



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

Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 0108**

Client **UL CCS USA**

Certificate No: **D2300V2-1002_Mar17**

CALIBRATION CERTIFICATE

Object **D2300V2 - SN:1002**

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

Calibration date: **March 10, 2017**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-----------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 05-Apr-16 (No. 217-02292) | Apr-17 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 05-Apr-16 (No. 217-02295) | Apr-17 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-16 (No. EX3-7349_Dec16) | Dec-17 |
| DAE4 | SN: 601 | 04-Jan-17 (No. DAE4-601_Jan17) | Jan-18 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-16) | In house check: Oct-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

| Calibrated by: | Name | Function | Signature |
|----------------|---------------|-----------------------|-----------|
| | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

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

Issued: March 14, 2017



Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

| | | |
|-------------------------------------|------------------------|-------------|
| DASY Version | DASY5 | V52.8.8 |
| Extrapolation | Advanced Extrapolation | |
| Phantom | Modular Flat Phantom | |
| Distance Dipole Center - TSL | 10 mm | with Spacer |
| Zoom Scan Resolution | dx, dy, dz = 5 mm | |
| Frequency | 2300 MHz ± 1 MHz | |

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 39.5 | 1.67 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 38.4 ± 6 % | 1.71 mho/m ± 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 | 12.6 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 49.5 W/kg ± 17.0 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR measured | 250 mW input power | 5.97 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 23.6 W/kg ± 16.5 % (k=2) |

Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|-----------------|--------------|------------------|
| Nominal Body TSL parameters | 22.0 °C | 52.9 | 1.81 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 53.2 ± 6 % | 1.85 mho/m ± 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 | 12.1 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 47.9 W/kg ± 17.0 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Body TSL | condition | |
| SAR measured | 250 mW input power | 5.80 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 23.1 W/kg ± 16.5 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 48.3 Ω - 2.7 $j\Omega$ |
| Return Loss | - 29.9 dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 44.4 Ω - 2.0 $j\Omega$ |
| Return Loss | - 24.0 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.165 ns |
|----------------------------------|----------|

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

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

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

Additional EUT Data

| | |
|-----------------|-------------------|
| Manufactured by | SPEAG |
| Manufactured on | December 23, 2006 |

DASY5 Validation Report for Head TSL

Date: 10.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1002

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used: $f = 2300 \text{ MHz}$; $\sigma = 1.71 \text{ S/m}$; $\epsilon_r = 38.4$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.99, 7.99, 7.99); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

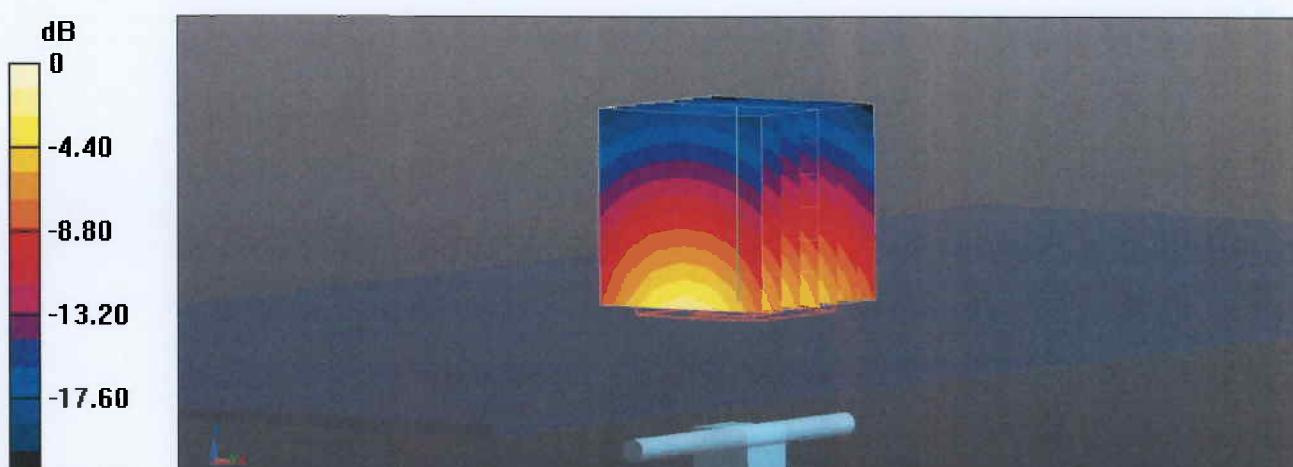
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 115.1 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 25.0 W/kg

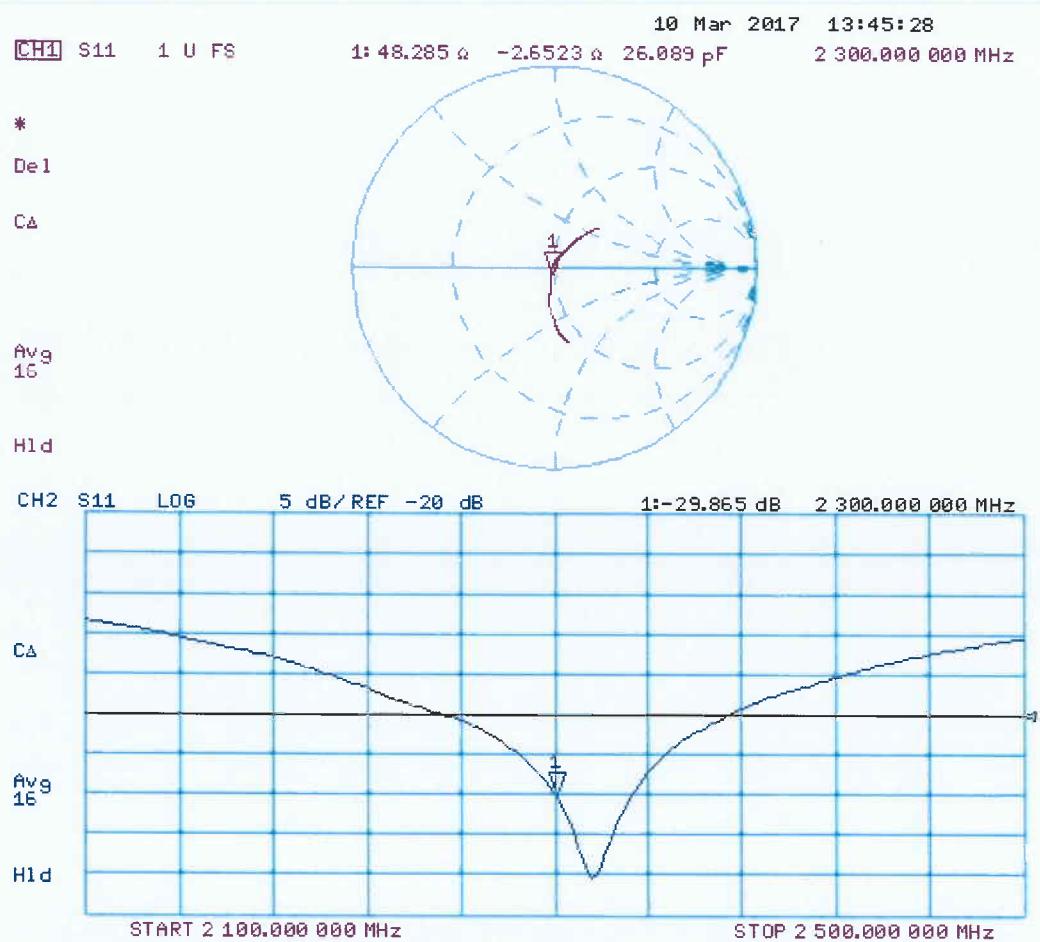
SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.97 W/kg

