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# **Appendix C**

# **Phantom Description**

Schmid & Partner Engineering AG a

Zeughausstrasse 43, 8004 Zurich, Switzerland Phone +41 44 245 9700, Fax +41 44 245 9779 info@speag.com, http://www.speag.com

### Certificate of Conformity / First Article Inspection

Item	Oval Flat Phantom ELI 5.0	
Type No	QD OVA 002 A	
Series No	1108 and higher	
Manufacturer	Untersee Composites Knebelstrasse 8, CH-8268 Mannenbach, Switzerland	

Complete tests were made on the prototype units QD OVA 001 A, pre-series units QD OVA 001 B as well as on some series units QD OVA 001 B. Some tests are made on all series units QD OVA 002 A.

Test	Requirement	Details	Units tested
Shape	Internal dimensions, depth and sagging are compatible with standards	Bottom elliptical 600 x 400 mm, Depth 190 mm, dimension compliant with [1] for f > 375 MHz	Prototypes
Material thickness	Bottom: 2.0mm +/- 0.2mm	dimension compliant with [3] for f > 800 MHz	all
Material parameters	rel. permittivity 2 – 5, loss tangent ≤ 0.05, at f ≤ 6 GHz	rel. permittivity 3.5 +/- 0.5 loss tangent ≤ 0.05	Material samples
Material resistivity	Compatibility with tissue simulating liquids .	Compatible with SPEAG liquids. **	Phantoms, Material sample
Sagging	Sagging of the flat section in tolerance when filled with tissue simulating liquid.	within tolerance for filling height up to 155 mm	Prototypes, samples

Note: Compatibility restrictions apply certain liquid components mentioned in the standard, containing e.g. DGBE, DGMHE or Triton X-100. Observe technical note on material compatibility.

### Standards

- OET Bulletin 65, Supplement C, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields", Edition 01-01
   IEEE 1528-2003, "Recommended Practice for Determining the Peak Spatial-Average Specific
- Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement
- Techniques, December 2003

  [3] IEC 62209–1 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices Human models, instrumentation, and procedures Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)\*, 2005-02-18
- IEC 62209–2 ed1.0, "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices Human models, instrumentation, and procedures Part 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)", 2010-03-30

Based on the sample tests above, we certify that this item is in compliance with the uncertainty requirements of body-worn SAR measurements and system performance checks as specified in [1 – 4] and further standards

Signature / Stamp

Doc No 881 - QD OVA 002 A - A

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# System Validation from Original Equipment Supplier



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





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Accreditation No.: SCS 0108

Accredited by the Swisa Accreditation Service (SAS)

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

Glossary:

fissue simulating liquid TSL ConvE 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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### 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%

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### Measurement Conditions

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

DASY Version	DASY5	V52.10,1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phentom	
Distance Dipole Center - TSL	15 mm	with Spager
Zoom Scan Resolution	dx, dy, d2. = 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	40.9 ± 6 %	0.89 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	2.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	8.23 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>1</sup> (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	5.34 W/kg ± 16.5 % (k=2)

### Body TSL parameters

ng 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	55.0 ± 6 %	0.96 mho/m ± 8 %
Body TSL temperature change during (est	< 0.5 °C	-	_

### SAR result with Body TSL

SAR averaged over 1 cm2 (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	2.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	8.62 W/kg = 17.0 % (k=2)

SAR averaged over 10 cm3 (10 g) of Body TSL.	condition	
SAR measured	250 mW input power	1.43 W/kg
SAFI for nominal Body TSL parameters	normalized to 1W	5.71 W/kg ± 16.5 % (k=2)

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

### Antenna Parameters with Head TSL

Imperdance, transformed in land point	53.4 62 + 0.0 βΩ
Fleturn Loss	-29.6 dB

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	48.2 (2 - 3.6 )(2
Fleturn Loss	= 27.8 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.037 ns
----------------------------------	----------

After long term use with 100W radiated power, only a slight warming of the dipole riear 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 and 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 SARI 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	

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### **DASY5 Validation Report for Head TSL**

Date: 22.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1015

Communication System: UID 0 - CW; Frequency: 750 MHz Medium parameters used: f=750 MHz;  $\alpha=0.89$  S/m;  $\epsilon_r=40.9$ ;  $\rho\simeq1000$  kg/m³ Phantom section: Flat Section

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

### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.22, 10.22, 10.22) @ 750 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

### 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 = 59.12 V/m; Power Drift = -0.04 dB Peak SAR (extrapolated) = 3.11 W/kg SAR(1 g) = 2.07 W/kg; SAR(10 g) = 1.34 W/kg Maximum value of SAR (measured) = 2.77 W/kg



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

Certificate No: D750V3-1015\_Aug18

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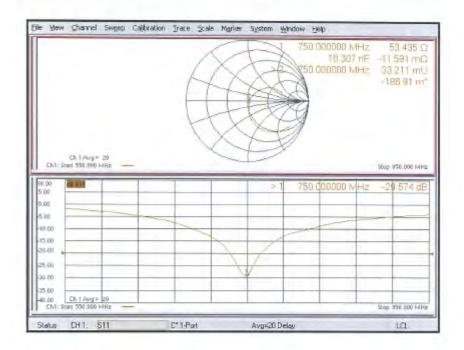
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### Impedance Measurement Plot for Head TSL



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### DASY5 Validation Report for Body TSL

Date: 23.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1015

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

Medium parameters used: f = 750 MHz;  $\sigma = 0.96$  S/m;  $\epsilon_r = 55$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

#### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.19, 10.19, 10.19) @ 750 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

### 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 = 57.93 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 3.17 W/kg

