



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

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D2450V2-719_Aug14**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN: 719**

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

Calibration date: **August 11, 2014**

✓ KOK
9/8/14

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	US37292783	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	MY41092317	09-Oct-13 (No. 217-01828)	Oct-14
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe ES3DV3	SN: 3205	30-Dec-13 (No. ES3-3205_Dec13)	Dec-14
DAE4	SN: 601	30-Apr-14 (No. DAE4-601_Apr14)	Apr-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

Calibrated by: **Michael Weber** Function: **Laboratory Technician**

Signature

M. Weber

Approved by: **Katja Pokovic** Technical Manager

Katja Pokovic

Issued: August 12, 2014

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 108**

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:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.0 $\pm$ 6 %	1.82 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (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	52.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.09 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.2 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	50.5 $\pm$ 6 %	2.02 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.3 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	51.8 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	6.10 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	24.0 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$54.9 \Omega + 3.0 j\Omega$
Return Loss	- 25.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$50.9 \Omega + 5.8 j\Omega$
Return Loss	- 24.7 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
Manufactured on	September 10, 2002

DASY5 Validation Report for Head TSL

Date: 11.08.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 719

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.82$ S/m; $\epsilon_r = 38$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

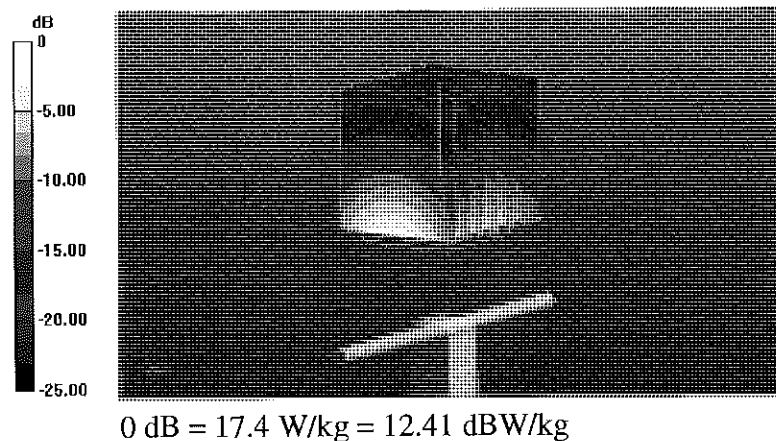
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.6 V/m; Power Drift = 0.03 dB

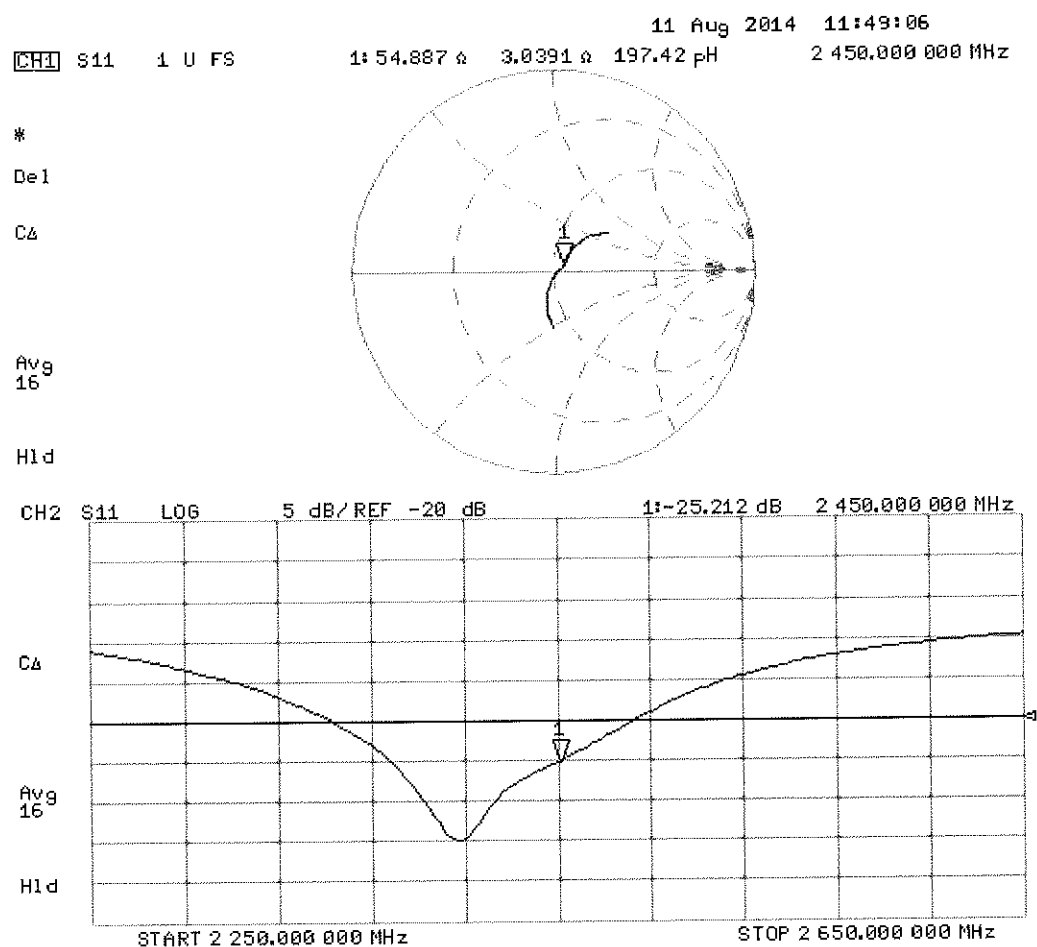
Peak SAR (extrapolated) = 27.5 W/kg

SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.09 W/kg

Maximum value of SAR (measured) = 17.4 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 11.08.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN: 719

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.02$ S/m; $\epsilon_r = 50.5$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

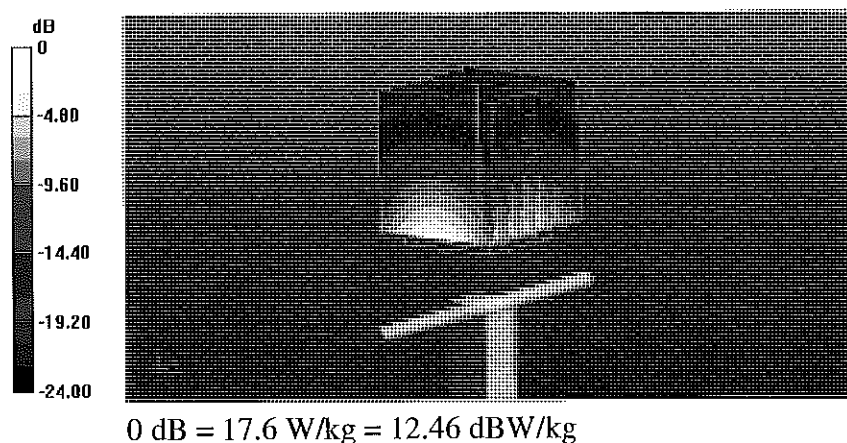
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 96.08 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 27.9 W/kg

SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.1 W/kg

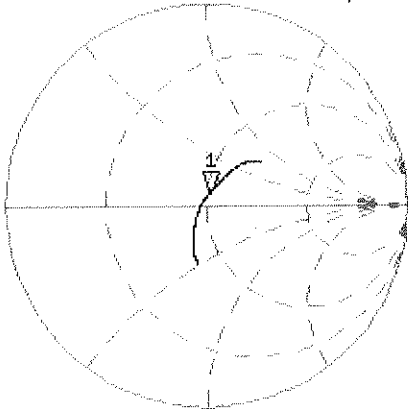
Maximum value of SAR (measured) = 17.6 W/kg



Impedance Measurement Plot for Body TSL

11 Aug 2014 11:48:32
[CH1] S11 1 U FS 1: 50.928 $\angle$ 5.8223 $\angle$ 378.22 pH 2 450.000 000 MHz

*
De1
CA



AVG
15

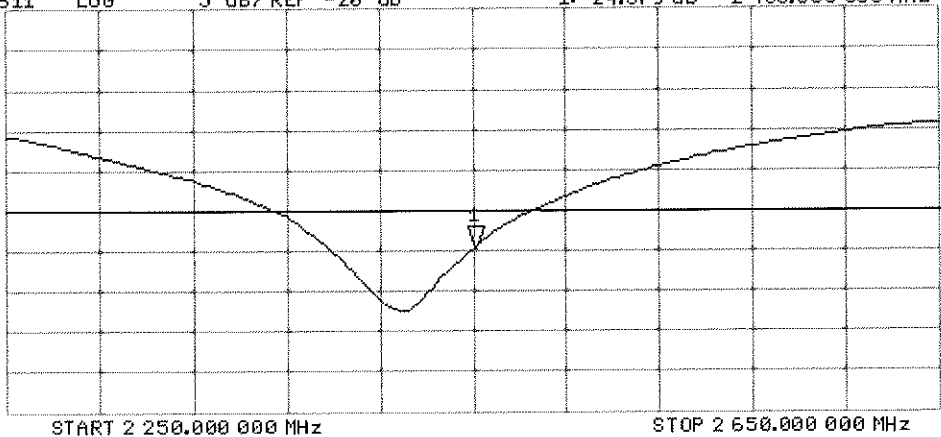
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -24.679 dB 2 450.000 000 MHz

CA

AVG
15

H1d





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

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D2600V2-1071_Oct14**

CALIBRATION CERTIFICATE

Object **D2600V2 - SN: 1071**

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

CC
 WMP

Calibration date: **October 20, 2014**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe ES3DV3	SN: 3205	30-Dec-13 (No. ES3-3205_Dec13)	Dec-14
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (In house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Michael Weber** Name: **Michael Weber** Function: **Laboratory Technician**

Signature

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

Issued: October 20, 2014

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



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

Accreditation No.: **SCS 108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2600 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.0	1.96 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	37.8 $\pm$ 6 %	2.03 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	14.7 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	57.5 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW Input power	6.57 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.9 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.5	2.16 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	50.8 $\pm$ 6 %	2.22 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW Input power	14.5 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	56.9 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW Input power	6.43 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	25.4 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	48.7 Ω - 5.2 j Ω
Return Loss	- 25.3 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	45.9 Ω - 4.2 j Ω
Return Loss	- 24.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.153 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	July 17, 2013

DASY5 Validation Report for Head TSL

Date: 20.10.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1071

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

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.03$ S/m; $\epsilon_r = 37.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.46, 4.46, 4.46); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

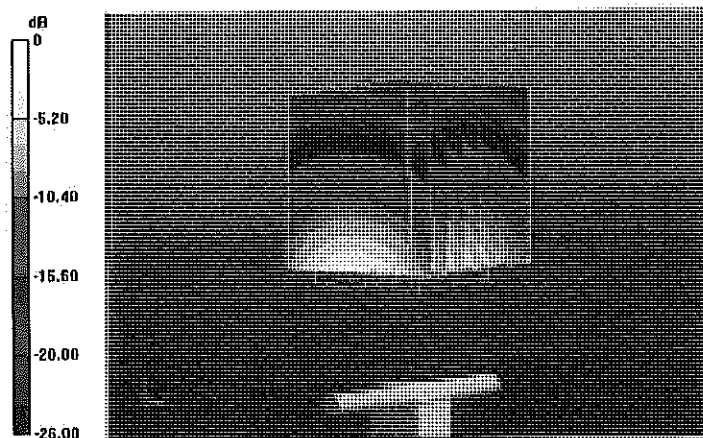
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.3 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 31.0 W/kg

SAR(1 g) = 14.7 W/kg; SAR(10 g) = 6.57 W/kg

Maximum value of SAR (measured) = 19.7 W/kg

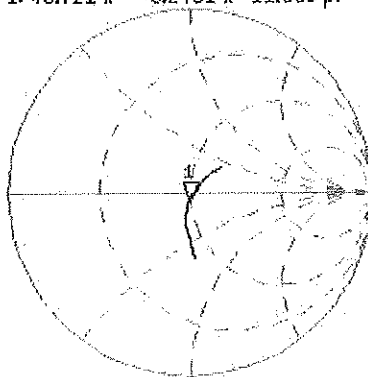


0 dB = 19.7 W/kg = 12.94 dBW/kg

Impedance Measurement Plot for Head TSL

20 Oct 2014 11:58:04
 CH1 S11 1 U.FS 1: 48.721 Ω -5.2461 Ω 11.668 pF 2 600.000 000 MHz

*
 Del
 CA



AVG
 16

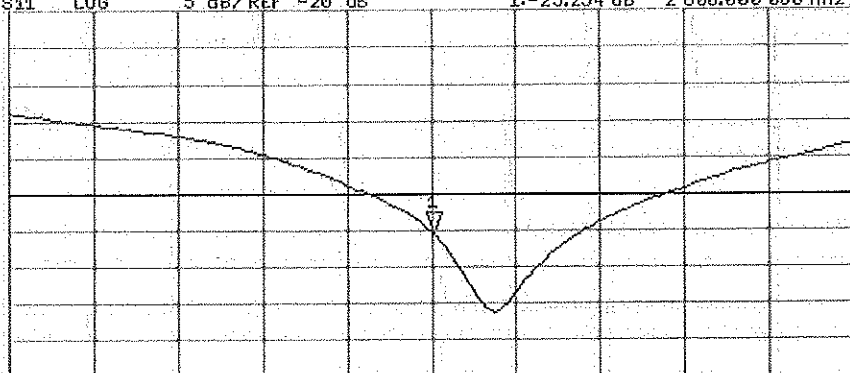
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -25.254 dB 2 600.000 000 MHz