Maximum value of SAR (measured) = 20.3 W/kg



0 dB = 20.3 W/kg = 13.07 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 10.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2300 MHz; Type: D2300V2; Serial: D2300V2 - SN:1002

Communication System: UID 0 - CW; Frequency: 2300 MHz

Medium parameters used: $f = 2300 \text{ MHz}$; $\sigma = 1.85 \text{ S/m}$; $\epsilon_r = 53.2$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

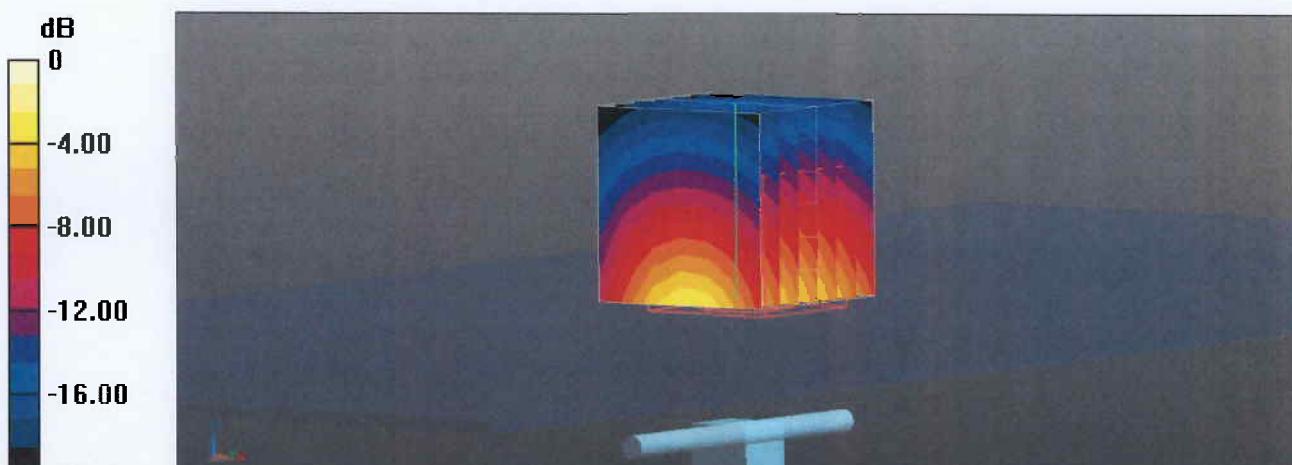
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 106.7 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 23.3 W/kg

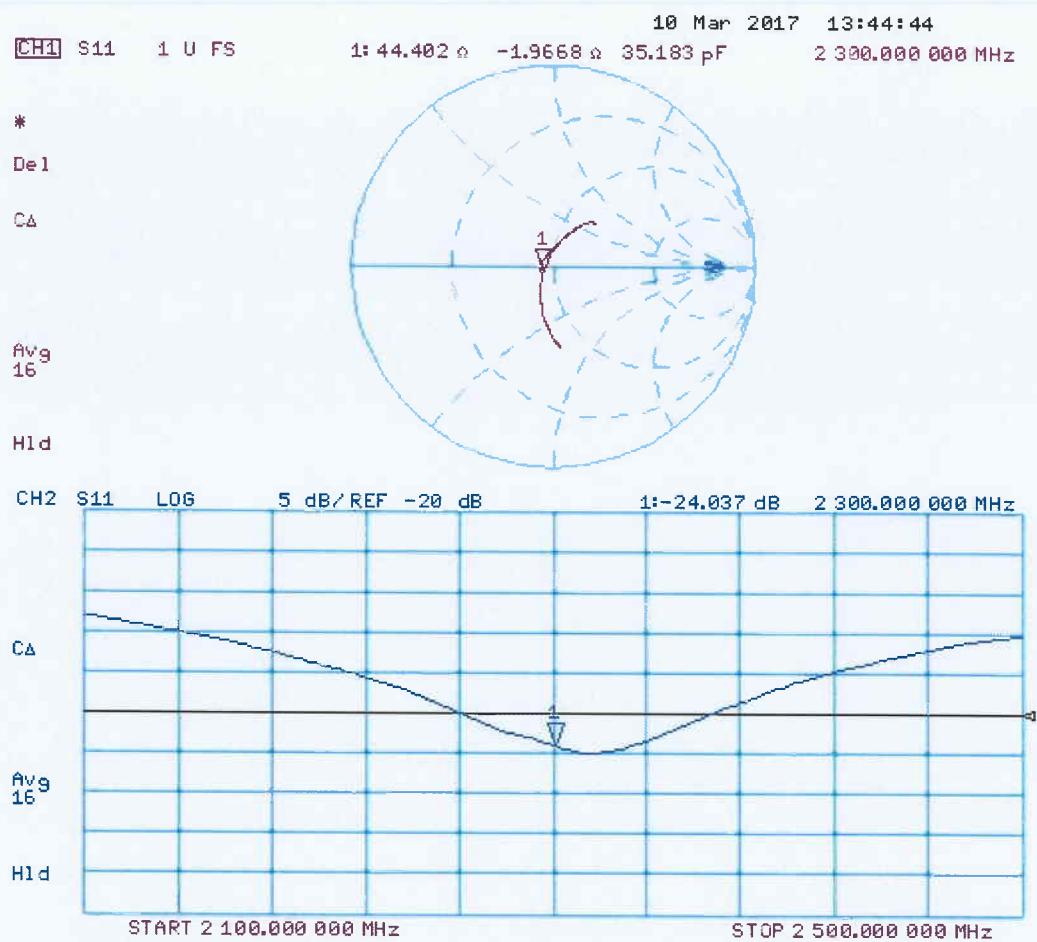
SAR(1 g) = 12.1 W/kg; SAR(10 g) = 5.8 W/kg