SAR(1 g) = 2.16 W/kg; SAR(10 g) = 1.43 W/kg

Maximum value of SAR (measured) = 2.85 W/kg



0 dB = 2.85 W/kg = 4.55 dBW/kg

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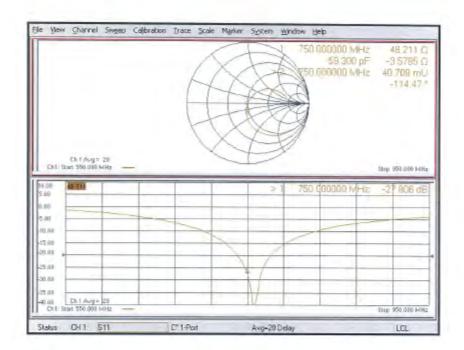
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### Impedance Measurement Plot for Body TSL



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Cuta No: D835V2-4d063 Aug 18

Object	D835V2 - SN:4di	063	
Calibration procedure(s)	QA CAL-05.v10 Cal oration proce	edure for dipole validation kits abo	ove 700 MHz
Calibration date:	August 23, 2018		
The measurements and the uncort	ainties with confidence p ed in the closed laborato	ional standards, which realize the physical un probability are given on the following pages ar ry facility, environment temperature (22 ± 3)*1	nd are part of the certificate
Primary Standards	ID#	Cal Daté (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-15 (No. 217-02672/02673)	April 9
Power sensor NRP (291	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-10
	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Power sensor NRP-Z91	GR 100240		
	SN: 5058 (20k)	04-Apr-16 (No. 217-02682)	Apr-18
Reference 20 dB Attenuator	The second second		Apr-18 Apr-19
Reference 20 dB Attenuator Type-N mismatch combination	SN: 5058 (20k)	04-Apr-16 (No. 217-02682)	
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 5058 (20k) SN: 5047.2 / 06327	04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683)	Apr.19
Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX3-7349_Dec17)	Apr.19 Dec-18
Reference 20 dB Attenuation Type-N mismatich combination Retaliance Probe EX3DV4 DAE4 Secundary Standards	SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-18 (No. 217-02802) 04-Apr-18 (No. 217-02883) 30-Dec-17 (No. EXS-7349, Dec-17) 28-Gol-17 (No. DAE4-601_Oct17)	Apr.18 Dec-18 Oct-18
Reference 20 dB Attenuation Type-N mismatich combination Reference Probe EX3DV4 DAE4 Secundary Standards Power mater EPM-442A	SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dac-17 (No. EXC-7349, Dec17) 26-Qch-17 (No. DAE-4-601_Och17) Check Date (in house)	April 18 Deb-18 Oct-18 Scheduled Check
Reference 20 dB Attenuation Type-N mismatich combination Retailance Probe EX3DV4 DAE4 Secundary Standards Power mater EPM-442A Power sensor HP 8481A	SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dac-17 (No. EXS-7349, Dac-17) 26-Qch-17 (No. DAE4-601_Oct17) Check Cate (in house) 07-Oct-15 (in house)	April 18 Debil 18 Oct-18 Scheduled Check In house check: Oct-18
Telerence 20 dB Abenustor Type-N internation combination Teletaionice Probe EX3DV4 DAE4 Securedary Standards Power mater EPM-442A Power sensor HP 8481A Power sensor HP 8481A	SN: 5058 (20k) SN: 5047.2 / D6327 SN: 7349 SN: 601 ID # SN: GB37490704 SN: US37292783	04-Apr-16 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dac-17 (No. EXS-7349, Dac-17) 26-Oct-17 (No. DAE4-601_Oct17) Check Cate (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr.19 Dec-18 Oct-16 Scheduled Check In house check: Oct-18 in house check: Oct-18
Telerence 20 dB Attenuator (yps-N mismatch combination relationse Probe EX30V4 DAE4 Secundary Standards Cower mater EPM-442A Cower sensor HP 8481A Generator R&B SMT-06	SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37450704 SN: US37259783 SN: MY41082317	04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EX-7348, Dec-17) 26-Oct-17 (No. DAE-4-601, Oct-17) Check Date Inhouse 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16)	Apr.19 Dec-18 Oct-16 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Reference 20 dB Attenuation Type-N mismatich combination Reference Probe EX3DV4 DAE4 Secundary Standards Power meter EPM-442A Power sensor HP 8481A RF generator R&B SMT-06	SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37450704 SN: US37292783 SN: MY41082317 SN: 106972	04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dac-17 (No. EXS-7349, Dac-17) 26-Gol-17 (No. DAE-4-601, Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr.19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Telerence 20 dB Attenuator Type-N information combination Teletainince Probe EX3DV4 DAE4 Securedary Standards Fower mater EPM-442A Power sensor HP 8481A Power sensor HP 8481A Figurator R&B SMT-06 Nativors Analyzar Agilent ERSS84	SN: 5058 (20k) SN: 5047.2 / D6327 SN: 7349 SN: 601 ID # SN: GB37490704 SN: US37292783 SN: MY41082317 SN: 108972 SN: US41080477	04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dac-17 (No. EXS-7349, Dec17) 26-Qct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr.19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Peterence 20 dB Attenuation Type-M mismation combination Relationce Probe EX3DV4 DAE4  Secundary Standards Power mater EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&B SMT-06 Network Analyzer Agilent ERSSR4	SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41082317 SN: 106972 SN: US41080477 Name	04-Apr-18 (No. 217-02882) 04-Apr-18 (No. 217-02883) 30-Bec-17 (No. EX9-7349, Dec-17) 26-Gol-17 (No. DAE-4-601, Oct17) Check Cate in house 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-14 (in house check Oct-17) Function	Apr.19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18
Power sensor NRP-281 Reference 20 dB Attenuator Typo-N internation combination Relationce Probe EX3DV4 DAE4 Secundary Standards Power mater EPM-442A Power sensor HP 8481A RF generator RAS SMT-06 National Analyzer Agilent ERSS84 Calibrated by:	SN: 5058 (20k) SN: 5047 2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41082317 SN: 106972 SN: US41080477 Name	04-Apr-18 (No. 217-02882) 04-Apr-18 (No. 217-02883) 30-Bec-17 (No. EX9-7349, Dec-17) 26-Gol-17 (No. DAE-4-601, Oct17) Check Cate in house 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-14 (in house check Oct-17) Function	Apr.19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18