CA

AVG
 16

H1d



START 2 400.000 000 MHz

STOP 2 800.000 000 MHz

DASY5 Validation Report for Body TSL

Date: 20.10.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN: 1071

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

Medium parameters used: $f = 2600$ MHz; $\sigma = 2.22$ S/m; $\epsilon_r = 50.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.24, 4.24, 4.24); Calibrated: 30.12.2013;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

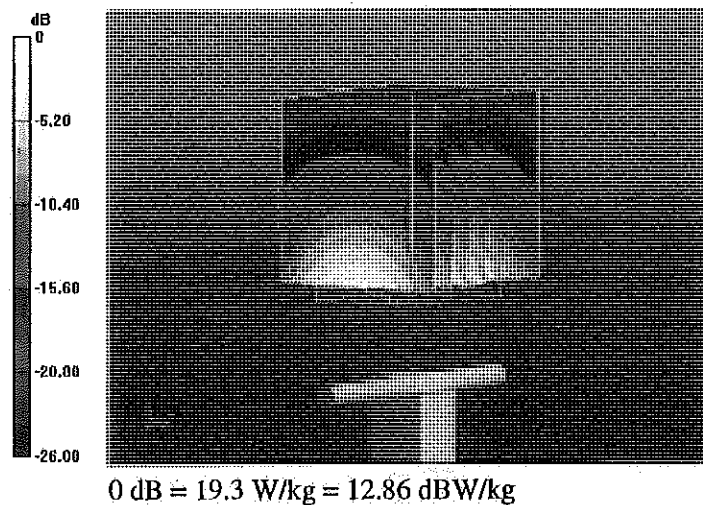
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 97.02 V/m; Power Drift = 0.00 dB

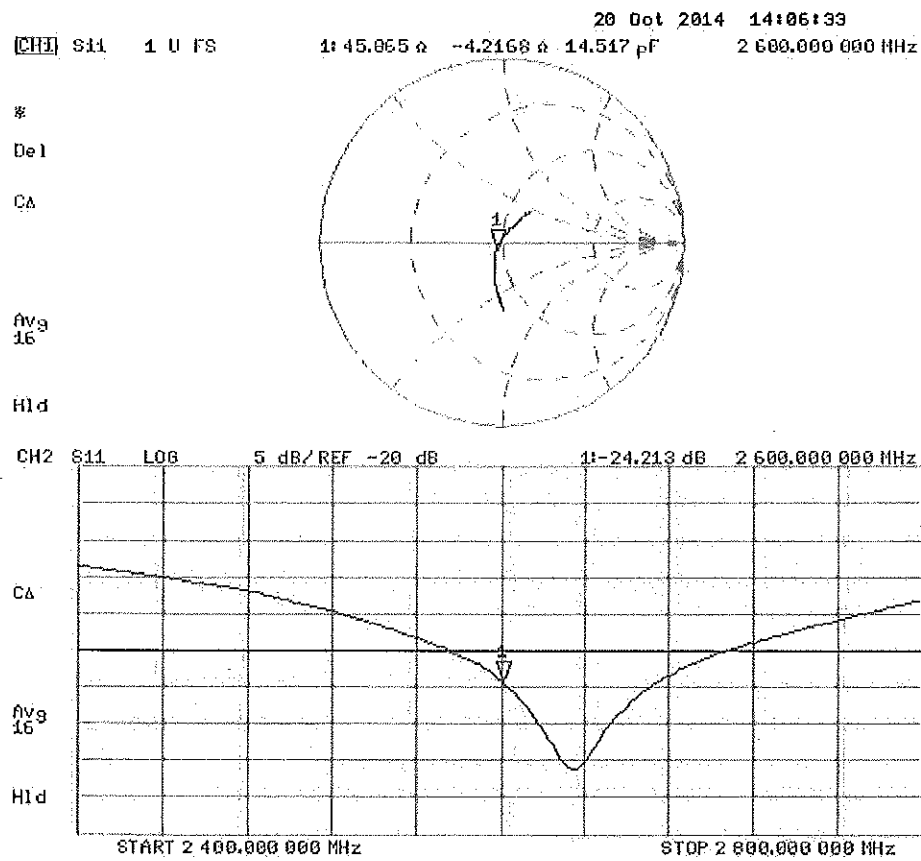
Peak SAR (extrapolated) = 31.0 W/kg

SAR(1 g) = 14.5 W/kg; SAR(10 g) = 6.43 W/kg

Maximum value of SAR (measured) = 19.3 W/kg



Impedance Measurement Plot for Body TSL





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

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D5GHzV2-1057_Jan15**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1057**

Calibration procedure(s) **QA CAL-22.v2**
Calibration procedure for dipole validation kits between 3-6 GHz

CC
2/3/15

Calibration date: **January 21, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe EX3DV4	SN: 3503	30-Dec-14 (No. EX3-3503_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician

Signature

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

Issued: January 22, 2015

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



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

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

- a) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
- c) 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

Additional Documentation:

- d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom 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 $\pm$ 1 MHz 5300 MHz $\pm$ 1 MHz 5500 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters 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 $\pm$ 0.2) °C	36.3 $\pm$ 6 %	4.56 mho/m $\pm$ 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	8.14 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.5 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.31 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg $\pm$ 19.5 % (k=2)

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	36.1 ± 6 %	4.66 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.47 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.7 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.41 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.1 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	4.86 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.43 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	84.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.8 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	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	35.6 ± 6 %	4.97 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.37 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.7 W/kg ± 19.5 % (k=2)

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	35.4 ± 6 %	5.18 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.29 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.9 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.4 ± 6 %	5.42 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.37 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.6 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	49.2 ± 6 %	5.55 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.41 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.08 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.9 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.9 ± 6 %	5.82 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.90 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	79.2 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.19 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.0 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.7 ± 6 %	5.96 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.75 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.7 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.14 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	48.4 ± 6 %	6.25 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.49 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	75.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.06 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.6 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	49.0 Ω - 9.4 j Ω
Return Loss	- 20.4 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	48.3 Ω - 4.2 j Ω
Return Loss	- 26.8 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	49.2 Ω - 5.0 j Ω
Return Loss	- 25.9 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	54.4 Ω - 4.8 j Ω
Return Loss	- 24.1 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	51.8 Ω - 2.6 j Ω
Return Loss	- 30.1 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	48.2 Ω - 8.4 j Ω
Return Loss	- 21.2 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	48.6 Ω - 3.6 j Ω
Return Loss	- 28.2 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	49.4 Ω - 4.1 j Ω
Return Loss	- 27.6 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	55.1 Ω - 4.0 j Ω
Return Loss	- 24.2 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	51.6 Ω - 1.6 j Ω
Return Loss	- 33.0 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	November 27, 2006

DASY5 Validation Report for Head TSL

Date: 21.01.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1057

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.56$ S/m; $\epsilon_r = 36.3$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5300$ MHz; $\sigma = 4.66$ S/m; $\epsilon_r = 36.1$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5500$ MHz; $\sigma = 4.86$ S/m; $\epsilon_r = 35.9$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5600$ MHz; $\sigma = 4.97$ S/m; $\epsilon_r = 35.6$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5800$ MHz; $\sigma = 5.18$ S/m; $\epsilon_r = 35.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.51, 5.51, 5.51); Calibrated: 30.12.2014, ConvF(5.21, 5.21, 5.21); Calibrated: 30.12.2014, ConvF(5.12, 5.12, 5.12); Calibrated: 30.12.2014, ConvF(4.92, 4.92, 4.92); Calibrated: 30.12.2014, ConvF(4.9, 4.9, 4.9); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Head Tissue/Pin=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 = 65.51 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 29.8 W/kg

SAR(1 g) = 8.14 W/kg; SAR(10 g) = 2.31 W/kg

Maximum value of SAR (measured) = 19.3 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 = 65.30 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 32.1 W/kg

SAR(1 g) = 8.47 W/kg; SAR(10 g) = 2.41 W/kg

Maximum value of SAR (measured) = 20.4 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.33 V/m; Power Drift = 0.07 dB

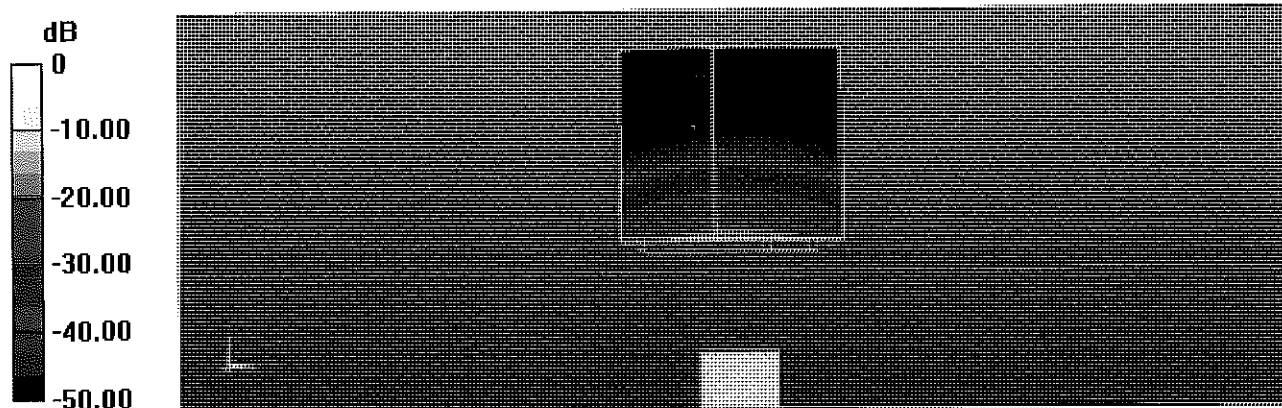
Peak SAR (extrapolated) = 33.5 W/kg

SAR(1 g) = 8.43 W/kg; SAR(10 g) = 2.38 W/kg

Maximum value of SAR (measured) = 20.6 W/kg

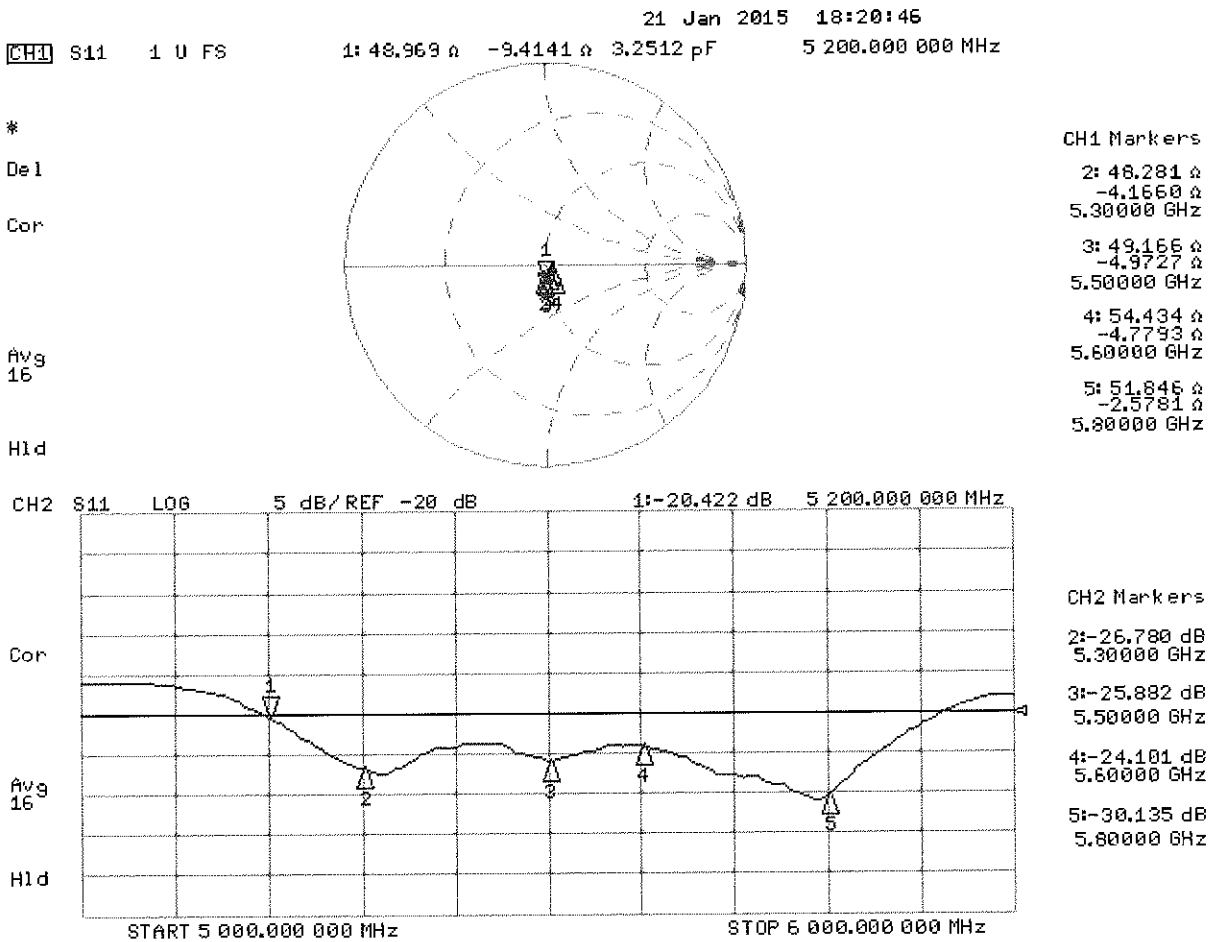
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 64.47 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 33.5 W/kg
SAR(1 g) = 8.38 W/kg; SAR(10 g) = 2.37 W/kg
Maximum value of SAR (measured) = 20.2 W/kg