Maximum value of SAR (measured) = 18.9 W/kg



$$0 \text{ dB} = 18.9 \text{ W/kg} = 12.76 \text{ dBW/kg}$$

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

Client **UL CCS USA**

Accreditation No.: **SCS 0108**

Certificate No: **D2450V2-899_Mar17**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:899**

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

Calibration date: **March 10, 2017**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-----------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 05-Apr-16 (No. 217-02292) | Apr-17 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 05-Apr-16 (No. 217-02295) | Apr-17 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-16 (No. EX3-7349_Dec16) | Dec-17 |
| DAE4 | SN: 601 | 04-Jan-17 (No. DAE4-601_Jan17) | Jan-18 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-16) | In house check: Oct-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

| Calibrated by: | Name | Function | Signature |
|----------------|---------------|-----------------------|-----------|
| | Leif Klysner | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

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

Issued: March 14, 2017



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:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

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

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|--------------------|---------------------|---------------------|
| Nominal Head TSL parameters | 22.0 °C | 39.2 | 1.80 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 37.8 ± 6 % | 1.87 mho/m ± 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 | 13.5 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 52.6 W/kg ± 17.0 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR measured | 250 mW input power | 6.25 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.6 W/kg ± 16.5 % (k=2) |

Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|--------------------|---------------------|---------------------|
| Nominal Body TSL parameters | 22.0 °C | 52.7 | 1.95 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 53.2 ± 6 % | 2.03 mho/m ± 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 | 12.8 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 50.3 W/kg ± 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 | 23.7 W/kg ± 16.5 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $54.3 \Omega + 7.9 j\Omega$ |
| Return Loss | - 21.3 dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $50.5 \Omega + 9.5 j\Omega$ |
| Return Loss | - 20.6 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.161 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 | June 19, 2012 |

DASY5 Validation Report for Head TSL

Date: 10.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:899

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

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

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.72, 7.72, 7.72); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

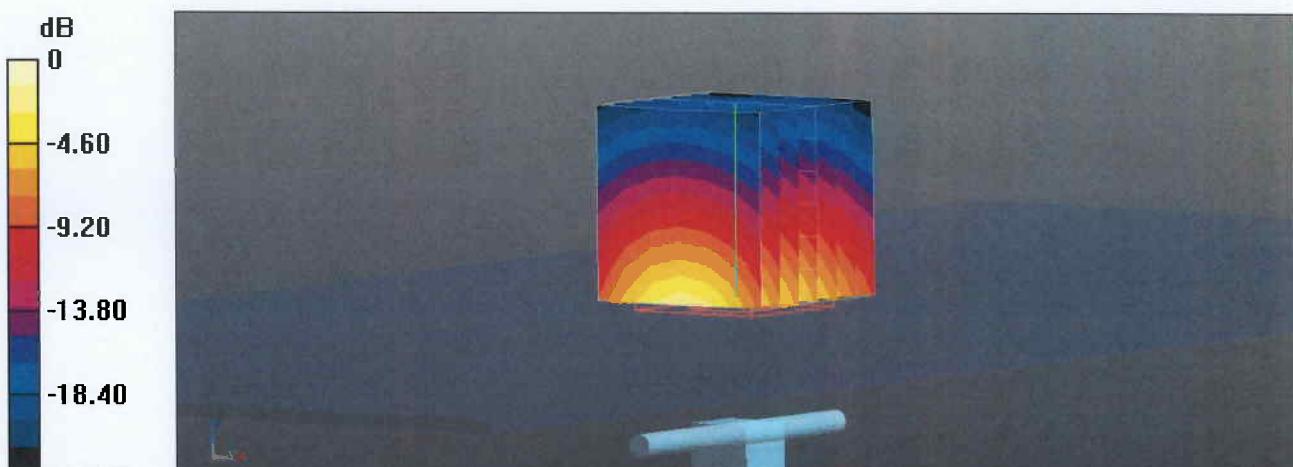
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 116.1 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 27.6 W/kg

