check)	In house check: Jan-15

Calibrated by: Name **Dominique Steffen** Function **Technician** Signature 

Approved by: Name **Fin Bomholt** Function **Deputy Technical Manager** Signature 

Issued: October 14, 2014



Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 108**

## Glossary

<b>DAE</b>	data acquisition electronics
<b>Connector angle</b>	information used in DASY system to align probe sensor X to the robot coordinate system.

## Methods Applied and Interpretation of Parameters

- **DC Voltage Measurement:** Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- **Connector angle:** The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - **DC Voltage Measurement Linearity:** Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - **Common mode sensitivity:** Influence of a positive or negative common mode voltage on the differential measurement.
  - **Channel separation:** Influence of a voltage on the neighbor channels not subject to an input voltage.
  - **AD Converter Values with inputs shorted:** Values on the internal AD converter corresponding to zero input voltage
  - **Input Offset Measurement:** Output voltage and statistical results over a large number of zero voltage measurements.
  - **Input Offset Current:** Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - **Input resistance:** Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - **Low Battery Alarm Voltage:** Typical value for information. Below this voltage, a battery alarm signal is generated.
  - **Power consumption:** Typical value for information. Supply currents in various operating modes.

## DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB =  $6.1\mu\text{V}$ , full range =  $-100...+300\text{ mV}$

Low Range: 1LSB =  $61\text{nV}$ , full range =  $-1.....+3\text{mV}$

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
<b>High Range</b>	$404.637 \pm 0.02\% \text{ (k=2)}$	$404.822 \pm 0.02\% \text{ (k=2)}$	$404.252 \pm 0.02\% \text{ (k=2)}$
<b>Low Range</b>	$3.92983 \pm 1.50\% \text{ (k=2)}$	$3.91835 \pm 1.50\% \text{ (k=2)}$	$3.94518 \pm 1.50\% \text{ (k=2)}$

## Connector Angle

Connector Angle to be used in DASY system	$141.0^\circ \pm 1^\circ$
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## Appendix (Additional assessments outside the scope of SCS108)

### 1. DC Voltage Linearity

High Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	199995.08	-1.66	-0.00
Channel X	+ Input	20002.21	1.08	0.01
Channel X	- Input	-20000.68	0.02	-0.00
Channel Y	+ Input	199994.29	-2.51	-0.00
Channel Y	+ Input	20003.95	2.80	0.01
Channel Y	- Input	-19993.87	6.83	-0.03
Channel Z	+ Input	199998.36	1.04	0.00
Channel Z	+ Input	19998.84	-2.32	-0.01
Channel Z	- Input	-19998.87	1.78	-0.01

Low Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	2001.52	0.61	0.03
Channel X	+ Input	202.04	0.52	0.26
Channel X	- Input	-199.11	-0.68	0.34
Channel Y	+ Input	2000.36	-0.59	-0.03
Channel Y	+ Input	200.66	-0.74	-0.37
Channel Y	- Input	-198.89	-0.40	0.20
Channel Z	+ Input	2000.93	0.07	0.00
Channel Z	+ Input	200.48	-0.82	-0.41
Channel Z	- Input	-199.35	-0.69	0.35

### 2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading ( $\mu$ V)	Low Range Average Reading ( $\mu$ V)
Channel X	200	2.93	1.03
	-200	-0.10	-2.11
Channel Y	200	2.28	2.64
	-200	-4.13	-3.84
Channel Z	200	-6.31	-7.07
	-200	4.44	4.48

### 3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X ( $\mu$ V)	Channel Y ( $\mu$ V)	Channel Z ( $\mu$ V)
Channel X	200	-	-0.15	-4.15
Channel Y	200	6.74	-	-0.20
Channel Z	200	7.03	5.14	-

#### 4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	16109	15608
Channel Y	16210	15968
Channel Z	16290	16554

#### 5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input  $10M\Omega$

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	1.05	-0.16	2.07	0.47
Channel Y	-0.22	-1.35	0.95	0.48
Channel Z	-0.26	-1.18	0.83	0.44

#### 6. Input Offset Current

Nominal Input circuitry offset current on all channels:  $<25fA$

#### 7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

#### 8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

#### 9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9