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 = 62.34 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 33.8 W/kg
SAR(1 g) = 8.11 W/kg; SAR(10 g) = 2.29 W/kg
Maximum value of SAR (measured) = 19.8 W/kg



0 dB = 19.3 W/kg = 12.86 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 20.01.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1057

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 5.42$ S/m; $\epsilon_r = 49.4$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5300$ MHz; $\sigma = 5.55$ S/m; $\epsilon_r = 49.2$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5500$ MHz; $\sigma = 5.82$ S/m; $\epsilon_r = 48.9$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5600$ MHz; $\sigma = 5.96$ S/m; $\epsilon_r = 48.7$; $\rho = 1000$ kg/m³, Medium parameters used: $f = 5800$ MHz; $\sigma = 6.25$ S/m; $\epsilon_r = 48.4$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(4.95, 4.95, 4.95); Calibrated: 30.12.2014, ConvF(4.78, 4.78, 4.78); Calibrated: 30.12.2014, ConvF(4.45, 4.45, 4.45); Calibrated: 30.12.2014, ConvF(4.35, 4.35, 4.35); Calibrated: 30.12.2014, ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Body Tissue/Pin=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 = 58.76 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 28.9 W/kg

SAR(1 g) = 7.37 W/kg; SAR(10 g) = 2.05 W/kg

Maximum value of SAR (measured) = 17.4 W/kg

Dipole Calibration for Body 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 = 58.35 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 29.8 W/kg

SAR(1 g) = 7.41 W/kg; SAR(10 g) = 2.08 W/kg

Maximum value of SAR (measured) = 17.6 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 59.04 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 33.7 W/kg

SAR(1 g) = 7.9 W/kg; SAR(10 g) = 2.19 W/kg

Maximum value of SAR (measured) = 19.2 W/kg

Dipole Calibration for Body 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 = 57.74 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 34.1 W/kg

SAR(1 g) = 7.75 W/kg; SAR(10 g) = 2.14 W/kg

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

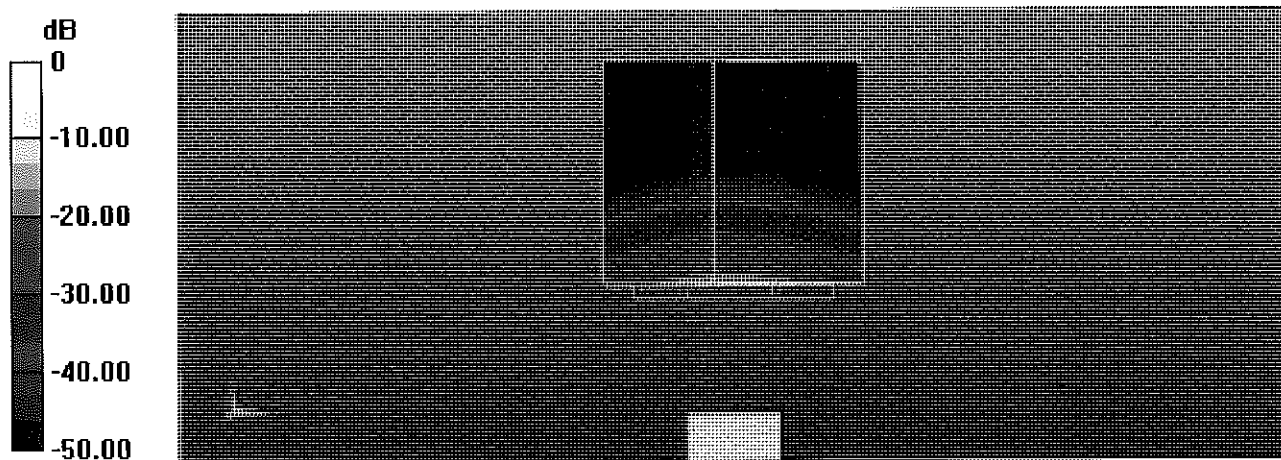
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 55.86 V/m; Power Drift = -0.01 dB

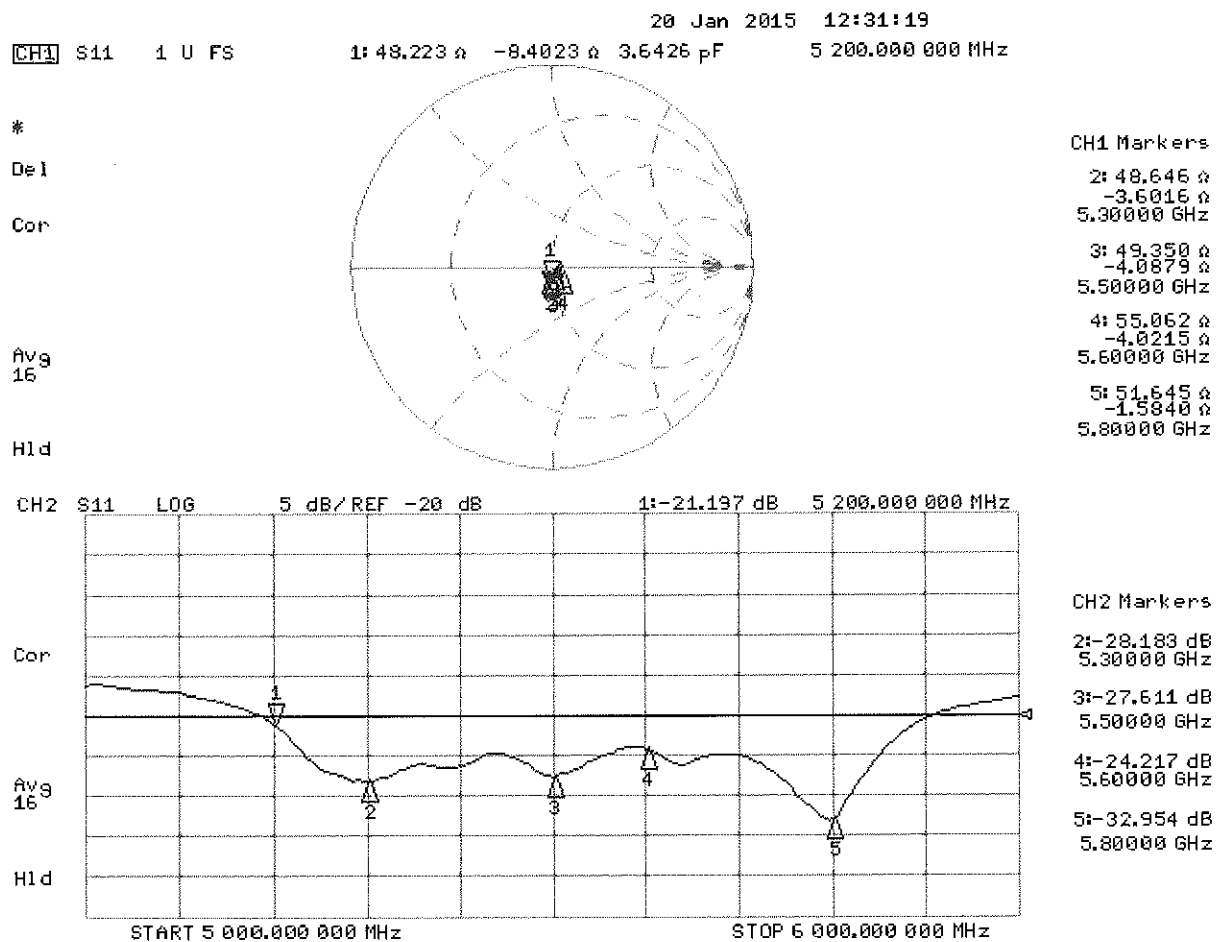
Peak SAR (extrapolated) = 34.7 W/kg

SAR(1 g) = 7.49 W/kg; SAR(10 g) = 2.06 W/kg

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



Impedance Measurement Plot for Body TSL





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Client **PC Test**

Certificate No: **D1750V2-1051_Apr15**

CALIBRATION CERTIFICATE

Object **D1750V2 - SN:1051**

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

PM ✓
 4/29/15

Calibration date: **April 15, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe ES3DV3	SN: 3205	30-Dec-14 (No. ES3-3205_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Jeton Kastrati** **Laboratory Technician**

Signature

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

Issued: April 15, 2015

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



Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 0108**

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1750 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.1	1.37 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.9 $\pm$ 6 %	1.35 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	9.04 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	36.2 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	4.80 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	19.2 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.4	1.49 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.5 $\pm$ 6 %	1.48 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	9.32 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	37.1 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.01 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.0 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	51.3 Ω - 0.2 j Ω
Return Loss	- 37.5 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	46.9 Ω + 0.3 j Ω
Return Loss	- 29.9 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.221 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	February 19, 2010

DASY5 Validation Report for Head TSL

Date: 15.04.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1051

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

Medium parameters used: $f = 1750 \text{ MHz}$; $\sigma = 1.35 \text{ S/m}$; $\epsilon_r = 38.9$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5.2, 5.2, 5.2); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

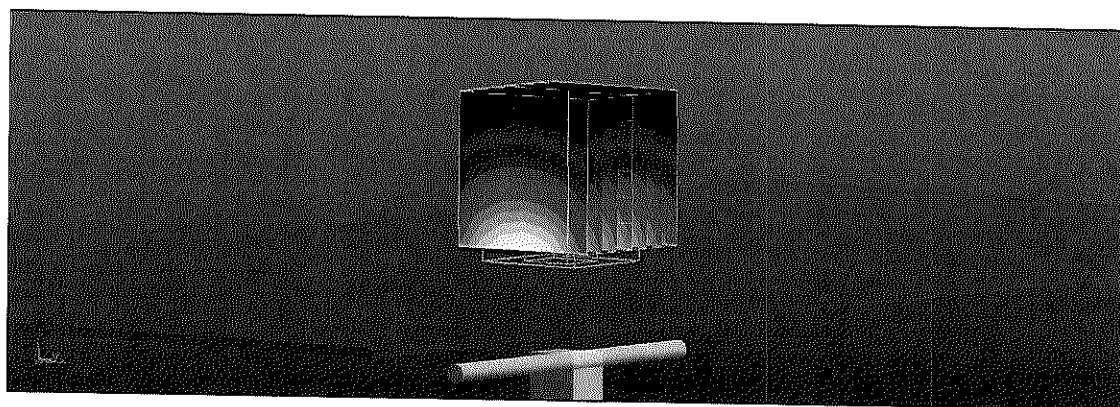
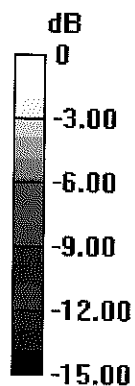
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 94.99 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 16.3 W/kg

SAR(1 g) = 9.04 W/kg; SAR(10 g) = 4.8 W/kg

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

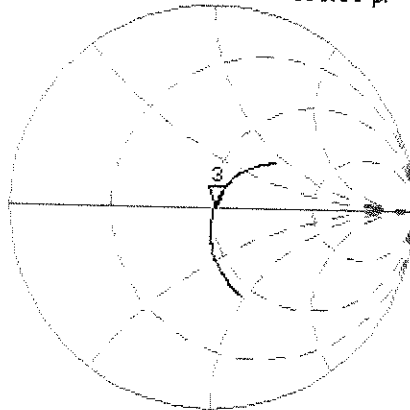


0 dB = 11.5 W/kg = 10.61 dBW/kg

Impedance Measurement Plot for Head TSL

CH1 S11 1 U FS 15 Apr 2015 12:25:31
 3: 51.330 Ω -248.05 m Ω 365.65 pF 1 750.000 000 MHz