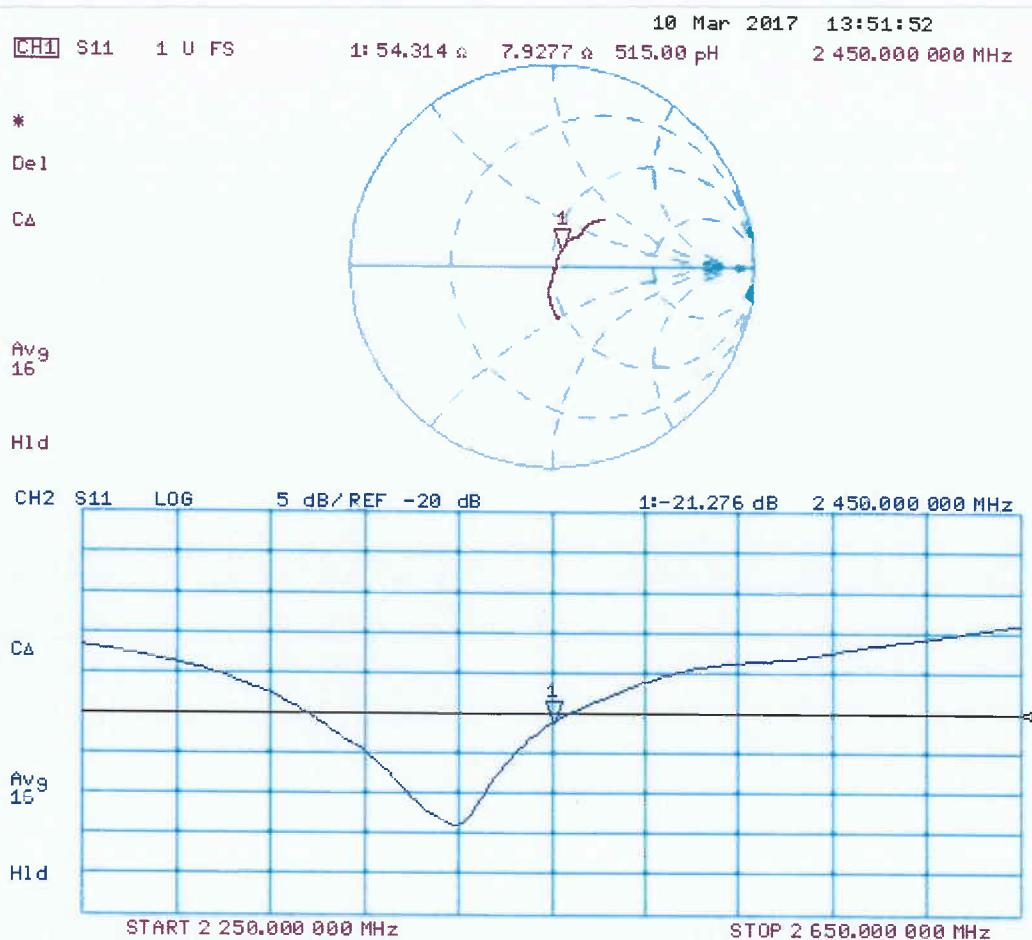
SAR(1 g) = 13.5 W/kg; SAR(10 g) = 6.25 W/kg

Maximum value of SAR (measured) = 22.3 W/kg



$$0 \text{ dB} = 22.3 \text{ W/kg} = 13.48 \text{ dBW/kg}$$

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 10.03.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:899

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

Medium parameters used: $f = 2450 \text{ MHz}$; $\sigma = 2.03 \text{ S/m}$; $\epsilon_r = 53.2$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 04.01.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

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

Reference Value = 105.8 V/m; Power Drift = -0.08 dB

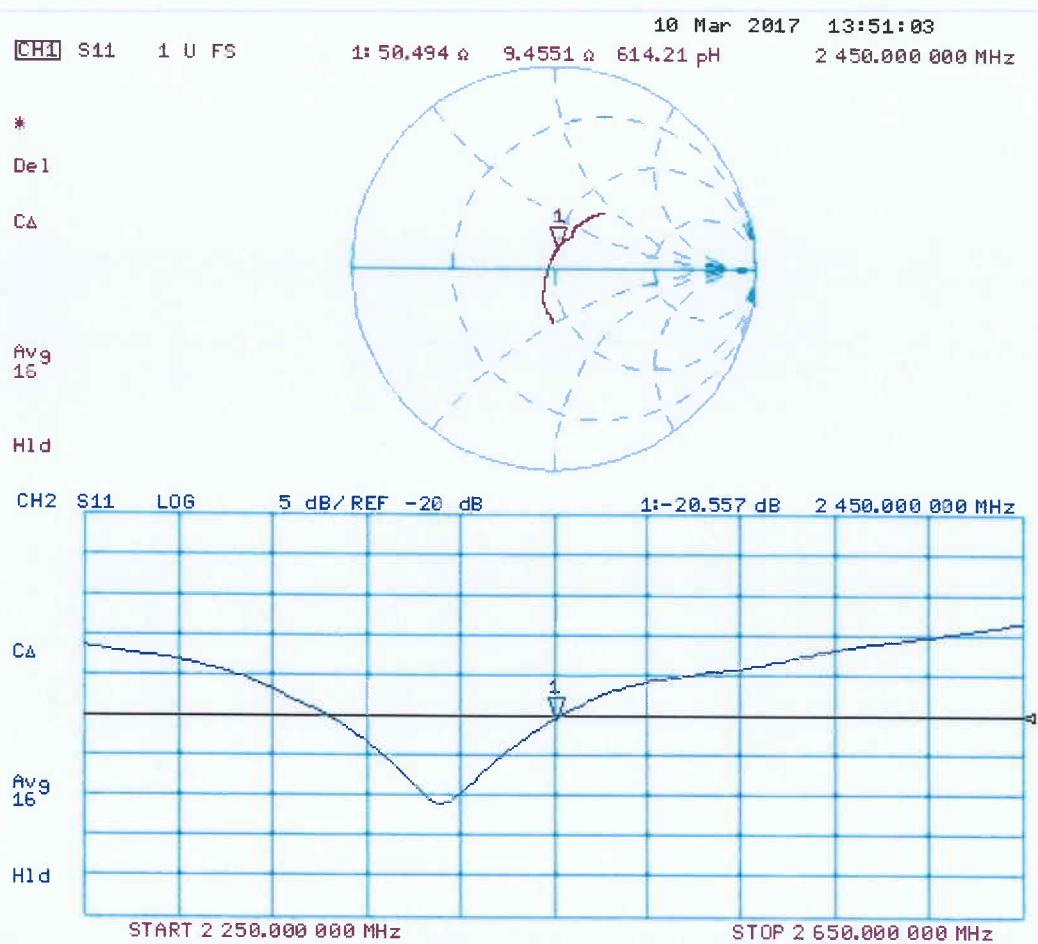
Peak SAR (extrapolated) = 25.3 W/kg

SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.97 W/kg

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



Impedance Measurement Plot for Body TSL





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

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 **UL CCS USA**

Certificate No: **D2450V2-706_May17**

CALIBRATION CERTIFICATE

Object **D2450V2 - SN:706**

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

Calibration date: **May 09, 2017**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-----------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 04-Apr-17 (No. 217-02521/02522) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-17 (No. 217-02521) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-17 (No. 217-02522) | Apr-18 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 07-Apr-17 (No. 217-02528) | Apr-18 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 07-Apr-17 (No. 217-02529) | Apr-18 |
| Reference Probe EX3DV4 | SN: 7349 | 31-Dec-16 (No. EX3-7349_Dec16) | Dec-17 |
| DAE4 | SN: 601 | 28-Mar-17 (No. DAE4-601_Mar17) | Mar-18 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-15 (in house check Oct-16) | In house check: Oct-18 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-16) | In house check: Oct-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-16) | In house check: Oct-17 |

