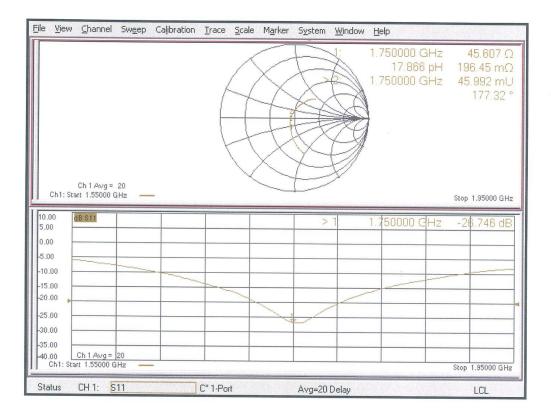




# Impedance Measurement Plot for Body TSL



Certificate No: D1750V2-1003\_Jul19

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# 1900 MHz Dipole Calibration Certificate

Engineering AG ughausstrasse 43, 8004 Zurich, 5	of Switzerland	S C S	Schweizerischer Kalibrierdienst Service suisse d'étalonnage Servizio svizzero di taratura Swiss Calibration Service
ccredited by the Swiss Accreditatione Swiss Accreditatione is		- 14	creditation No.: SCS 0108
ultilateral Agreement for the reco	ognition of calibration		
lient CTTL (Auden)		Certificate No	: D1900V2-5d101_Jul19
CALIBRATION CE	ERTIFICATE		
Dbject	D1900V2 - SN:5c	3101	
Calibration procedure(s)	QA CAL-05.v11 Calibration Proce	edure for SAR Validation Sources	between 0.7-3 GHz
Calibration date:	July 17, 2019		
The measurements and the uncerta	ainties with confidence p ed in the closed laborator	ional standards, which realize the physical un robability are given on the following pages an ry facility: environment temperature (22 ± 3)°C	d are part of the certificate.
The measurements and the uncertain and the uncertains have been conducted calibration Equipment used (M&TE	ainties with confidence p ed in the closed laborator E critical for calibration)	robability are given on the following pages an ry facility: environment temperature $(22 \pm 3)^{\circ}$	d are part of the certificate.
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The measurements and the uncerta	ainties with confidence p ed in the closed laborator E critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477	Cal Date (Certificate No.)         03-Apr-19 (No. 217-02892/02893)         03-Apr-19 (No. 217-02892)         03-Apr-19 (No. 217-02892)         03-Apr-19 (No. 217-02892)         03-Apr-19 (No. 217-02893)         04-Apr-19 (No. 217-02894)         04-Apr-19 (No. 217-02895)         29-May-19 (No. 217-02895)         30-Oct-14 (in house check Feb-19)         07-Oct-15 (in house check Oct-18)         07-Oct-15 (in house check Oct-18)         15-Jun-15 (in house check Oct-18)         31-Mar-14 (in house check Oct-18)	d are part of the certificate. C and humidity < 70%. Scheduled Calibration Apr-20 Apr-20 Apr-20 Apr-20 May-20 Apr-20 Scheduled Check In house check: Oct-20 In house check: Oct-19
The measurements and the uncertain All calibrations have been conducted Calibration Equipment used (M&TE 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 Secondary Standards Power meter E4419B Power sensor HP 8481A Power sensor HP 8481A RF generator R&S SMT-06 Network Analyzer Agilent E8358A	ainties with confidence p ed in the closed laborator E critical for calibration) ID # SN: 104778 SN: 103244 SN: 103245 SN: 103245 SN: 5058 (20k) SN: 5047.2 / 06327 SN: 7349 SN: 601 ID # SN: GB39512475 SN: US37292783 SN: MY41092317 SN: 100972 SN: US41080477 Name	Cal Date (Certificate No.)         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)         29-May-19 (No. 217-02895)         29-May-19 (No. EX3-7349_May19)         30-Oct-14 (in house check Feb-19)         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)	d are part of the certificate. C and humidity < 70%. Scheduled Calibration Apr-20 Apr-20 Apr-20 Apr-20 May-20 Apr-20 Scheduled Check In house check: Oct-20 In house check: Oct-19

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



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

Accreditation No.: SCS 0108

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

### **Glossary:**

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

# Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "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%.