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





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Accreditation No.: SCS 0108

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

Glossary:

fissue simulating liquid TSL sensitivity in TSL / NORM x,y,z ConvE 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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)\*, July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)\*, March 2010
- 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 priented 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%

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### Measurement Conditions

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

DASY Version	DASY5	V52.10.1
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 param

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 ℃	41.5	0.90 inhorm
Measured Head TSL parameters	(22.0 ± 0.2) °C	40.7 ± fi %	0.92 mho/m ± 8 %
Head TSL temperature change during test	< 0.5 °C	_	-

### SAR result with Head TSL

SAR averaged over 1 cm <sup>1</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.42 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.48 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm² (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.55 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6,10 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	54.9±6%	0.99 mha/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 pawer	2.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	9.58 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	1.59 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	6.28 W/kg ± 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Propedance, transformed to feed point.	51.3 Ω - 1.8 <u>Ι</u> Ω	
Relum Loss	- 33.3 dB	

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	47.7 \( \O = 4.4 \)	
Return Loss	-25,8 dB	

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.393 ns

After long term use with 100W radiated power, only a slight warming of the dipole near the leedpoint 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 digore 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 27, 2006

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### **DASY5 Validation Report for Head TSL**

Date: 22.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d063

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

Medium parameters used: f = 835 MHz;  $\sigma = 0.92 \text{ S/m}$ ;  $\varepsilon_c = 40.7$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

#### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(9.9, 9.9, 9.9) @ 835 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10,2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

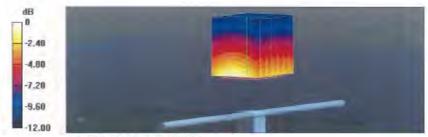
### Dipole Calibration for Head Tissue/Pin=250 mW, d=15mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 62,96 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 3.70 W/kg

SAR(1 g) = 2.42 W/kg; SAR(10 g) = 1.55 W/kg

Maximum value of SAR (measured) = 3.25 W/kg



0 dB = 3.25 W/kg = 5.12 dBW/kg

Certificate No: D835V2-4d063\_Aug18

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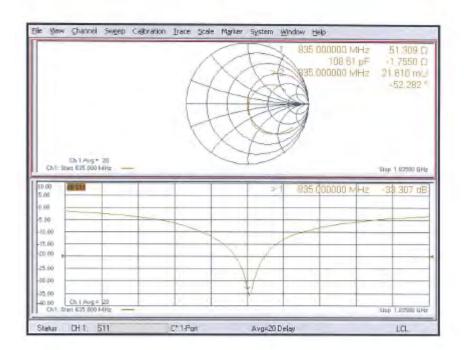
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### Impedance Measurement Plot for Head TSL



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### DASY5 Validation Report for Body TSL

Date: 23.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d063

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

Medium parameters used: f = 835 MHz;  $\sigma = 0.99$  S/m;  $\epsilon_0 = 54.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

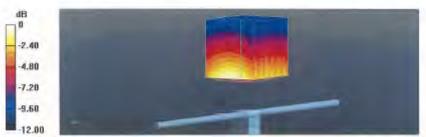
#### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(10.05, 10.05, 10.05) @ 835 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

### 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 = 60.67 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 3.61 W/kg

SAR(1 g) = 2.43 W/kg; SAR(10 g) = 1.59 W/kgMaximum value of SAR (measured) = 3.23 W/kg



0 dB = 3.23 W/kg = 5.09 dBW/kg

Certificate No: D635V2-4d063\_Aug18

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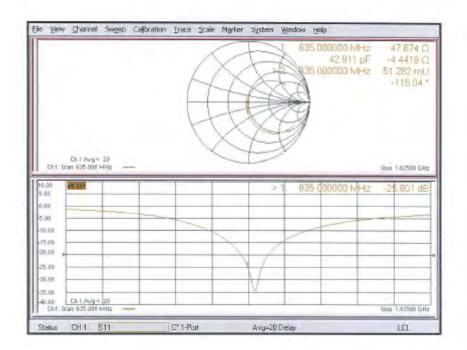
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### Impedance Measurement Plot for Body TSL



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SGS-TW (Auden)