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

Signature

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

Issued: May 11, 2017

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

Calibration Laboratory of

Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland



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

Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: SCS 0108

Glossary:

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

Calibration is Performed According to the Following Standards:

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

| | | |
|-------------------------------------|------------------------|-------------|
| DASY Version | DASY5 | V52.10.0 |
| Extrapolation | Advanced Extrapolation | |
| Phantom | Modular Flat Phantom | |
| Distance Dipole Center - TSL | 10 mm | with Spacer |
| Zoom Scan Resolution | dx, dy, dz = 5 mm | |
| Frequency | 2450 MHz ± 1 MHz | |

Head TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|-----------------|--------------|------------------|
| Nominal Head TSL parameters | 22.0 °C | 39.2 | 1.80 mho/m |
| Measured Head TSL parameters | (22.0 ± 0.2) °C | 37.9 ± 6 % | 1.88 mho/m ± 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 | 52.1 W/kg ± 17.0 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR measured | 250 mW input power | 6.20 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.4 W/kg ± 16.5 % (k=2) |

Body TSL parameters

The following parameters and calculations were applied.

| | Temperature | Permittivity | Conductivity |
|--|-----------------|--------------|------------------|
| Nominal Body TSL parameters | 22.0 °C | 52.7 | 1.95 mho/m |
| Measured Body TSL parameters | (22.0 ± 0.2) °C | 52.4 ± 6 % | 2.03 mho/m ± 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 | 12.9 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 50.6 W/kg ± 17.0 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Body TSL | condition | |
| SAR measured | 250 mW input power | 6.01 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 23.8 W/kg ± 16.5 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

| | |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $52.4 \Omega + 5.1 j\Omega$ |
| Return Loss | - 25.2 dB |

Antenna Parameters with Body TSL

| | |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $47.1 \Omega + 6.2 j\Omega$ |
| Return Loss | - 23.1 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.144 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 | May 28, 2002 |

DASY5 Validation Report for Head TSL

Date: 09.05.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:706

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

Medium parameters used: $f = 2450 \text{ MHz}$; $\sigma = 1.88 \text{ S/m}$; $\epsilon_r = 37.9$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.72, 7.72, 7.72); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1442); SEMCAD X 14.6.10(7413)

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

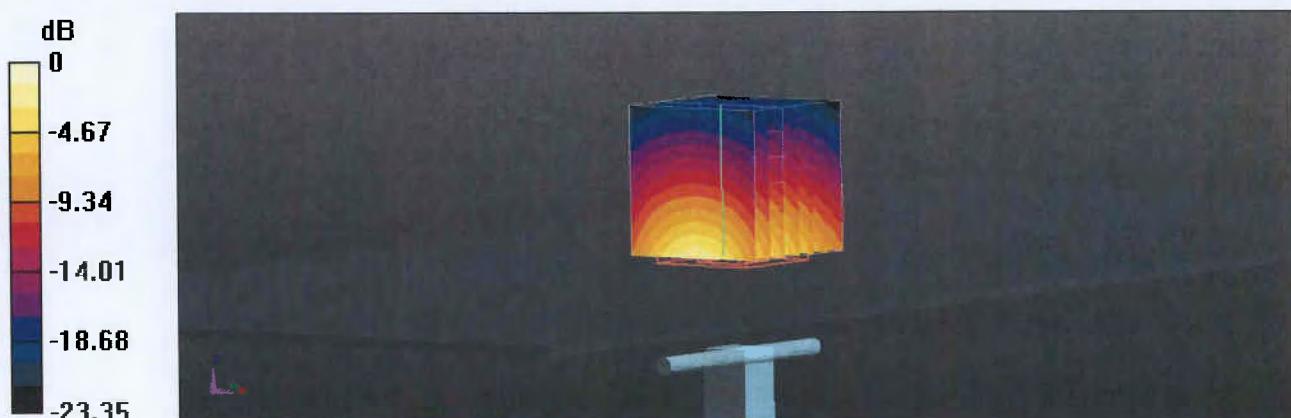
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 113.9 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 27.6 W/kg