*
 Del
 C Δ



Avg
 15

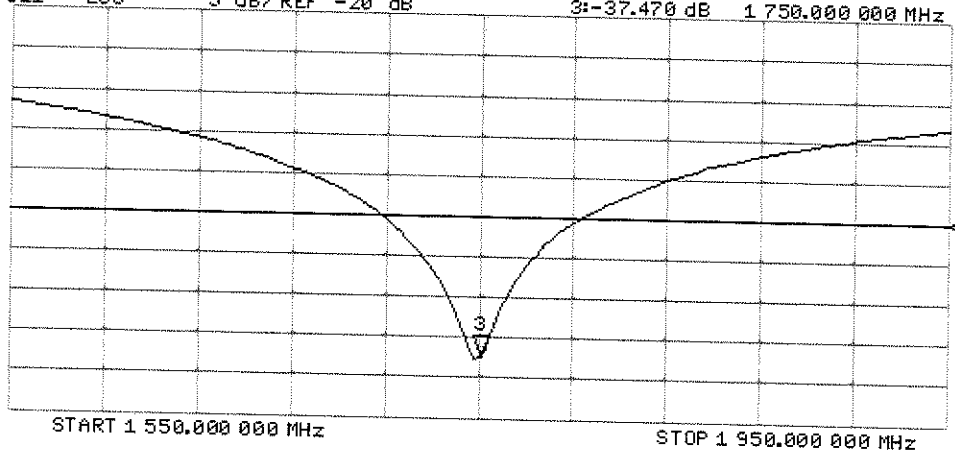
H1d

CH2 S11 LOG 5 dB/REF -20 dB 3:-37.470 dB 1 750.000 000 MHz

C Δ

Avg
 15

H1d



DASY5 Validation Report for Body TSL

Date: 15.04.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1051

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

Medium parameters used: $f = 1750$ MHz; $\sigma = 1.48$ S/m; $\epsilon_r = 51.5$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.88, 4.88, 4.88); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

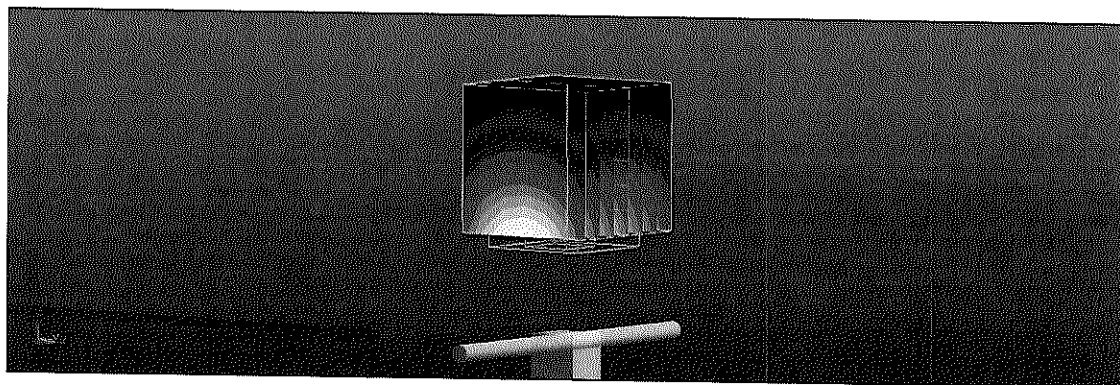
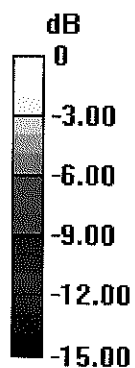
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 92.87 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 16.0 W/kg

SAR(1 g) = 9.32 W/kg; SAR(10 g) = 5.01 W/kg

Maximum value of SAR (measured) = 11.7 W/kg

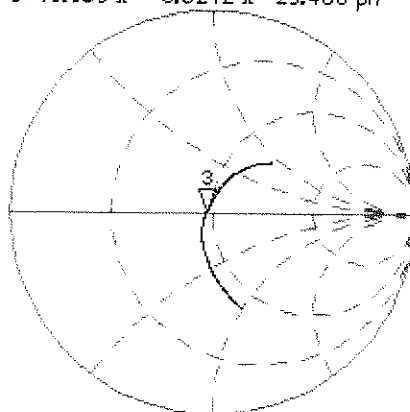


0 dB = 11.7 W/kg = 10.68 dBW/kg

Impedance Measurement Plot for Body TSL

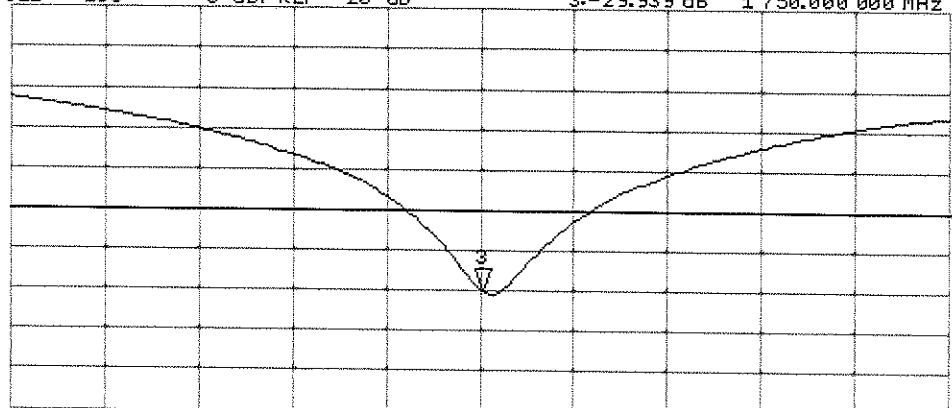
15 Apr 2015 12:23:57
 [CH1] S11 1 U FS 3: 46.930 Ω 0.3242 Ω 29.486 pH 1 750.000 000 MHz

*
 Del
 Ca
 Avg
 16
 H1d



CH2 S11 LOG 5 dB/REF -20 dB 3:-29.939 dB 1 750.000 000 MHz

Ca
 Avg
 16
 H1d



START 1 550.000 000 MHz

STOP 1 950.000 000 MHz



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

Accreditation No.: **SCS 0108**

Client **PC Test**

Certificate No: **D1900V2-5d149_Jul15**

CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d149**

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

CC✓
8/4/15

Calibration date: **July 14, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe ES3DV3	SN: 3205	30-Dec-14 (No. ES3-3205_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Leif Klysner** **Leif Klysner** **Leif Klysner**
 Name Function Laboratory Technician

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

Issued: July 14, 2015

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	1900 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	40.0	1.40 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	39.7 $\pm$ 6 %	1.38 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	10.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	40.7 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	5.34 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	21.5 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	53.3	1.52 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	52.7 $\pm$ 6 %	1.54 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	10.2 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	40.4 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.49 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.8 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	$51.4 \Omega + 5.6 j\Omega$
Return Loss	- 24.9 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	$47.7 \Omega + 6.1 j\Omega$
Return Loss	- 23.5 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.197 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	March 11, 2011

DASY5 Validation Report for Head TSL

Date: 14.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149

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

Medium parameters used: $f = 1900 \text{ MHz}$; $\sigma = 1.38 \text{ S/m}$; $\epsilon_r = 39.7$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(5, 5, 5); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

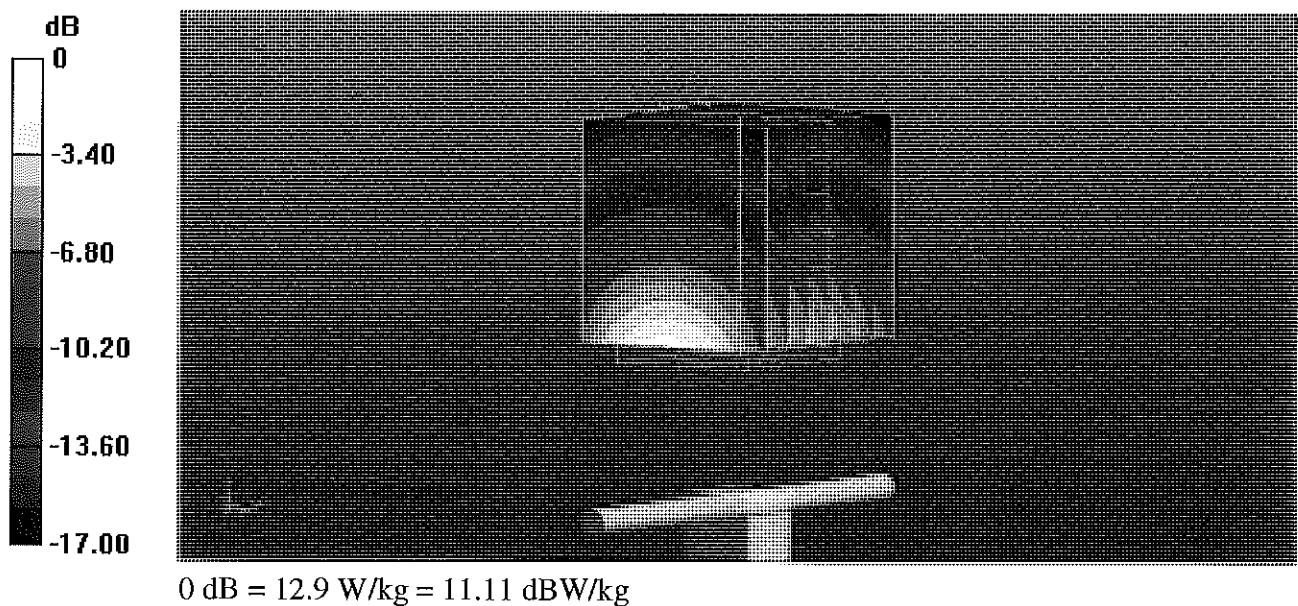
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 99.22 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 18.3 W/kg

SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.34 W/kg

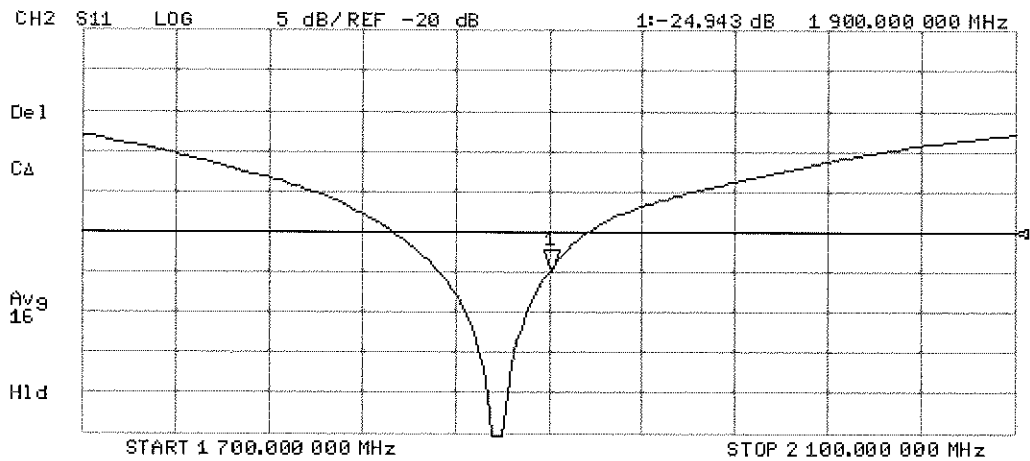
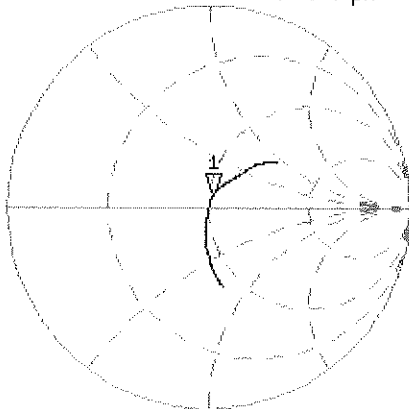
Maximum value of SAR (measured) = 12.9 W/kg



Impedance Measurement Plot for Head TSL

14 Jul 2015 09:20:59
[CH1] S11 1 U FS 1: 51.447 Ω 5.5664 Ω 466.27 μ H 1 900.000 000 MHz

*
De1
CA
Avg
16
H1d



DASY5 Validation Report for Body TSL

Date: 14.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d149

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

Medium parameters used: $f = 1900$ MHz; $\sigma = 1.54$ S/m; $\epsilon_r = 52.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.65, 4.65, 4.65); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