Certificate No: D1750V2-1008\_Aug18

Object	D1750V2 - SN:1	800	
Columnion procedure(s)	QA CAL-05.v10 Cal bratien proce	idure for dipole validation kits abo	ove 700 MHz
Calibration date:	August 30, 2018		
The measurements and the uncer	tainties with confidence p	ional standards, which realize the physical un robability are given on the following pages ar ry facility: environment temperature (22 ± 3)*1	nd are part of the certificate.
Primary Standards	IDe	Car Date (Certificate No.)	Scheduled Calibration
Power mater NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N internated combination Reference Probe EX3DV4 DAE4	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2706307 SN: 7346 SN: 601	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EXX-7349, Dec-17) 26-Oct-17 (No. DAE4-601_Oct17)	Apr-19 Apr-19 Apr-19 Apr-19 Oec-18 Oct-18
Power mater NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 103244 SN: 103246 SN: 5058 (20k) SN: 5047.27 06327 SN: 7348	04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EXX-7349_Dec17)	Apr-18 Apr-18 Apr-19 Apr-19 Oec-18
Power mater NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.27.06327 SN: 7348 SN: 601 ID # SN: GB37440704 SN: US37292783 SN: MY41082317 SN: 100972	04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 30-Dec-17 (No. 213-7348 Dec-17) 26-Det-17 (No. DAE4-601 Dcf17)	Apr-19 Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Schedulad Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18
Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismalch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.27.06327 SN: 7348 SN: 601 ID # SN: GB37440704 SN: US37292783 SN: MY41082317 SN: 100972	04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 30-Dec-17 (No. EXXE-7348, Dec-17) 26-Oct-17 (No. DAE4-601_Oct17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr.19 Apr.19 Apr.19 Apr.19 Dec-18 Oct-18
Power sensor NRP-Z91 Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismalch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06	SN: 103244 SN: 103246 SN: 5058 (20k) SN: 5058 (20k) SN: 5057 SN: 7349 SN: 601 ID # SN: GB37490704 SN: US37292783 SN: MY41082317 SN: 100972 SN: US41080477	04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 03-Dec-17 (No. 5X3-7349_Dec17) 26-Oct-17 (No. 5X3-7349_Dec17) Check Date (in house) 07-Oct-15 (in house check Oct-16) 07-Oct-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16) 15-Jun-15 (in house check Oct-16)	Apr-19 Apr-19 Apr-19 Dec-18 Oct-18 Scheduled Check In house check: Oct-18 In house check: Oct-18 In house check: Oct-18 In house check: Oct-18

Certificate No. D1750V2-1008\_Aug18

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





S Schweizerischer Kalibrierdiener
C Service suisse d'étatominge
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S Swiss Calibration Service

Accreditation No.: SCS 0108

According by the Swas Accordance Service (SAS)

The Swas Accordination Service in one of the signaturies to the EA Multilitieral Agreement for the recognition of calibration certificines

Glossary:

TSL ConvF N/A tissue simulating liquid sensitivity in TSL / NORM x,y,z

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, "Measurement procedure for the assessment of Specific Absorption Rate
- EC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- EC 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 Regulirements 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%.

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### Measurement Conditions

DASY an

DASY Version	DASYS	V52,10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flad Pharmorn	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz; = 5 mm	
Frequency	1750 MHz ± I MHz	

### Head TSL parameters

on parameters and calculations were annual

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mholm
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.9 ± 6 %	1.34 mha/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	-10-	-

### SAR result with Head TSL

SAR averaged over 1 cm <sup>1</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.07 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.5 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	4.B1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.3 W/kg ± 16.5 % (k=2)

### **Body TSL parameters**

ng parameters and calculations were applied.

	Temperatura	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	53.4 = 6 %	1.47 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	9.16 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	37.0 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm2 (10 g) of Body TSL	condition	
SAR measured	250 mW input power	4.93 W/kg
SAR for nominal Body TSL parameters	normalized to TW	19.8 W/kg ± 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.0 \Omega + 1.6 \mu	
Ratum Loss	+ 32.2 pH	

#### Antenna Parameters with Body TSL

Impedance, transformed to feed point	#6.3 Ω ± 0.6 jΩ
Return Loss	- 34.7 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1:207 rs
minoritary solely forth distributions	1.207 113

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 coaxist 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 dipote 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 dipote 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 11, 2009

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### DASY5 Validation Report for Head TSL

Date: 30.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT; Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1008

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

Medium parameters used: f = 1750 MHz;  $\sigma = 1.34$  S/m;  $\epsilon_r = 38.9$ ; p = 1000 kg/m<sup>3</sup>

Phantom section: Flat Section

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

### DASY52 Configuration:

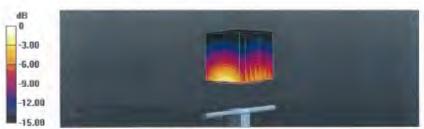
- Probe: EX3DV4 SN7349; ConvF(8.5, 8.5, 8.5) @ 1750 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

### 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 = 107.6 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 16.3 W/kg SAR(1 g) = 9.07 W/kg; SAR(10 g) = 4.81 W/kg

Maximum value of SAR (measured) = 13.9 W/kg



0 dB = 13.9 W/kg = 11.43 dBW/kg

Certificate No: D1750V2-1008\_Aug18

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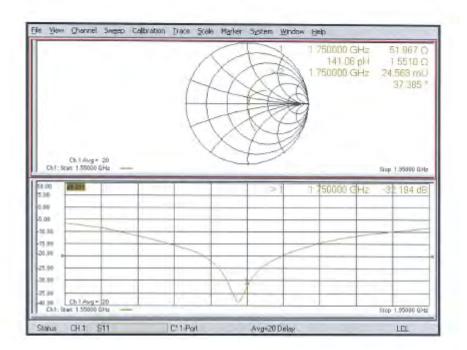
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### Impedance Measurement Plot for Head TSL



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### DASY5 Validation Report for Body TSL

Date: 30.08.2018

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1008

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

Medium parameters used: f = 1750 MHz;  $\sigma = 1.47 \text{ S/m}$ ;  $\epsilon_c = 53.4$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

### DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.35, 8.35, 8.35) @ 1750 MHz; Calibrated: 30.12,2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

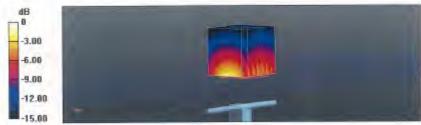
### Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 101.7 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 15.9 W/kg