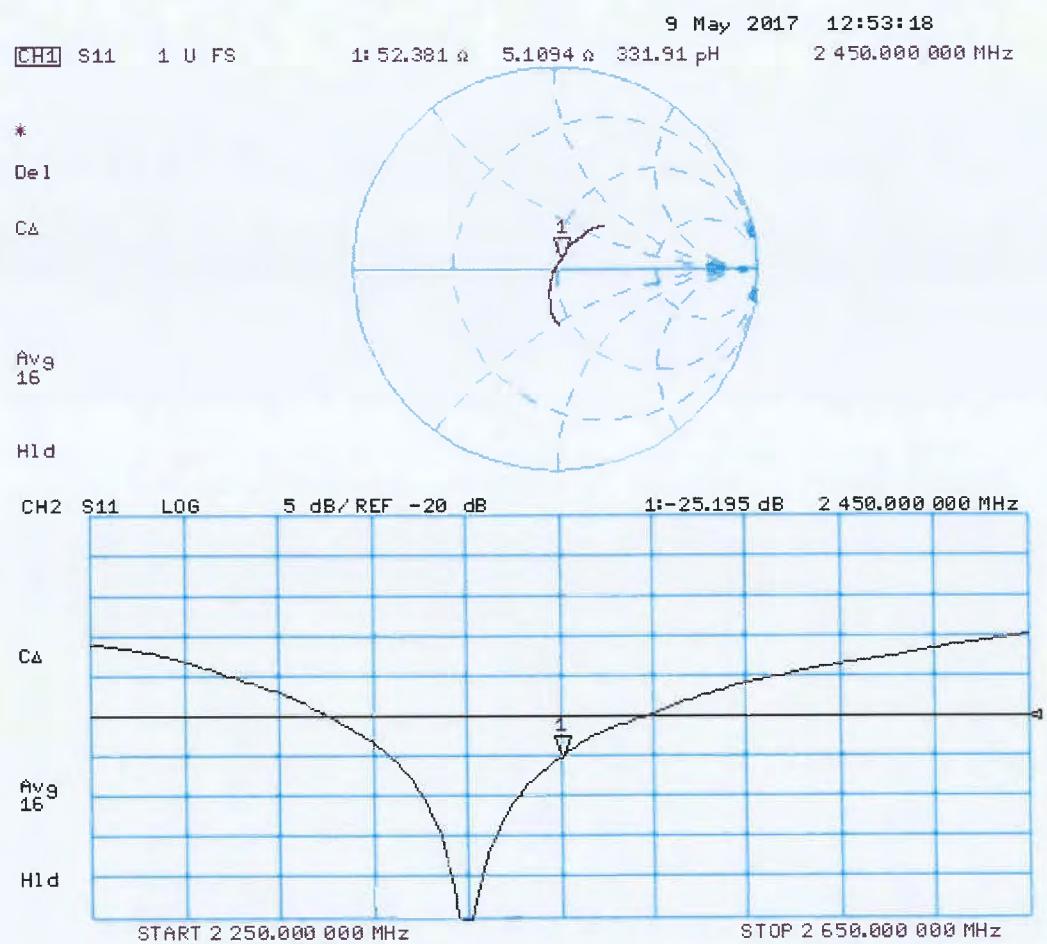
SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.2 W/kg

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



$$0 \text{ dB} = 22.2 \text{ W/kg} = 13.46 \text{ dBW/kg}$$

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 09.05.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:706

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

Medium parameters used: $f = 2450 \text{ MHz}$; $\sigma = 2.03 \text{ S/m}$; $\epsilon_r = 52.4$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.79, 7.79, 7.79); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1442); SEMCAD X 14.6.10(7413)

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

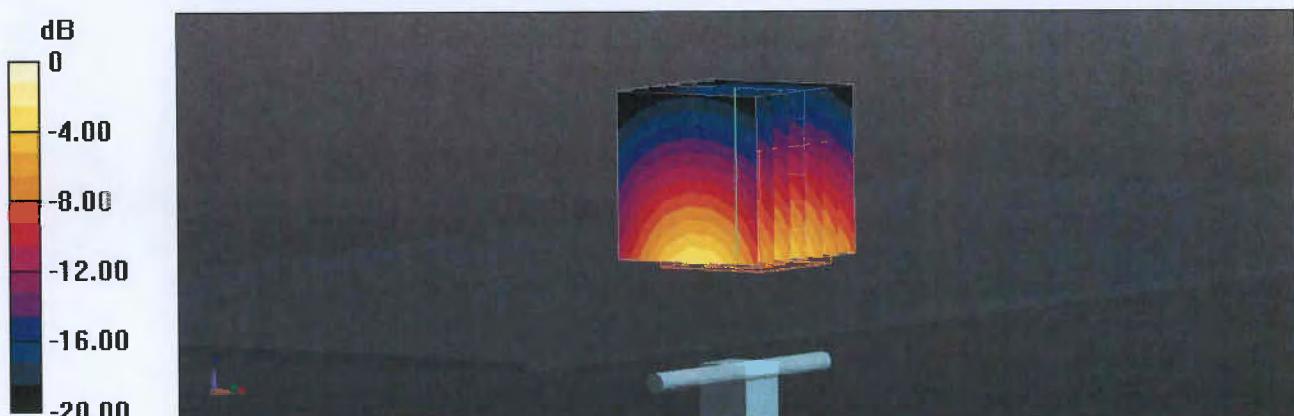
Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 105.5 V/m; Power Drift = -0.06 dB