Certificate No: D1900V2-5d101\_Jul19

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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	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz ± 1 MHz	

## Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	41.5 ± 6 %	1.37 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C		

### SAR result with Head TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.71 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	39.7 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm3 (10 g) of Head TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL SAR measured	condition 250 mW input power	5.12 W/kg

### **Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	54.1 ± 6 %	1.48 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	9.74 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	39.7 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.9 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	50.7 Ω + 4.6 jΩ	
Return Loss	- 26.6 dB	

### Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.5 Ω + 6.4 jΩ	
Return Loss	- 22.4 dB	

### **General Antenna Parameters and Design**

Electrical Delay (one direction)	1.203 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: 15.07.2019

Test Laboratory: SPEAG, Zurich, Switzerland

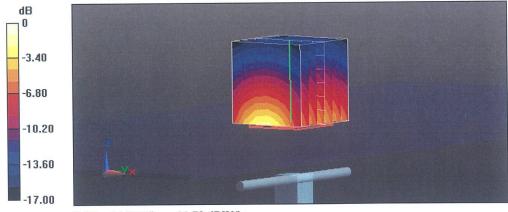
# DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d101

Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.37 S/m;  $\epsilon_r$  = 41.5;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.44, 8.44, 8.44) @ 1900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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 = 108.4 V/m; Power Drift = 0.00 dB Peak SAR (extrapolated) = 17.6 W/kg SAR(1 g) = 9.71 W/kg; SAR(10 g) = 5.12 W/kg Maximum value of SAR (measured) = 14.9 W/kg



0 dB = 14.9 W/kg = 11.73 dBW/kg

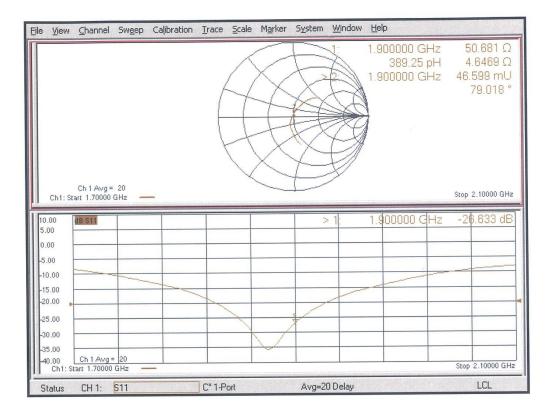
Certificate No: D1900V2-5d101\_Jul19

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# Impedance Measurement Plot for Head TSL



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## DASY5 Validation Report for Body TSL

Date: 17.07.2019

Test Laboratory: SPEAG, Zurich, Switzerland

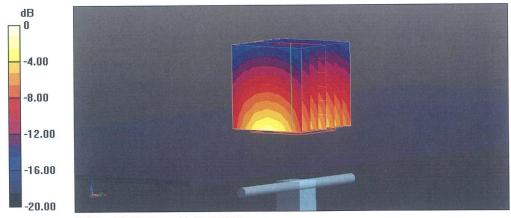
## DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d101

Communication System: UID 0 - CW; Frequency: 1900 MHz Medium parameters used: f = 1900 MHz;  $\sigma$  = 1.48 S/m;  $\epsilon_r$  = 54.1;  $\rho$  = 1000 kg/m<sup>3</sup> Phantom section: Flat Section Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 SN7349; ConvF(8.42, 8.42, 8.42) @ 1900 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm Reference Value = 104.3 V/m; Power Drift = -0.02 dB Peak SAR (extrapolated) = 17.3 W/kg SAR(1 g) = 9.74 W/kg; SAR(10 g) = 5.17 W/kg Maximum value of SAR (measured) = 14.7 W/kg



0 dB = 14.7 W/kg = 11.67 dBW/kg

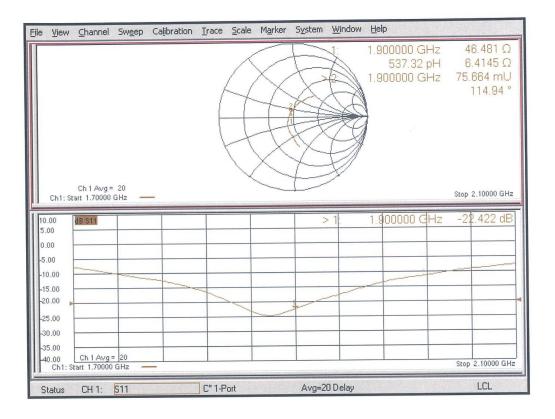
Certificate No: D1900V2-5d101\_Jul19

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# Impedance Measurement Plot for Body TSL



Certificate No: D1900V2-5d101\_Jul19

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# 2450 MHz Dipole Calibration Certificate