SAR(1 g) = 9.16 W/kg; SAR(10 g) = 4.93 W/kg

Maximum value of SAR (measured) = 13.7 W/kg



0 dB = 13.7 W/kg = 11.37 dBW/kg

Cortificate No: D1750V2-1008\_Aug18

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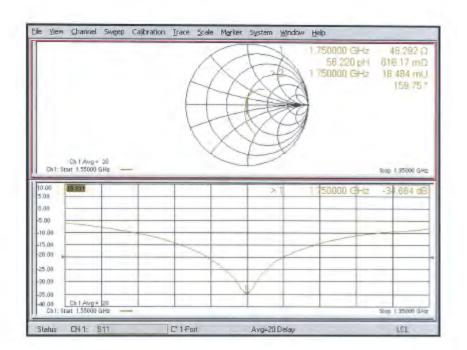
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### Impedance Measurement Plot for Body TSL



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Swiss Calibration Service

Accreditation No.: SCS 0108

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SGS-TW (Auden)

Certificate No: D1900V2-5d173\_Apr19

**CALIBRATION CERTIFICATE** D1900V2 - SN:5d173 Object QA CAL-05.v11 Calibration procedure(s) Calibration Procedure for SAR Validation Sources between 0.7-3 GHz April 23, 2019 Calibration date: 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) Scheduled Calibration Primary Standards Cal Date (Certificate No.) SN: 104778 03-Apr-19 (No. 217-02892/02893) Apr-20 Power meter NRP Power sensor NRP-Z91 SN: 103244 03-Apr-19 (No. 217-02892) Apr-20 Power sensor NRP-Z91 SN: 103245 03-Apr-19 (No. 217-02893) Apr-20 SN: 5058 (20k) Reference 20 dB Attenuator 04-Apr-19 (No. 217-02894) Apr-20 Type-N mismatch combination SN: 5047.2 / 06327 04-Apr-19 (No. 217-02895) Apr-20 Dec-19 Reference Probe EX3DV4 SN: 7349 31-Dec-18 (No. EX3-7349\_Dec18) DAE4 SN: 601 04-Oct-18 (No. DAE4-601\_Oct18) Oct-19 Secondary Standards ID# Check Date (in house) Scheduled Check Power meter E4419B SN: GB39512475 07-Oct-15 (in house check Feb-19) In house check: Oct-20 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-20 Power sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-18) In house check: Oct-20 RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct-20 Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (in house check Oct-18) In house check: Oct-19 Function Michael Weber Laboratory Technician Calibrated by: Approved by: Katja Pokovic Technical Manager Issued: April 23, 2019 This calibration certificate shall not be reproduced except in full without written approval of the laboratory

Certificate No: D1900V2-5d173\_Apr19

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Swiss Calibration Service

Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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Glossary:

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

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

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

### **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
- 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%.

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### **Measurement Conditions**

DASY Version	DASY5	V52.10.2
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.

to following parameters and executions and executions	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	40.6 ± 6 %	1.38 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	9.92 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.2 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	5.22 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.0 W/kg ± 16.5 % (k=2)

Certificate No: D1900V2-5d173\_Apr19

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$52.3 \Omega + 5.1 j\Omega$
Return Loss	- 25.3 dB

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.201 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

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### **DASY5 Validation Report for Head TSL**

Date: 23.04.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d173

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

Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.38 S/m;  $\epsilon_r$  = 40.6;  $\rho$  = 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(8.26, 8.26, 8.26) @ 1900 MHz; Calibrated: 31.12.2018

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Electronics: DAE4 Sn601; Calibrated: 04.10.2018

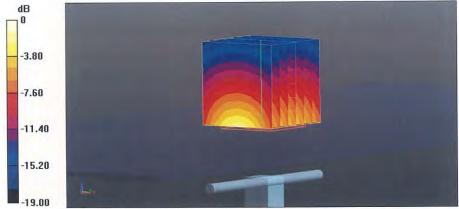
Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001

DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

## 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 = 110.1 V/m; Power Drift = 0.03 dB Peak SAR (extrapolated) = 18.1 W/kg SAR(1 g) = 9.92 W/kg; SAR(10 g) = 5.22 W/kg

Maximum value of SAR (measured) = 15.3 W/kg



0 dB = 15.3 W/kg = 11.85 dBW/kg

Certificate No: D1900V2-5d173\_Apr19

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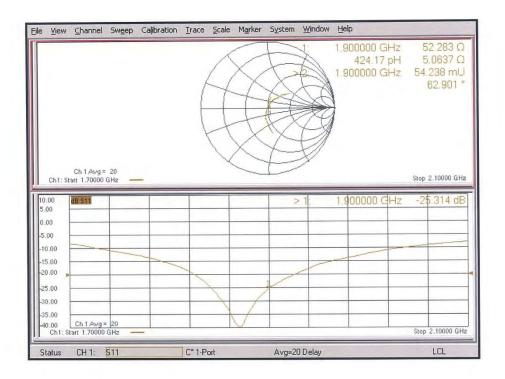
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### Impedance Measurement Plot for Head TSL



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Certificate No: D2450V2-727\_Apr19