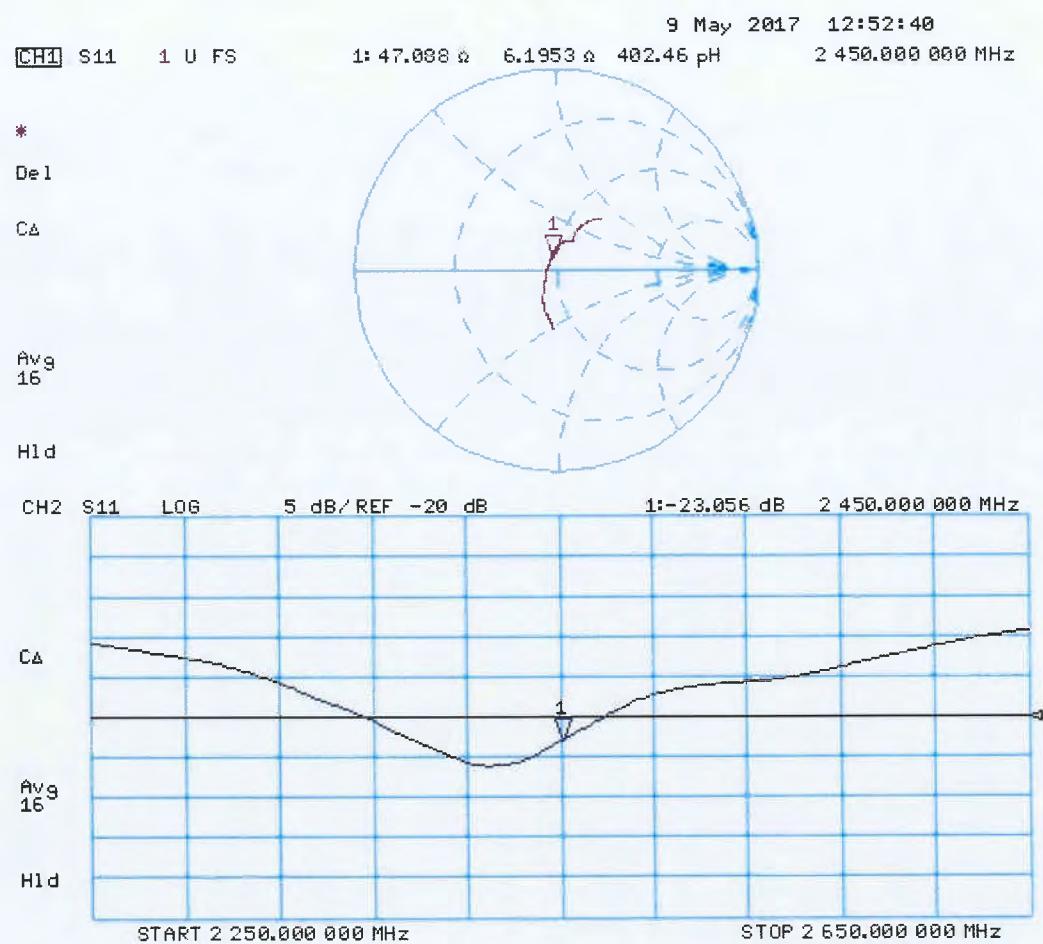
Peak SAR (extrapolated) = 25.4 W/kg

SAR(1 g) = 12.9 W/kg; SAR(10 g) = 6.01 W/kg

Maximum value of SAR (measured) = 20.3 W/kg



Impedance Measurement Plot for Body TSL



Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Condition

| | | |
|---------|------------------|-----------------------------|
| Phantom | SAM Head Phantom | For usage with cSAR3DV2-R/L |
|---------|------------------|-----------------------------|

SAR result with SAM Head (Top)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|--------------------------|
| SAR (average measured) | 250 mW input power | 13.9 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 55.9 W/kg ± 17.5 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|--------------------------|
| SAR measured | 250 mW input power | 6.49 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 26.1 W/kg ± 16.9 % (k=2) |

SAR result with SAM Head (Mouth)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|--------------------------|
| SAR (average measured) | 250 mW input power | 14.2 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 57.0 W/kg ± 17.5 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|--------------------------|
| SAR (average measured) | 250 mW input power | 6.82 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 27.4 W/kg ± 16.9 % (k=2) |

SAR result with SAM Head (Neck)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|--------------------------|
| SAR (average measured) | 250 mW input power | 13.3 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 53.7 W/kg ± 17.5 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|--------------------------|
| SAR (average measured) | 250 mW input power | 6.22 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 25.0 W/kg ± 16.9 % (k=2) |

SAR result with SAM Head (Ear)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|--------------------------|
| SAR (average measured) | 250 mW input power | 8.56 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 34.4 W/kg ± 17.5 % (k=2) |

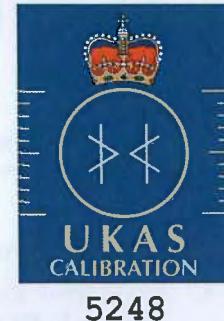
| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|--------------------------|
| SAR (average measured) | 250 mW input power | 4.32 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 17.4 W/kg ± 16.9 % (k=2) |

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

DATE OF ISSUE: 10/Oct/2017

CERTIFICATE NUMBER : 11903941JD01E



UL VS LTD
PAVILION A
ASHWOOD PARK, ASHWOOD WAY
BASINGSTOKE, HAMPSHIRE
RG23 8BG, UK
TEL: +44 (0) 1256 312000
FAX: +44 (0) 1256 312001
Email: LST.UK.Calibration@ul.com

Page 1 of 10



APPROVED SIGNATORY

Naseer Mirza

Customer :

UL VS Inc
47173 Benicia Street
Fremont, CA 94538, USA

Equipment Details:

| | | | |
|--------------------|---|------------------|-------------|
| Description: | Dipole Validation Kit | Date of Receipt: | 29/Sep/2017 |
| Manufacturer: | Speag | | |
| Type/Model Number: | D2600V2 | | |
| Serial Number: | 1006 | | |
| Calibration Date: | 05/Oct/2017 | | |
| Calibrated By: | Chanthu Thevarajah Laboratory Engineer | | |

Signature:

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) °C and humidity < 70%

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Use of the UKAS mark demonstrates that compliance with the requirements of BS/EN/ISO/IEC 17025 has been independently assessed.

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01E

Page 2 of 10

The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2005**: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
2. **IEC 62209-2:2010**: 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)
3. **IEEE 1528: 2013**: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques
4. FCC KDB Publication Number: "KDB865664 D01 SAR Measurement 100 MHz to 6 GHz"
5. **SPEAG DASY4/ DASY5 System Handbook**

The measuring equipment used to perform the calibration, documented in this certificate has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

| UL No. | Instrument | Manufacturer | Type No. | Serial No. | Date Last Calibrated | Cal. Interval (Months) |
|------------|------------------------------|----------------------|---------------|-------------|-----------------------|------------------------|
| A2546 | Data Acquisition Electronics | SPEAG | DAE4 | 1435 | 10 Feb 2017 | 12 |
| A2587 | Probe | SPEAG | ES3DV3 | 3341 | 14 Aug 2017 | 12 |
| A2767 | Dipole | SPEAG | D2600V2 | 1109 | 13 Feb 2017 | 12 |
| PRE0151451 | Power Monitoring Kit | Art-Fi | ART 100850-01 | 0001 | Cal as part of System | 12 |
| PRE0151441 | Power Sensor | Rhode & Schwarz | NRP8S | 102481 | 16 Nov 2016 | 12 |
| M1015 | Network Analyser | Agilent Technologies | 8753ES | US39172406 | 26 Sept 2016 | 12 |
| PRE0151154 | Network Analyser | Rhode & Schwarz | ZND8 | 100151 | 22 Nov 2016 | 12 |
| PRE0151877 | Calibration Kit | Rhode & Schwarz | Z135 | 102947-Bt | 02 Dec 2016 | 12 |
| M1908 | Signal Generator | Rhode & Schwarz | SMIQ 03B | 1125.555.03 | 08 Nov 2016 | 12 |