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

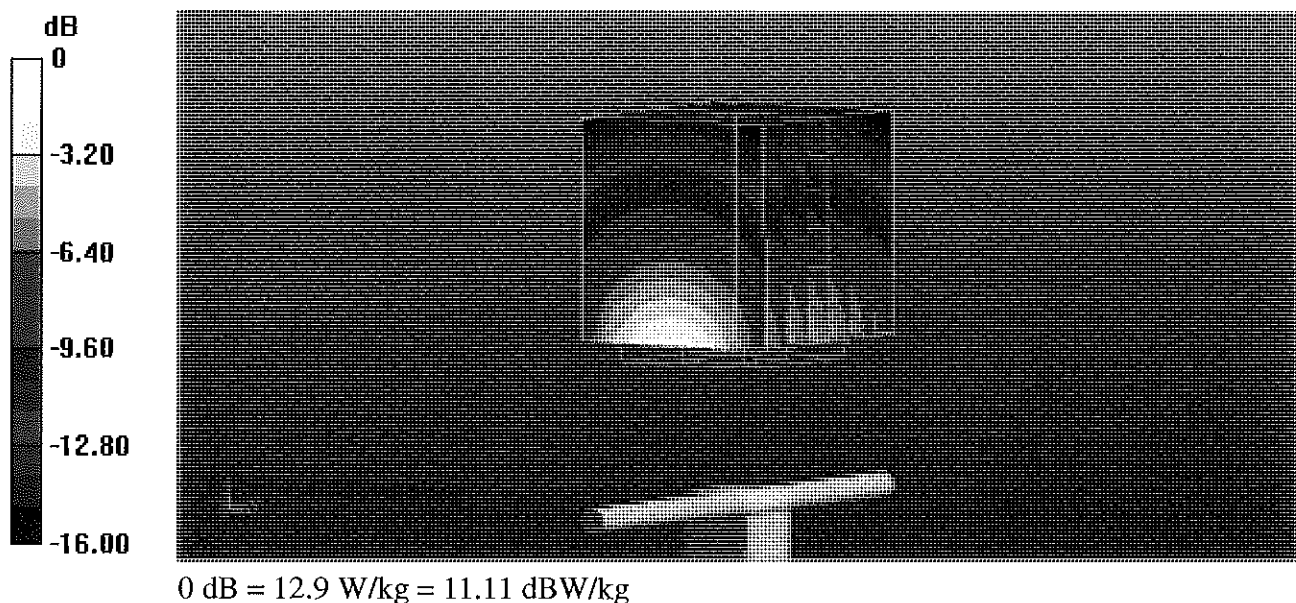
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 95.96 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 17.2 W/kg

SAR(1 g) = 10.2 W/kg; SAR(10 g) = 5.49 W/kg

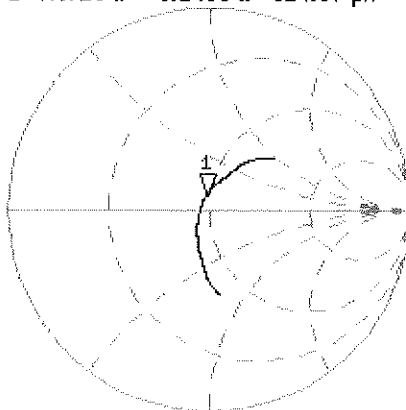
Maximum value of SAR (measured) = 12.9 W/kg



Impedance Measurement Plot for Body TSL

14 Jul 2015 09:20:09
 [CH1] S11 1 U FS 1: 47.723 Ω 6.1406 Ω 514.37 μ H 1 900.000 000 MHz

*
 De1
 CA



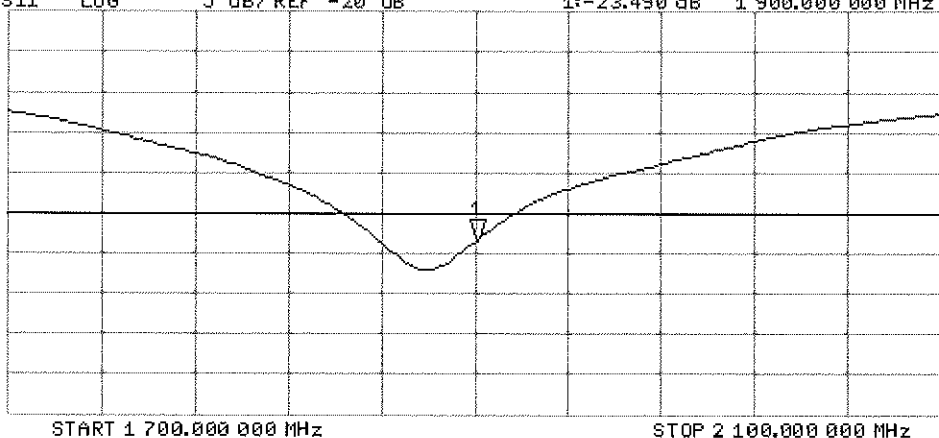
Avg
 16
 H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-23.490 dB 1 900.000 000 MHz

De1
 CA

Avg
 16

H1d





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Client **PC Test**

Certificate No: **D2450V2-882_Feb15**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:882**

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

PNV
 3/6/15

Calibration date: **February 18, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe ES3DV3	SN: 3205	30-Dec-14 (No. ES3-3205_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by: **Name** Michael Weber **Function** Laboratory Technician

Signature

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

Issued: February 18, 2015

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	38.2 $\pm$ 6 %	1.87 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.4 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	52.3 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.16 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.3 W/kg $\pm$ 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 $\pm$ 0.2) °C	51.7 $\pm$ 6 %	2.04 mho/m $\pm$ 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	13.0 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	50.7 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.97 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.5 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	52.8 Ω - 0.2 j Ω
Return Loss	- 31.2 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.4 Ω + 1.9 j Ω
Return Loss	- 34.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.156 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	October 06, 2011

DASY5 Validation Report for Head TSL

Date: 18.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:882

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.87$ S/m; $\epsilon_r = 38.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.54, 4.54, 4.54); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Head Tissue - ES Probe/Pin=250 mW, d=10mm/Zoom Scan

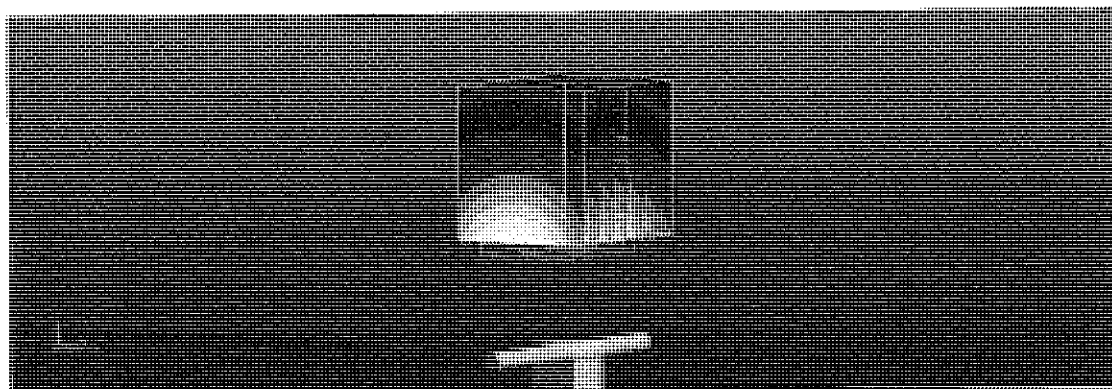
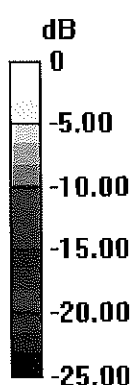
(7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 99.95 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 27.9 W/kg

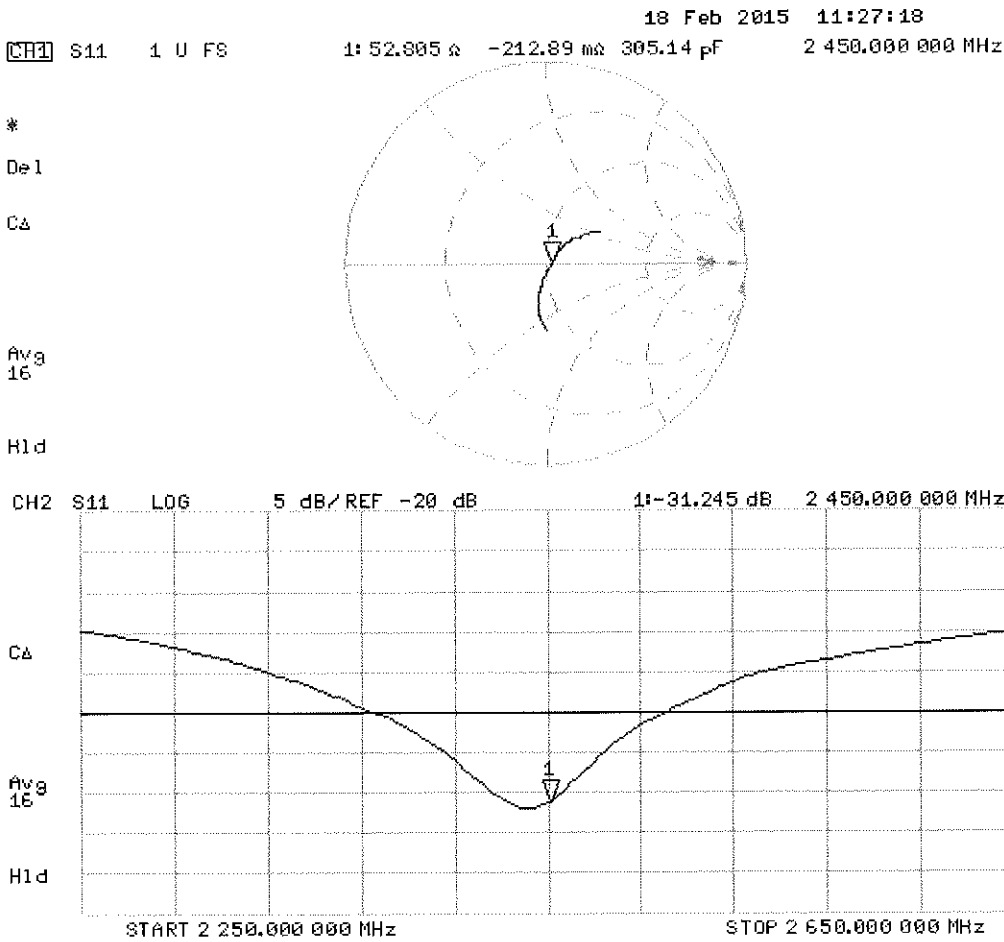
SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.16 W/kg

Maximum value of SAR (measured) = 17.3 W/kg



0 dB = 17.3 W/kg = 12.38 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 18.02.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:882

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

Medium parameters used: $f = 2450$ MHz; $\sigma = 2.04$ S/m; $\epsilon_r = 51.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ES3DV3 - SN3205; ConvF(4.32, 4.32, 4.32); Calibrated: 30.12.2014;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Body Tissue - ES Probe/Pin=250 mW, d=10mm/Zoom Scan

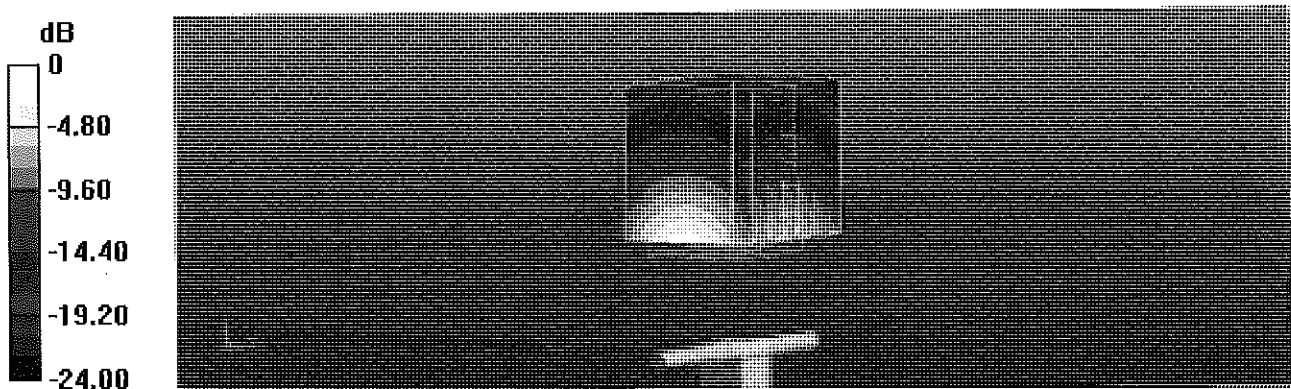
(7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 94.16 V/m; Power Drift = 0.02 dB