Object	D2450V2 - SN:7	27	
Calibration procedure(s)	QA CAL-05.v11 Calibration Proce	edure for SAR Validation Sources	s between 0.7-3 GHz
Calibration date:	April 24, 2019		
The measurements and the uncer	tainties with confidence p	ional standards, which realize the physical un probability are given on the following pages ar my facility: environment temperature $(22 \pm 3)^{\circ}$	nd are part of the certificate.
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Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator ype-N mismatch combination Reference Probe EX3DV4 RASE4 Recondary Standards Power meter E4419B	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	03-Apr-19 (No. 217-02892/02893) 03-Apr-19 (No. 217-02892) 03-Apr-19 (No. 217-02893) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02895) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18) Check Date (in house) 07-Oct-15 (in house check Feb-19)	Apr-20 Apr-20 Apr-20 Apr-20 Apr-20 Dec-19 Oct-19 Scheduled Check In house check: Oct-20
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Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Recondary Standards Power meter E4419B Power sensor HP 8481A Regenerator R&S SMT-06	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: US41080477	03-Apr-19 (No. 217-02892/02893) 03-Apr-19 (No. 217-02892) 03-Apr-19 (No. 217-02893) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02895) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18) Check Date (in house) 07-Oct-15 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-18)	Apr-20 Apr-20 Apr-20 Apr-20 Apr-20 Dec-19 Oct-19 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Reference 20 dB Attenuator Reference Probe EX3DV4 Re	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY4109217 SN: US41080477 Name	03-Apr-19 (No. 217-02892/02893) 03-Apr-19 (No. 217-02892) 03-Apr-19 (No. 217-02893) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02895) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18)  Check Date (in house) 07-Oct-15 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-18)	Apr-20 Apr-20 Apr-20 Apr-20 Apr-20 Dec-19 Oct-19 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Primary Standards Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 DAE4 Decondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A Calibrated by:	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: US41080477	03-Apr-19 (No. 217-02892/02893) 03-Apr-19 (No. 217-02892) 03-Apr-19 (No. 217-02893) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02895) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18) Check Date (in house) 07-Oct-15 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-18)	Apr-20 Apr-20 Apr-20 Apr-20 Apr-20 Dec-19 Oct-19 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY4109217 SN: US41080477 Name	03-Apr-19 (No. 217-02892/02893) 03-Apr-19 (No. 217-02892) 03-Apr-19 (No. 217-02893) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02894) 04-Apr-19 (No. 217-02895) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18)  Check Date (in house) 07-Oct-15 (in house check Feb-19) 07-Oct-15 (in house check Oct-18) 15-Jun-15 (in house check Oct-18) 31-Mar-14 (in house check Oct-18)	Apr-20 Apr-20 Apr-20 Apr-20 Apr-20 Dec-19 Oct-19 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20

Certificate No: D2450V2-727\_Apr19 Page 1 of 6

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





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Accreditation No.: SCS 0108

Accredited by the Swiss Accreditation Service (SAS)

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#### Glossary:

TSL

tissue simulating liquid

ConvF N/A

sensitivity in TSL / NORM x,y,z 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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

### 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
- 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%.

Certificate No: D2450V2-727 Apr19 Page 2 of 6

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### Measurement Conditions

DASY Version	DASY5	V52.10.2
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	37.8 ± 6 %	1.87 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		4-4-1

### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.6 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	53.0 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	6.28 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.7 W/kg ± 16.5 % (k=2)

Certificate No: D2450V2-727\_Apr19

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

### Antenna Parameters with Head TSL

Impedance, transformed to feed point	$55.8 \Omega + 2.9 j\Omega$	
Return Loss	- 24.2 dB	

### General Antenna Parameters and Design

Electrical Delay (one direction)	1.149 ns

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

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

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

### **Additional EUT Data**

Manufactured by	SPEAG
-----------------	-------

Certificate No: D2450V2-727 Apr19

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### **DASY5 Validation Report for Head TSL**

Date: 24.04.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:727

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

Medium parameters used: f = 2450 MHz;  $\sigma = 1.87 \text{ S/m}$ ;  $\varepsilon_r = 37.8$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

### DASY52 Configuration:

Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 31.12.2018

Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Electronics: DAE4 Sn601; Calibrated: 04.10.2018

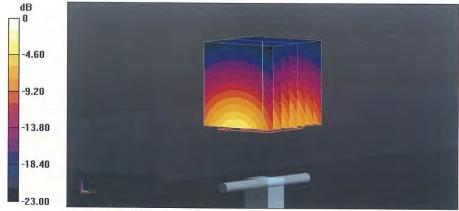
Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001

DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

### 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 = 116.3 V/m; Power Drift = 0.04 dB Peak SAR (extrapolated) = 26.9 W/kgSAR(1 g) = 13.6 W/kg; SAR(10 g) = 6.28 W/kg

Maximum value of SAR (measured) = 22.2 W/kg



0 dB = 22.2 W/kg = 13.46 dBW/kg

Certificate No: D2450V2-727\_Apr19 Page 5 of 6

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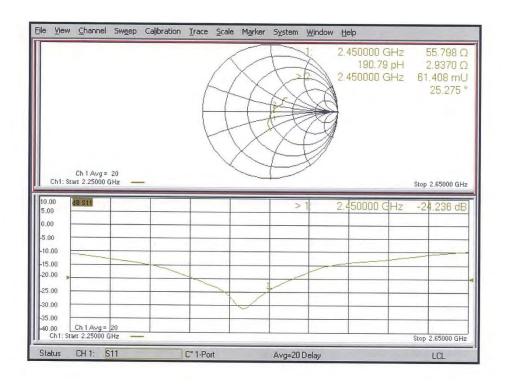
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### Impedance Measurement Plot for Head TSL



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SGS-TW (Auden)