Calibration Laboratory Schmid & Partner Engineering AG Zeughausstrasse 43, 8004 Zurich		ACCREDING OF	<ul> <li>S Schweizerischer Kalibrierdienst</li> <li>Service suisse d'étalonnage</li> <li>Servizio svizzero di taratura</li> <li>S Swiss Calibration Service</li> </ul>	
Accredited by the Swiss Accreditat The Swiss Accreditation Service Multilateral Agreement for the rea	is one of the signatorie		Accreditation No.: SCS 0108	
Client CTTL (Auden)		Certificate	No: D2450V2-853_Jul19	
<b>CALIBRATION C</b>	ERTIFICATI			
Object	D2450V2 - SN:8	53		
Calibration procedure(s)	QA CAL-05.v11 Calibration Proce	edure for SAR Validation Sourc	es between 0.7-3 GHz	
Calibration date:	July 17, 2019			
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 Power meter NRP	ID #	Cal Date (Certificate No.)	Scheduled Calibration	
Power sensor NRP-Z91	SN: 104778 SN: 103244	03-Apr-19 (No. 217-02892/02893)	Apr-20	
Power sensor NRP-Z91	SN: 103245	03-Apr-19 (No. 217-02892)	Apr-20	
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-19 (No. 217-02893) 04-Apr-19 (No. 217-02894)	Apr-20	
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-19 (No. 217-02895)	Apr-20	
Reference Probe EX3DV4	SN: 7349	29-May-19 (No. EX3-7349_May19)	Apr-20 May-20	
DAE4	SN: 601	30-Apr-19 (No. DAE4-601_Apr19)	Apr-20	
Secondary Standards	ID #	Check Data (in house)	Calculated Classic	
Power meter E4419B	SN: GB39512475	Check Date (in house) 30-Oct-14 (in house check Feb-19)	Scheduled Check	
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-18)	In house check: Oct-20 In house check: Oct-20	
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-18)		
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-18)	In house check: Oct-20 In house check: Oct-20	
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19	
, ,	1		in house check. Oct 19	
	Name	Function	Signature	
Calibrated by:	Michael Weber	Laboratory Technician	Mers	
Approved by:	Katja Pokovic	Technical Manager	filly	
This calibration certificate shall not	be reproduced except in	full without written approval of the laborate	Issued: July 17, 2019 pry.	

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



Schweizerischer Kalibrierdienst

- C Service suisse d'étalonnage
- Servizio svizzero di taratura

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Swiss Calibration Service

Accreditation No.: SCS 0108

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

# Glossary:

TSLtissue simulating liquidConvFsensitivity in TSL / NORM x,y,zN/Anot 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	V52.10.2
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	37.6 ± 6 %	1.85 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	13.2 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.6 W/kg ± 17.0 % (k=2)
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL	condition	
SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL SAR measured	condition 250 mW input power	6.13 W/kg

### **Body TSL parameters**

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	50.8 ± 6 %	2.02 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C		

### SAR result with Body TSL

SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	52.3 W/kg ± 17.0 % (k=2)

SAR averaged over 10 $\text{cm}^3$ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.23 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.5 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	54.5 Ω + 2.7 jΩ	
Return Loss	- 25.9 dB	

## Antenna Parameters with Body TSL

Impedance, transformed to feed point	49.6 Ω + 5.6 jΩ	
Return Loss	- 25.0 dB	

# General Antenna Parameters and Design

Electrical Delay (one direction)	1.162 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

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

Date: 16.07.2019

Test Laboratory: SPEAG, Zurich, Switzerland

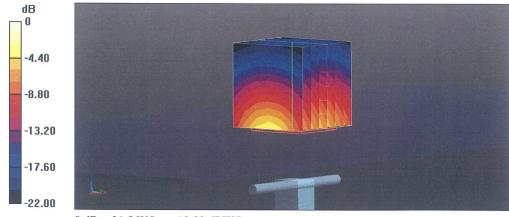
# DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:853

Communication System: UID 0 - CW; Frequency: 2450 MHz Medium parameters used: f = 2450 MHz;  $\sigma$  = 1.85 S/m;  $\epsilon_r$  = 37.6;  $\rho$  = 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(7.9, 7.9, 7.9) @ 2450 MHz; Calibrated: 29.05.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.2(1504); SEMCAD X 14.6.12(7470)

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 = 115.6 V/m; Power Drift = -0.01 dB Peak SAR (extrapolated) = 25.7 W/kg SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.13 W/kg Maximum value of SAR (measured) = 21.5 W/kg



0 dB = 21.5 W/kg = 13.32 dBW/kg

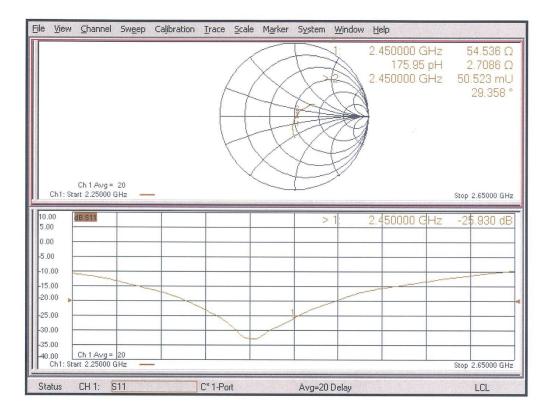
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# Impedance Measurement Plot for Head TSL



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