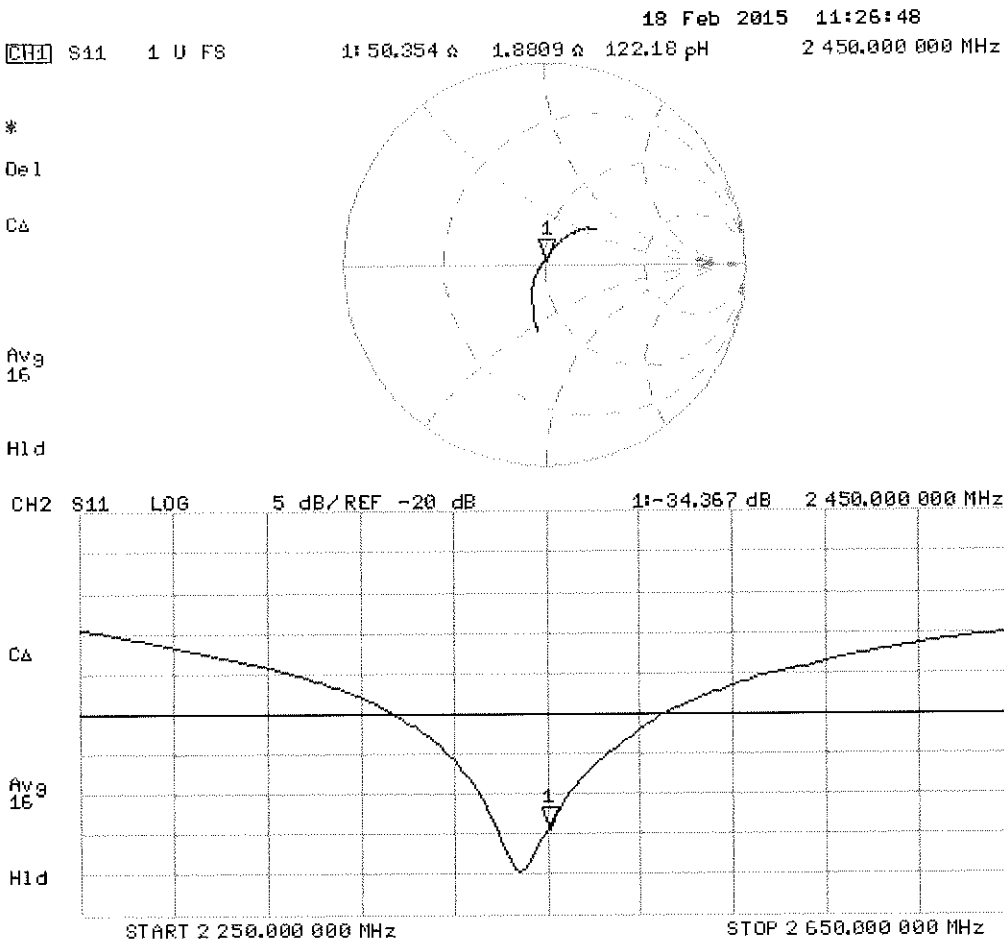
Peak SAR (extrapolated) = 27.2 W/kg

SAR(1 g) = 13 W/kg; SAR(10 g) = 5.97 W/kg

Maximum value of SAR (measured) = 17.0 W/kg



Impedance Measurement Plot for Body TSL





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

Accreditation No.: **SCS 108**

Client **PC Test**

Certificate No: **D5GHzV2-1191_Sep14**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1191**

Calibration procedure(s) **QA CAL-22.v2**
Calibration procedure for dipole validation kits between 3-6 GHz

CC
11/14

Calibration date: **September 25, 2014**

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

All calibrations have been conducted in the closed laboratory facility; environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	US37292783	09-Oct-13 (No. 217-01827)	Oct-14
Power sensor HP 8481A	MY41092317	09-Oct-13 (No. 217-01828)	Oct-14
Reference 20 dB Attenuator	SN: 5058 (20k)	03-Apr-14 (No. 217-01918)	Apr-15
Type-N mismatch combination	SN: 5047.2 / 06327	03-Apr-14 (No. 217-01921)	Apr-15
Reference Probe EX3DV4	SN: 3503	30-Dec-13 (No. EX3-3503_Dec13)	Dec-14
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-13)	In house check: Oct-14

Calibrated by: **Claudio Leubler** **Laboratory Technician**

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

Signature

Issued: September 25, 2014

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



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) IEC 62209-2, "Evaluation of Human Exposure to Radio Frequency Fields from Handheld and Body-Mounted Wireless Communication Devices in the Frequency Range of 30 MHz to 6 GHz: Human models, Instrumentation, and Procedures"; Part 2: "Procedure to determine the Specific Absorption Rate (SAR) for including accessories and multiple transmitters", March 2010
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"
- c) 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

Additional Documentation:

- d) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom 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 $\pm$ 1 MHz 5300 MHz $\pm$ 1 MHz 5500 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters 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 $\pm$ 0.2) °C	34.9 $\pm$ 6 %	4.54 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.17 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.1 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.1 W/kg $\pm$ 19.5 % (k=2)

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	34.8 ± 6 %	4.64 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.64 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	85.8 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.47 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.5 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.5 ± 6 %	4.83 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.93 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	88.6 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.54 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	25.2 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	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	34.4 ± 6 %	4.93 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.76 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	86.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.49 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.7 W/kg ± 19.5 % (k=2)

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	34.1 ± 6 %	5.14 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.30 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.1 ± 6 %	5.40 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.84 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.18 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.6 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.9 ± 6 %	5.53 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.05 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	79.9 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.25 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	22.3 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.6 ± 6 %	5.79 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.37 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	83.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.0 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.4 ± 6 %	5.93 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	8.48 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	84.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.35 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.1 ± 6 %	6.21 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.86 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	78.0 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	51.8 Ω - 9.9 j Ω
Return Loss	- 20.1 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	54.5 Ω - 1.5 j Ω
Return Loss	- 26.8 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	49.6 Ω - 2.0 j Ω
Return Loss	- 33.9 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	56.5 Ω - 4.4 j Ω
Return Loss	- 22.7 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.6 Ω + 4.4 j Ω
Return Loss	- 22.6 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.9 Ω - 8.1 j Ω
Return Loss	- 21.8 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	54.5 Ω + 0.1 j Ω
Return Loss	- 27.3 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	50.2 Ω - 0.6 j Ω
Return Loss	- 43.8 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	57.5 Ω - 3.2 j Ω
Return Loss	- 22.4 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	57.2 Ω + 5.2 j Ω
Return Loss	- 21.7 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 ns
----------------------------------	----------

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

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

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

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	April 01, 2014

DASY5 Validation Report for Head TSL

Date: 25.09.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1191

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 4.54$ S/m; $\epsilon_r = 34.9$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5300$ MHz; $\sigma = 4.64$ S/m; $\epsilon_r = 34.8$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5500$ MHz; $\sigma = 4.83$ S/m; $\epsilon_r = 34.5$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5600$ MHz; $\sigma = 4.93$ S/m; $\epsilon_r = 34.4$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5800$ MHz; $\sigma = 5.14$ S/m; $\epsilon_r = 34.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.52, 5.52, 5.52); Calibrated: 30.12.2013, ConvF(5.2, 5.2, 5.2); Calibrated: 30.12.2013, ConvF(5.01, 5.01, 5.01); Calibrated: 30.12.2013, ConvF(4.86, 4.86, 4.86); Calibrated: 30.12.2013, ConvF(4.91, 4.91, 4.91); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Head Tissue/Pin=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 = 65.20 V/m; Power Drift = 0.04 dB

Peak SAR (extrapolated) = 30.0 W/kg

SAR(1 g) = 8.17 W/kg; SAR(10 g) = 2.33 W/kg

Maximum value of SAR (measured) = 18.5 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 = 65.90 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 32.7 W/kg

SAR(1 g) = 8.64 W/kg; SAR(10 g) = 2.47 W/kg

Maximum value of SAR (measured) = 19.8 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 65.91 V/m; Power Drift = 0.09 dB

Peak SAR (extrapolated) = 35.3 W/kg

SAR(1 g) = 8.93 W/kg; SAR(10 g) = 2.54 W/kg

Maximum value of SAR (measured) = 20.9 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 = 65.29 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 34.8 W/kg

SAR(1 g) = 8.76 W/kg; SAR(10 g) = 2.49 W/kg

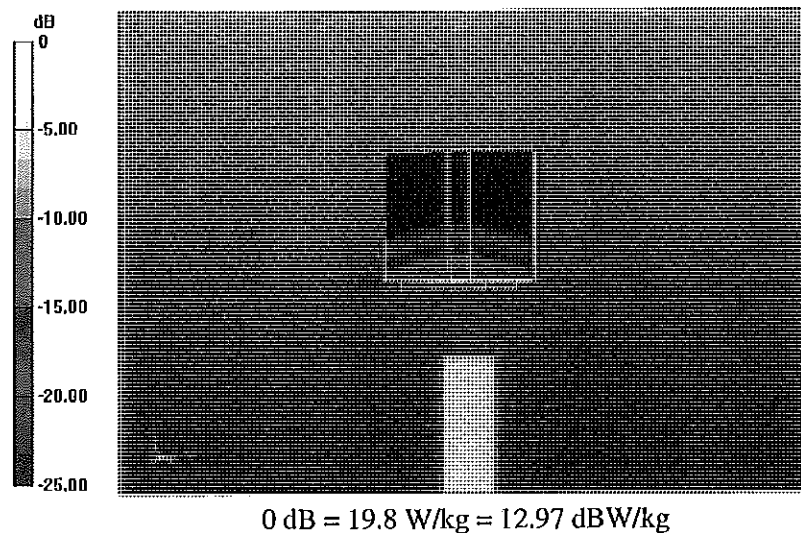
Maximum value of SAR (measured) = 20.7 W/kg

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 = 62.74 V/m; Power Drift = 0.06 dB

Peak SAR (extrapolated) = 34.4 W/kg

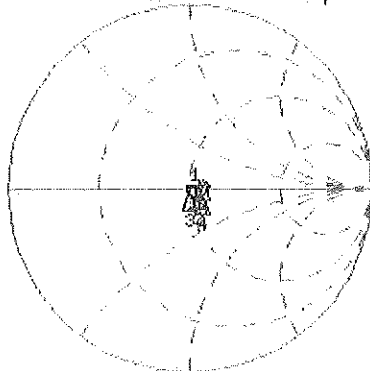
SAR(1 g) = 8.3 W/kg; SAR(10 g) = 2.35 W/kg



Impedance Measurement Plot for Head TSL

25 Sep 2014 11:07:52
 [CH1] S11 1 U FS 1: 51.911 Ω -9.9180 Ω 3.0060 pF 5 200.000 000 MHz

 Del
 Cor
 Avg
 0
 H1d

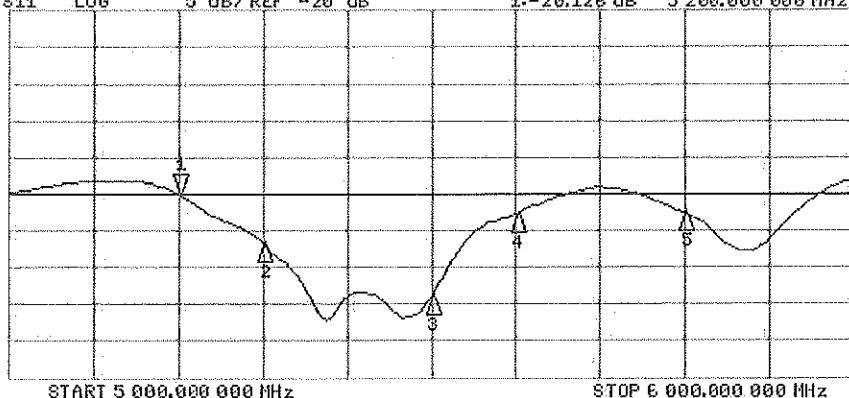


CH1 Markers

2: 54.518 Ω
 -1.5078 Ω
 5.30000 GHz
 3: 49.566 Ω
 -1.9707 Ω
 5.50000 GHz
 4: 56.516 Ω
 -4.3633 Ω
 5.60000 GHz
 5: 56.555 Ω
 4.3904 Ω
 5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1:-20.126 dB 5 200.000 000 MHz

Cor
 Avg
 0
 H1d



CH2 Markers

2:-26.825 dB
 5.30000 GHz
 3:-33.878 dB
 5.50000 GHz
 4:-22.660 dB
 5.60000 GHz
 5:-22.611 dB
 5.80000 GHz

DASY5 Validation Report for Body TSL

Date: 24.09.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN:1191

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz

Medium parameters used: $f = 5200$ MHz; $\sigma = 5.4$ S/m; $\epsilon_r = 47.1$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5300$ MHz; $\sigma = 5.53$ S/m; $\epsilon_r = 46.9$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5500$ MHz; $\sigma = 5.79$ S/m; $\epsilon_r = 46.6$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5600$ MHz; $\sigma = 5.93$ S/m; $\epsilon_r = 46.4$; $\rho = 1000$ kg/m³

Medium parameters used: $f = 5800$ MHz; $\sigma = 6.21$ S/m; $\epsilon_r = 46.1$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.01, 5.01, 5.01); Calibrated: 30.12.2013, ConvF(4.76, 4.76, 4.76); Calibrated: 30.12.2013, ConvF(4.52, 4.52, 4.52); Calibrated: 30.12.2013, ConvF(4.3, 4.3, 4.3); Calibrated: 30.12.2013, ConvF(4.47, 4.47, 4.47); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 18.08.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Body Tissue/Pin=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 = 60.46 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 30.7 W/kg

SAR(1 g) = 7.84 W/kg; SAR(10 g) = 2.18 W/kg

Maximum value of SAR (measured) = 18.5 W/kg

Dipole Calibration for Body 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 = 60.42 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 32.1 W/kg