Certificate No: D2600V2-1005\_Jan19

Object	D2600V2 - SN:10	005	
Calibration procedure(s)	QA CAL-05.v11 Calibration Procedure for SAR Validation Sources between 0.7-3 GHz		
Calibration date:	January 28, 2019	9	
The measurements and the uncert	tainties with confidence p	ional standards, which realize the physical un probability are given on the following pages and ry facility: environment temperature (22 $\pm$ 3)°0	nd are part of the certificate.
Calibration Equipment used (M&TI	1-2		
	ID#	Cal Date (Certificate No.)	Scheduled Calibration
			A== 10
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power meter NRP Power sensor NRP-Z91	SN: 104778 SN: 103244	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672)	Apr-19
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91	SN: 104778 SN: 103244 SN: 103245	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673)	Apr-19 Apr-19
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682)	Apr-19 Apr-19 Apr-19
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683)	Apr-19 Apr-19 Apr-19 Apr-19
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k)	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682)	Apr-19 Apr-19 Apr-19
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18)	Apr-19 Apr-19 Apr-19 Apr-19 Dec-19 Oct-19
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18) Check Date (in house)	Apr-19 Apr-19 Apr-19 Apr-19 Dec-19 Oct-19 Scheduled Check
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02683) 31-Dec-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18) Check Date (in house) 07-Oct-15 (in house check Oct-18)	Apr-19 Apr-19 Apr-19 Apr-19 Dec-19 Oct-19 Scheduled Check In house check: Oct-20
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Fype-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18) Check Date (in house) 07-Oct-15 (in house check Oct-18)	Apr-19 Apr-19 Apr-19 Apr-19 Dec-19 Oct-19 Scheduled Check In house check: Oct-20 In house check: Oct-20
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Type-N mismatch combination Reference Probe EX3DV4 DAE4 Secondary Standards Power meter EPM-442A Power sensor HP 8481A	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02683) 04-Apr-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18)  Check Date (in house) 07-Oct-15 (in house check Oct-18) 07-Oct-15 (in house check Oct-18)	Apr-19 Apr-19 Apr-19 Apr-19 Apr-19 Dec-19 Oct-19 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
Power meter NRP Power sensor NRP-Z91 Power sensor NRP-Z91 Reference 20 dB Attenuator Power sensor NRP-Z91 Reference Probe EX3DV4 Power sensor HP 8481A Reference Res SMT-06	SN: 104778 SN: 103244 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB37480704 SN: US37292783 SN: MY41092317	04-Apr-18 (No. 217-02672/02673) 04-Apr-18 (No. 217-02672) 04-Apr-18 (No. 217-02673) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. 217-02682) 04-Apr-18 (No. EX3-7349_Dec18) 04-Oct-18 (No. DAE4-601_Oct18) Check Date (in house) 07-Oct-15 (in house check Oct-18)	Apr-19 Apr-19 Apr-19 Apr-19 Dec-19 Oct-19 Scheduled Check In house check: Oct-20 In house check: Oct-20 In house check: Oct-20 In house check: Oct-20
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Certificate No: D2600V2-1005\_Jan19

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#### Glossarv:

tissue simulating liquid TSL

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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

#### 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
- SAR for nominal TSL parameters: The measured TSL parameters are used to calculate the

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%.

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## **Measurement Conditions**

DASY Version	DASY5	V52.10.2
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	A

## **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	37.3 ± 6 %	2.03 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	14.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	55.3 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	6.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.7 W/kg ± 16.5 % (k=2)

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

#### Antenna Parameters with Head TSL

Impedance, transformed to feed point	49.4 Ω - 4.0 jΩ	
Return Loss	- 27.7 dB	

#### General Antenna Parameters and Design

Electrical Delay (one direction)	1.157 ns
The state of the s	

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
iviality by	SI EAG

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## **DASY5 Validation Report for Head TSL**

Date: 28.01.2019

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1005

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

Medium parameters used: f = 2600 MHz;  $\sigma = 2.03 \text{ S/m}$ ;  $\varepsilon_r = 37.3$ ;  $\rho = 1000 \text{ kg/m}^3$ 

Phantom section: Flat Section

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

#### DASY52 Configuration:

Probe: EX3DV4 - SN7349; ConvF(7.74, 7.74, 7.74) @ 2600 MHz; Calibrated: 31.12.2018

• Sensor-Surface: 1.4mm (Mechanical Surface Detection)

Electronics: DAE4 Sn601; Calibrated: 04.10.2018

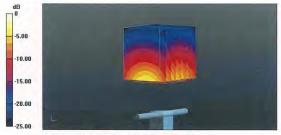
Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001

DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

## 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 = 118.2 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 28.9 W/kg SAR(1 g) = 14.2 W/kg; SAR(10 g) = 6.27 W/kg

SAR(1 g) = 14.2 W/kg; SAR(10 g) = 6.27 W/kgMaximum value of SAR (measured) = 23.9 W/kg



0 dB = 23.9 W/kg = 13.78 dBW/kg

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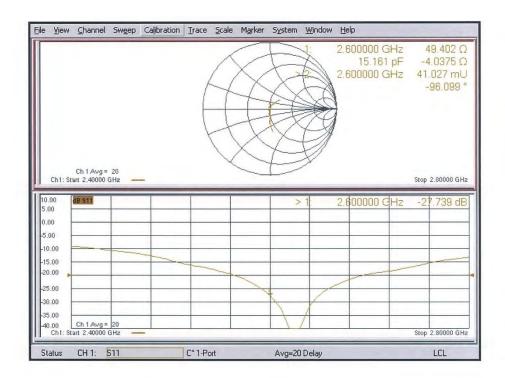
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#### Impedance Measurement Plot for Head TSL



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SGS-TW (Auden)