SAR(1 g) = 8.05 W/kg; SAR(10 g) = 2.25 W/kg

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

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 60.44 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 35.8 W/kg

SAR(1 g) = 8.37 W/kg; SAR(10 g) = 2.32 W/kg

Maximum value of SAR (measured) = 20.4 W/kg

Dipole Calibration for Body 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 = 60.44 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 37.0 W/kg

SAR(1 g) = 8.48 W/kg; SAR(10 g) = 2.35 W/kg

Maximum value of SAR (measured) = 20.9 W/kg

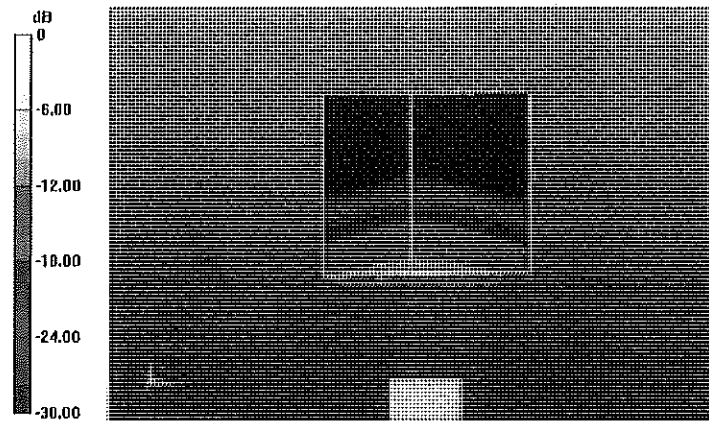
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 56.69 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 36.4 W/kg

SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.17 W/kg

Maximum value of SAR (measured) = 19.7 W/kg

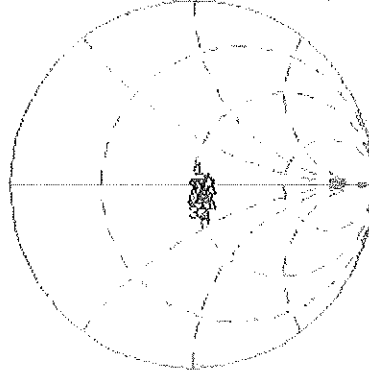


0 dB = 19.7 W/kg = 12.94 dBW/kg

Impedance Measurement Plot for Body TSL

24 Sep 2014 11:05:50
 [CH1] S11 1 U FS 1: 51.867 Ω -8.0566 Ω 3.7989 pF 5 200.000 000 MHz

 Del
 Cor
 Avg
 16
 H1d

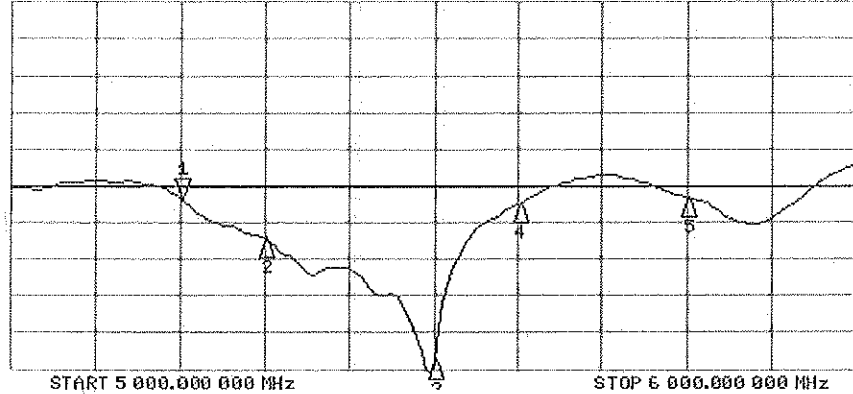


CH1 Markers

2: 54.531 Ω
 0.1015 Ω
 5.30000 GHz
 3: 50.207 Ω
 -613.28 Ω
 5.50000 GHz
 4: 57.480 Ω
 -3.1563 Ω
 5.60000 GHz
 5: 57.150 Ω
 5.1934 Ω
 5.80000 GHz

CH2 S11 LOG 5 dB/REF -20 dB 1: -21.835 dB 5 200.000 000 MHz

Cor
 Avg
 16
 H1d



CH2 Markers

2: -27.251 dB
 5.30000 GHz
 3: -43.776 dB
 5.50000 GHz
 4: -22.442 dB
 5.60000 GHz
 5: -21.682 dB
 5.80000 GHz

APPENDIX D: SAR TISSUE SPECIFICATIONS

Measurement Procedure for Tissue verification:

- 1) The network analyzer and probe system was configured and calibrated.
- 2) The probe was immersed in the tissue. The tissue was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
- 3) The complex admittance with respect to the probe aperture was measured
- 4) The complex relative permittivity ϵ can be calculated from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\epsilon_r\epsilon_0}{[\ln(b/a)]^2} \int_a^b \int_a^b \int_0^\pi \cos\phi' \frac{\exp[-j\omega r(\mu_0\epsilon_r'\epsilon_0)^{1/2}]}{r} d\phi' d\rho' d\rho$$

where Y is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively, $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$, ω is the angular frequency, and $j = \sqrt{-1}$.

Table D-I
Composition of the Tissue Equivalent Matter

Frequency (MHz)	750	750	835	835	1750	1750	1900	1900	2300-2450	2300-2450	5200-5800	5200-5800
Tissue	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Ingredients (% by weight)												
Bactericide	See page 2-3	See page 2	0.1	0.1					See page 4		See page 5	
DGBE					47	31	44.92	29.44		26.7		
HEC			1	1								
NaCl			1.45	0.94	0.4	0.2	0.18	0.39		0.1		
Sucrose			57	44.9								20
Polysorbate (Tween) 80												
Water			40.45	53.06	52.6	68.8	54.9	70.17		73.2		80

FCC ID: ZNFVS990		SAR EVALUATION REPORT		Reviewed by: Quality Manager
Test Dates: 08/10/15 – 08/31/15	DUT Type: Portable Handset			APPENDIX D: Page 1 of 5

2 Composition / Information on ingredients

The Item is composed of the following ingredients:

H ₂ O	Water, 35 – 58%
Sucrose	Sugar, white, refined, 40 – 60%
NaCl	Sodium Chloride, 0 – 6%
Hydroxyethyl-cellulose	Medium Viscosity (CAS# 9004-62-0), <0.3%
Preventol-D7	Preservative: aqueous preparation, (CAS# 55965-84-9), containing 5-chloro-2-methyl-3(2H)-isothiazolone and 2-methyl-3(2H)-isothiazolone, 0.1 – 0.7%
Relevant for safety; Refer to the respective Safety Data Sheet*.	

Figure D-1

Composition of 750 MHz Head and Body Tissue Equivalent Matter

Note: 750MHz liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

Measurement Certificate / Material Test

Item Name	Body Tissue Simulating Liquid (MSL750V2)
Product No.	SL AAM 075 AA (Charge: 150223-3)
Manufacturer	SPEAG

Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

Setup Validation

Validation results were within $\pm 2.5\%$ towards the target values of Methanol.

Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

Test Condition

Ambient	Environment temperatur (22 ± 3)°C and humidity < 70%.
TSL Temperature	22°C
Test Date	25-Feb-15
Operator	IEN

Additional Information

TSL Density	1.212 g/cm ³
TSL Heat-capacity	3.006 kJ/(kg*K)

f [MHz]	Measured			Target		Diff. to Target [%]	
	HP-e'	HP-e''	sigma	eps	sigma	Δ-eps	Δ-sigma
600	57.3	24.76	0.83	56.1	0.95	2.2	-13.2
625	57.1	24.43	0.85	56.0	0.95	1.8	-11.0
650	56.8	24.09	0.87	55.9	0.96	1.5	-8.8
675	56.5	23.80	0.89	55.8	0.96	1.2	-6.7
700	56.2	23.51	0.92	55.7	0.96	0.9	-4.6
725	56.0	23.28	0.94	55.6	0.96	0.6	-2.4
750	55.7	23.06	0.96	55.5	0.96	0.4	-0.1
775	55.5	22.87	0.99	55.4	0.97	0.1	2.1
800	55.2	22.68	1.01	55.3	0.97	-0.2	4.4
825	55.0	22.52	1.03	55.2	0.98	-0.5	5.7
838	54.9	22.44	1.05	55.2	0.98	-0.6	6.3
850	54.8	22.36	1.06	55.2	0.99	-0.7	7.0
875	54.5	22.24	1.08	55.1	1.02	-1.0	6.2
900	54.3	22.12	1.11	55.0	1.05	-1.3	5.5
925	54.1	22.01	1.13	55.0	1.06	-1.6	6.5
950	53.9	21.89	1.16	54.9	1.08	-2.0	7.6
975	53.6	21.81	1.18	54.9	1.09	-2.3	8.8
1000	53.4	21.73	1.21	54.8	1.10	-2.7	10.1

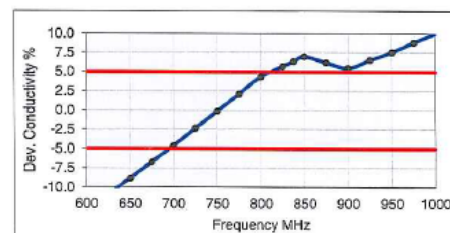
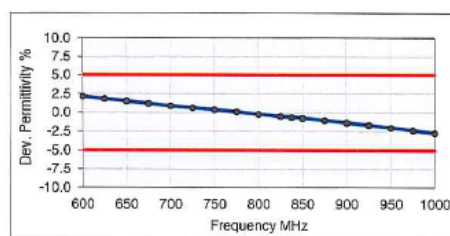


Figure D-2

750MHz Body Tissue Equivalent Matter

FCC ID: ZNFVS990		SAR EVALUATION REPORT		Reviewed by: Quality Manager
Test Dates: 08/10/15 – 08/31/15	DUT Type: Portable Handset			APPENDIX D: Page 2 of 5

Measurement Certificate / Material Test

Item Name **Head Tissue Simulating Liquid (HSL750V2)**
 Product No. SL AAH 075 AA (Charge: 150213-1)
 Manufacturer SPEAG

Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

Setup Validation

Validation results were within $\pm 2.5\%$ towards the target values of Methanol.

Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

Test Condition

Ambient Environment temperatur (22 ± 3)°C and humidity < 70%.
 TSL Temperature 22°C
 Test Date 18-Feb-15
 Operator IEN

Additional Information

TSL Density 1.284 g/cm³
 TSL Heat-capacity 2.701 kJ/(kg*K)

f [MHz]	Measured			Target		Diff.to Target [%]	
	HP-e'	HP-e''	sigma	eps	sigma	Δ-eps	Δ-sigma
600	44.6	22.42	0.75	42.7	0.88	4.5	-15.1
625	44.3	22.20	0.77	42.6	0.88	3.9	-12.7
650	43.9	21.98	0.79	42.5	0.89	3.3	-10.3
675	43.5	21.75	0.82	42.3	0.89	2.8	-8.0
700	43.1	21.53	0.84	42.2	0.89	2.2	-5.7
725	42.8	21.36	0.86	42.1	0.89	1.8	-3.3
750	42.5	21.22	0.89	41.9	0.89	1.3	-0.9
775	42.2	21.06	0.91	41.8	0.90	0.8	1.4
800	41.8	20.90	0.93	41.7	0.90	0.3	3.7
825	41.5	20.77	0.95	41.6	0.91	-0.2	5.1
838	41.4	20.71	0.96	41.5	0.91	-0.4	5.8
850	41.2	20.65	0.98	41.5	0.92	-0.7	6.6
875	40.9	20.53	1.00	41.5	0.94	-1.4	6.0
900	40.6	20.42	1.02	41.5	0.97	-2.1	5.4
925	40.4	20.32	1.05	41.5	0.98	-2.6	6.5
950	40.1	20.22	1.07	41.4	0.99	-3.2	7.5
975	39.8	20.14	1.09	41.4	1.00	-3.8	8.7
1000	39.5	20.05	1.12	41.3	1.01	-4.3	9.9

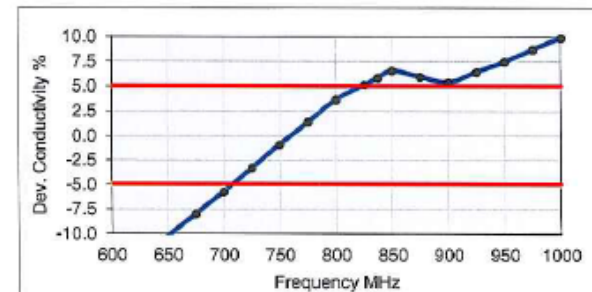
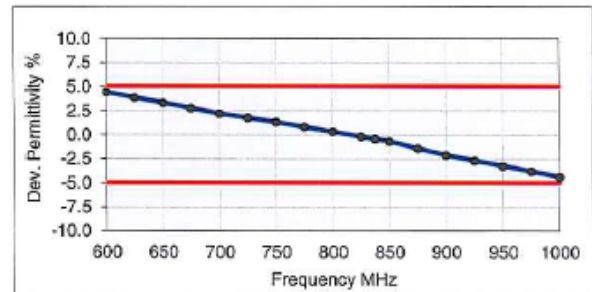


Figure D-3
 750MHz Head Tissue Equivalent Matter

FCC ID: ZNFVS990		SAR EVALUATION REPORT		Reviewed by: Quality Manager
Test Dates: 08/10/15 – 08/31/15	DUT Type: Portable Handset			APPENDIX D: Page 3 of 5

2 Composition / Information on ingredients

The Item is composed of the following ingredients:

H ₂ O	Water, 52 – 75%
C ₈ H ₁₈ O ₃	Diethylene glycol monobutyl ether (DGBE), 25 – 48% (CAS-No. 112-34-5, EC-No. 203-961-6, EC-index-No. 603-096-00-8) Relevant for safety; Refer to the respective Safety Data Sheet*.
NaCl	Sodium Chloride, <1.0%

Figure D-4

Composition of 2.3 – 2.4 GHz Head Tissue Equivalent Matter

Note: 2.4 GHz head liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

Measurement Certificate / Material Test

Item Name	Head Tissue Simulating Liquid (HSL2450V2)
Product No.	SL AAH 245 BA (Charge: 150206-3)
Manufacturer	SPEAG

Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

Setup Validation

Validation results were within $\pm 2.5\%$ towards the target values of Methanol.

Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

Test Condition

Ambient	Environment temperatur (22 ± 3)°C and humidity < 70%.
TSL Temperature	23°C
Test Date	11-Feb-15
Operator	IEN

Additional Information

TSL Density	0.988 g/cm ³
TSL Heat-capacity	3.680 kJ/(kg·K)

f (MHz)	Measured			Target		Diff.to Target [%]	
	HP-e'	HP-e''	sigma	eps	sigma	Δ-eps	Δ-sigma
1900	40.4	11.89	1.26	40.0	1.40	1.0	-10.2
1925	40.3	11.98	1.28	40.0	1.40	0.7	-8.3
1950	40.2	12.07	1.31	40.0	1.40	0.4	-6.4
1975	40.1	12.15	1.34	40.0	1.40	0.2	-4.6
2000	40.0	12.23	1.36	40.0	1.40	-0.1	-2.8
2025	39.9	12.32	1.39	40.0	1.42	-0.2	-2.4
2050	39.8	12.41	1.42	39.9	1.44	-0.3	-2.0
2075	39.7	12.50	1.44	39.9	1.47	-0.4	-1.6
2100	39.6	12.59	1.47	39.8	1.49	-0.5	-1.2
2125	39.5	12.66	1.50	39.8	1.51	-0.7	-0.9
2150	39.4	12.73	1.52	39.7	1.53	-0.8	-0.7
2175	39.3	12.83	1.55	39.7	1.56	-0.9	-0.2
2200	39.2	12.92	1.58	39.6	1.58	-1.1	0.2
2225	39.1	13.00	1.61	39.6	1.60	-1.2	0.6
2250	39.0	13.08	1.64	39.6	1.62	-1.3	0.9
2275	38.9	13.17	1.67	39.5	1.64	-1.5	1.4
2300	38.8	13.26	1.70	39.5	1.67	-1.7	1.8
2325	38.7	13.34	1.73	39.4	1.69	-1.8	2.2
2350	38.6	13.42	1.75	39.4	1.71	-2.0	2.5
2375	38.5	13.50	1.78	39.3	1.73	-2.1	2.9
2400	38.4	13.58	1.81	39.3	1.76	-2.3	3.3
2425	38.3	13.65	1.84	39.2	1.78	-2.4	3.6
2450	38.2	13.73	1.87	39.2	1.80	-2.6	3.9
2475	38.1	13.80	1.90	39.2	1.83	-2.8	4.0
2500	38.0	13.87	1.93	39.1	1.85	-3.0	4.0
2525	37.9	13.90	1.95	39.1	1.88	-3.1	3.8
2550	37.8	13.93	1.98	39.1	1.91	-3.2	3.5
2575	37.7	14.05	2.01	39.0	1.94	-3.5	4.0
2600	37.6	14.17	2.05	39.0	1.96	-3.7	4.4
2625	37.4	14.23	2.08	39.0	1.99	-3.9	4.4
2650	37.3	14.29	2.11	38.9	2.02	-4.1	4.4
2675	37.2	14.37	2.14	38.9	2.05	-4.3	4.6
2700	37.1	14.45	2.17	38.9	2.07	-4.5	4.7

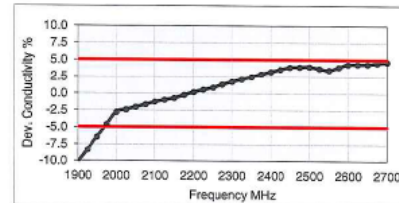
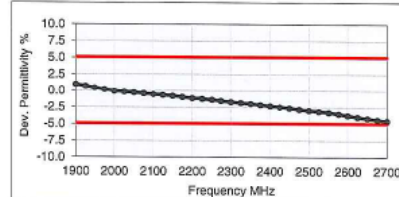


Figure D-5

2.3 – 2.4 GHz Head Tissue Equivalent Matter

FCC ID: ZNFVS990		SAR EVALUATION REPORT		Reviewed by: Quality Manager
Test Dates: 08/10/15 – 08/31/15	DUT Type: Portable Handset	APPENDIX D: Page 4 of 5		

2 Composition / Information on ingredients

The Item is composed of the following ingredients:

Water	50 – 65%
Mineral oil	10 – 30%
Emulsifiers	8 – 25%
Sodium salt	0 – 1.5%

Figure D-6
Composition of 5 GHz Head Tissue Equivalent Matter

Note: 5GHz head liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

Measurement Certificate / Material Test

Item Name	Head Tissue Simulating Liquid (HBBL3500-5800V5)
Product No.	SL AAH 502 AE (Charge: 141104-1)
Manufacturer	SPEAG

Measurement Method

TSL dielectric parameters measured using calibrated OCP probe.

Setup Validation

Validation results were within $\pm 2.5\%$ towards the target values of Methanol.

Target Parameters

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

Test Condition

Ambient	Environment temperatur (22 ± 3)°C and humidity < 70%.
TSL Temperature	22°C
Test Date	25-Feb-15
Operator	IEH

Additional Information

TSL Density	0.985 g/cm ³
TSL Heat-capacity	3.383 kJ/(kg*K)

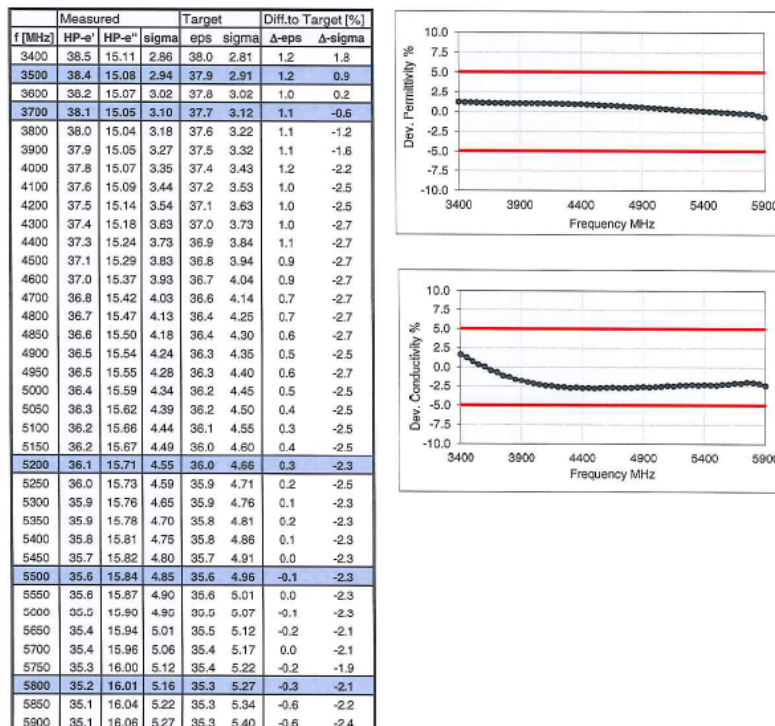


Figure D-7
5GHz Head Tissue Equivalent Matter

FCC ID: ZNFVS990		SAR EVALUATION REPORT		Reviewed by: Quality Manager
Test Dates: 08/10/15 – 08/31/15	DUT Type: Portable Handset			APPENDIX D: Page 5 of 5

APPENDIX E: SAR SYSTEM VALIDATION

Per FCC KDB 865664 D02v01, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01 v01 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

Table E-I
SAR System Validation Summary – 1g

SAR SYSTEM #	FREQ. [MHz]	DATE	PROBE SN	PROBE TYPE	PROBE CAL. POINT	COND.	PERM.	CW VALIDATION			MOD. VALIDATION		
						(σ)	(τ)	SENSITIVITY	PROBE LINEARITY	PROBE ISOTROPY	MOD. TYPE	DUTY FACTOR	PAR
H	750	7/23/2015	3263	ES3DV3	750 Head	0.890	42.151	PASS	PASS	PASS	N/A	N/A	N/A
G	835	5/21/2015	3318	ES3DV3	835 Head	0.894	41.400	PASS	PASS	PASS	GMSK	PASS	N/A
B	1750	1/4/2015	3334	ES3DV3	1750 Head	1.369	39.910	PASS	PASS	PASS	N/A	N/A	N/A
J	1900	5/25/2015	3319	ES3DV3	1900 Head	1.447	39.423	PASS	PASS	PASS	GMSK	PASS	N/A
E	2450	11/5/2014	3332	ES3DV3	2450 Head	1.868	39.670	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
E	2600	11/5/2014	3332	ES3DV3	2600 Head	2.042	39.070	PASS	PASS	PASS	TDD	PASS	N/A
D	5300	5/21/2015	7357	EX3DV4	5300 Head	4.592	36.469	PASS	PASS	PASS	OFDM	N/A	PASS
D	5600	5/21/2015	7357	EX3DV4	5600 Head	4.913	36.055	PASS	PASS	PASS	OFDM	N/A	PASS
D	5800	5/21/2015	7357	EX3DV4	5800 Head	5.109	35.781	PASS	PASS	PASS	OFDM	N/A	PASS
G	750	4/28/2015	3318	ES3DV3	750 Body	0.963	53.510	PASS	PASS	PASS	N/A	N/A	N/A
G	835	5/26/2015	3318	ES3DV3	835 Body	1.018	53.930	PASS	PASS	PASS	GMSK	PASS	N/A
I	835	5/30/2015	3213	ES3DV3	835 Body	0.987	53.378	PASS	PASS	PASS	GMSK	PASS	N/A
H	1750	7/15/2015	3263	ES3DV3	1750 Body	1.471	51.582	PASS	PASS	PASS	N/A	N/A	N/A
K	1900	10/15/2014	3288	ES3DV3	1900 Body	1.532	50.910	PASS	PASS	PASS	GMSK	PASS	N/A
E	2450	11/3/2014	3332	ES3DV3	2450 Body	1.996	52.210	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
G	2450	4/9/2015	3318	ES3DV3	2450 Body	1.938	52.340	PASS	PASS	PASS	OFDM/TDD	PASS	PASS
G	2600	4/9/2015	3318	ES3DV3	2600 Body	2.140	51.790	PASS	PASS	PASS	TDD	PASS	N/A
A	5300	2/19/2015	3914	EX3DV4	5300 Body	5.181	47.440	PASS	PASS	PASS	OFDM	N/A	PASS
A	5600	2/19/2015	3914	EX3DV4	5600 Body	5.607	46.700	PASS	PASS	PASS	OFDM	N/A	PASS
A	5800	2/19/2015	3914	EX3DV4	5800 Body	5.942	46.310	PASS	PASS	PASS	OFDM	N/A	PASS

Table E-II
SAR System Validation Summary – 10g

SAR SYSTEM #	FREQ. [MHz]	DATE	PROBE SN	PROBE TYPE	PROBE CAL. POINT		COND.		PERM.	CW VALIDATION			MOD. VALIDATION		
							(σ)	(τ)	SENSITIVITY	PROBE LINEARITY	PROBE ISOTROPY	MOD. TYPE	DUTY FACTOR	PAR	
A	5300	2/19/2015	3914	EX3DV4	5300	Body	5.181	47.440	PASS	PASS	PASS	OFDM	N/A	PASS	
A	5600	2/19/2015	3914	EX3DV4	5600	Body	5.607	46.700	PASS	PASS	PASS	OFDM	N/A	PASS	

NOTE: While the probes have been calibrated for both CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (>5 dB), such as OFDM according to KDB 865664.

FCC ID: ZNFVS990		SAR EVALUATION REPORT		Reviewed by: Quality Manager
Test Dates: 08/10/15 – 08/31/15	DUT Type: Portable Handset	APPENDIX E: Page 1 of 1		