Certificate No: D5GHzV2-1023\_Jan19

#### **CALIBRATION CERTIFICATE** D5GHzV2 - SN:1023 Object QA CAL-22.v4 Calibration procedure(s) Calibration Procedure for SAR Validation Sources between 3-6 GHz January 30, 2019 Calibration date: 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) Cal Date (Certificate No.) Scheduled Calibration Primary Standards ID# SN: 104778 04-Apr-18 (No. 217-02672/02673) Apr-19 Power meter NRF Power sensor NRP-Z91 SN: 103244 04-Apr-18 (No. 217-02672) Apr-19 Power sensor NRP-Z91 SN: 103245 04-Apr-18 (No. 217-02673) Apr-19 Reference 20 dB Attenuator SN: 5058 (20k) 04-Apr-18 (No. 217-02682) Apr-19 Type-N mismatch combination SN: 5047.2 / 06327 04-Apr-18 (No. 217-02683) Apr-19 Reference Probe EX3DV4 SN: 3503 31-Dec-18 (No. EX3-3503\_Dec18) Dec-19 DAE4 SN: 601 04-Oct-18 (No. DAE4-601\_Oct18) Oct-19 ID# Check Date (in house) Scheduled Check Secondary Standards Power meter EPM-442A SN: GB37480704 07-Oct-15 (in house check Oct-18) In house check: Oct-20 Power sensor HP 8481A SN: US37292783 07-Oct-15 (in house check Oct-18) In house check: Oct-20 Power sensor HP 8481A SN: MY41092317 07-Oct-15 (in house check Oct-18) In house check: Oct-20 RF generator R&S SMT-06 SN: 100972 15-Jun-15 (in house check Oct-18) In house check: Oct-20 Network Analyzer Agilent E8358A SN: US41080477 31-Mar-14 (in house check Oct-18) In house check: Oct-19 Function Name Michael Weber Laboratory Technician Calibrated by: Technical Manager Katja Pokovic Approved by: Issued: January 30, 2019 This calibration certificate shall not be reproduced except in full without written approval of the laboratory

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TSL

tissue simulating liquid

sensitivity in TSL / NORM x,y,z

ConvF N/A

not applicable or not measured

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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%.

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## Measurement Conditions

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

DASY Version	DASY5	V52.10.2
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

## Head TSL parameters at 5200 MHz

and calculations were applied

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.8 ± 6 %	4.49 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

## SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm3 (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.89 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2,24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.5 W/kg ± 19.5 % (k=2)

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## Head TSL parameters at 5300 MHz

The following parameters and calculations were applied

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.6 ± 6 %	4.59 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	1,000	Sec.

#### SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.24 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.6 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.5 W/kg ± 19.5 % (k=2)

## Head TSL parameters at 5600 MHz

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.2 ± 6 %	4.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	1444	

## SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.55 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	85.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL.	condition	
SAR measured	100 mW input power	2.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.4 W/kg ± 19.5 % (k=2)

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## Head TSL parameters at 5800 MHz

The following parameters and calculations were applied

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35,3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	5.11 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	- Consider	Take 1

#### SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.02 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.26 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.7 W/kg ± 19.5 % (k=2)

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

## Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	51.2 Ω - 8.5 jΩ
Return Loss	- 21.4 dB

#### Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	51.0 Ω - 3.9 jΩ	
Return Loss	- 28.0 dB	

#### Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	54.9 Ω - 1.6 jΩ	
Return Loss	- 26.2 dB	

### Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	$55.8 \Omega + 1.3 j\Omega$	
Return Loss	- 25.0 dB	

## General Antenna Parameters and Design

1.199 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
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## **DASY5 Validation Report for Head TSL**

Date: 30.01.2019

Test Laboratory: SPEAG, Zurich, Switzerland

### DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1023

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

MHz, Frequency: 5800 MHz

Medium parameters used: f = 5200 MHz;  $\sigma = 4.49$  S/m;  $\epsilon_r = 36.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5300 MHz;  $\sigma = 4.59$  S/m;  $\epsilon_r = 36.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5600 MHz;  $\sigma = 4.9$  S/m;  $\epsilon_r = 36.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>, Medium parameters used: f = 5800 MHz;  $\sigma = 5.11$  S/m;  $\epsilon_r = 35.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

#### DASY52 Configuration:

- Probe: EX3DV4 SN3503; ConvF(5.69, 5.69, 5.69) @ 5200 MHz, ConvF(5.45, 5.45, 5.45) @ 5300 MHz, ConvF(5, 5, 5) @ 5600 MHz, ConvF(4.96, 4.96, 4.96) @ 5800 MHz; Calibrated: 31.12.2018
- · Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.10.2018
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1495); SEMCAD X 14.6.12(7450)

## Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 75.39 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 28.7 W/kg

SAR(1 g) = 7.89 W/kg; SAR(10 g) = 2.24 W/kg

Maximum value of SAR (measured) = 18.0 W/kg

#### Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 76.71 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 8.24 W/kg; SAR(10 g) = 2.34 W/kg

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

## Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan,

dist=1.4mm (8x8x7)/Cube 0; Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 76.95 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 32.9 W/kg

SAR(1 g) = 8.55 W/kg; SAR(10 g) = 2.43 W/kg

Maximum value of SAR (measured) = 20.1 W/kg

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Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan,

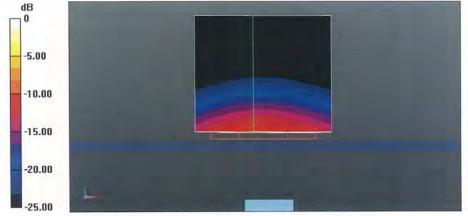
dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 74.52 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 32.1 W/kg

SAR(1 g) = 8.02 W/kg; SAR(10 g) = 2.26 W/kg

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



0 dB = 19.1 W/kg = 12.81 dBW/kg

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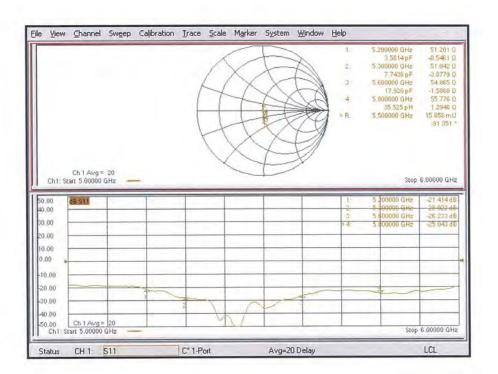
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## Impedance Measurement Plot for Head TSL



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# - End of report -

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