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01E

Page 3 of 10

SAR System Specification

| | |
|--------------------------|--|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number: | F14/5T5ZA1/A/01 |
| DASY Version: | DASY 52 (v52.8.8.1258) |
| Phantom: | Flat section of SAM Twin Phantom |
| Distance Dipole Centre: | 10 mm (with spacer) |
| Frequency: | 2600 MHz |

Dielectric Property Measurements – Head Simulating Liquid (HSL)

| Simulant Liquid | Frequency (MHz) | Room Temp | | Liquid Temp | | Parameters | Target Value | Measured Value | Uncertainty (%) |
|-----------------|--------------------|-----------|---------|-------------|--------|--------------|--------------|----------------|-----------------|
| | | Start | End | Start | End | | | | |
| Head | 2600 | 23.0 °C | 22.0 °C | 20.0°C | 22.0°C | ϵ_r | 39.00 | 37.06 | ± 5% |
| | | | | | | σ | 1.96 | 1.97 | ± 5% |

SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured | 250 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Head | SAR averaged over 1g | 14.00 W/Kg | 55.73 W/Kg | ± 17.57% |
| | SAR averaged over 10g | 6.30 W/Kg | 25.08 W/Kg | ± 17.32% |

Antenna Parameters – Head Simulating Liquid (HSL)

| Simulant Liquid | Parameter | Measured Level | Uncertainty (%) |
|-----------------|-------------|-----------------|---------------------|
| Head | Impedance | 50.38 Ω 6.70 jΩ | ± 0.28 Ω ± 0.044 jΩ |
| | Return Loss | 23.52 | ± 1.27 dB |

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

CERTIFICATE
NUMBER :
11903941JD01E

UKAS Accredited Calibration Laboratory No. 5248

Page 4 of 10

Dielectric Property Measurements – Body Simulating Liquid (MSL)

| Simulant Liquid | Frequency (MHz) | Room Temp | | Liquid Temp | | Parameters | Target Value | Measured Value | Uncertainty (%) |
|-----------------|--------------------|-----------|---------|-------------|--------|--------------|-----------------|-------------------|--------------------|
| | | Start | End | Start | End | | | | |
| Body | 2600 | 22.0 °C | 22.0 °C | 22.0°C | 22.0°C | ϵ_r | 52.50 | 51.39 | ± 5% |
| | | | | | | σ | 2.16 | 2.19 | ± 5% |

SAR Results – Body Simulating Liquid (MSL)

| Simulant Liquid | SAR Measured | 250 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Body | SAR averaged over 1g | 14.10 W/Kg | 56.13 W/Kg | ± 18.06% |
| | SAR averaged over 10g | 6.28 W/Kg | 25.00 W/Kg | ± 17.44% |

Antenna Parameters – Body Simulating Liquid (MSL)

| Simulant Liquid | Parameter | Measured Level | Uncertainty (%) |
|-----------------|-------------|------------------|---------------------|
| Body | Impedance | 48.51 Ω -2.73 jΩ | ± 0.28 Ω ± 0.044 jΩ |
| | Return Loss | 30.37 | ± 1.27 dB |

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

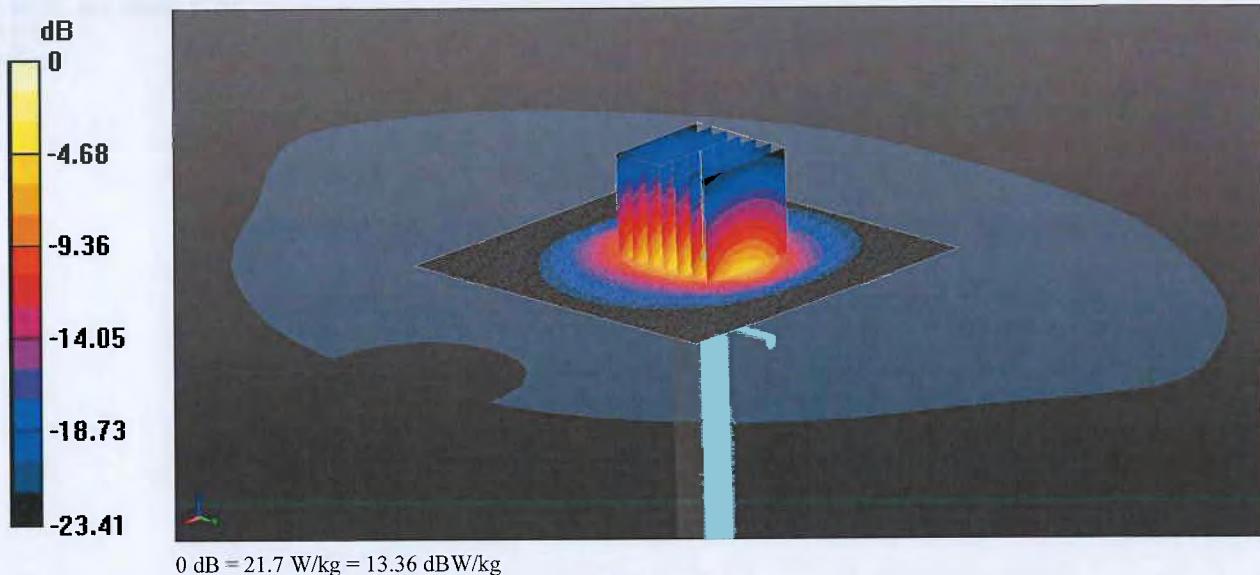
UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01E

Page 5 of 10

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1006



0 dB = 21.7 W/kg = 13.36 dBW/kg

Communication System: UID 0, CW (0); Frequency: 2600 MHz; Duty Cycle: 1:1

Medium: 2600 MHz HSL Medium parameters used: $f = 2600$ MHz; $\sigma = 1.971$ S/m; $\epsilon_r = 37.058$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(4.5, 4.5, 4.5); Calibrated: 14/08/2017;
- Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW 2 2/Area Scan (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 15.9 W/kg

Configuration/d=10mm, Pin=250mW 2 2/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 91.28 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 14 W/kg; SAR(10 g) = 6.3 W/kg

Maximum value of SAR (measured) = 21.7 W/kg

CERTIFICATE OF CALIBRATION

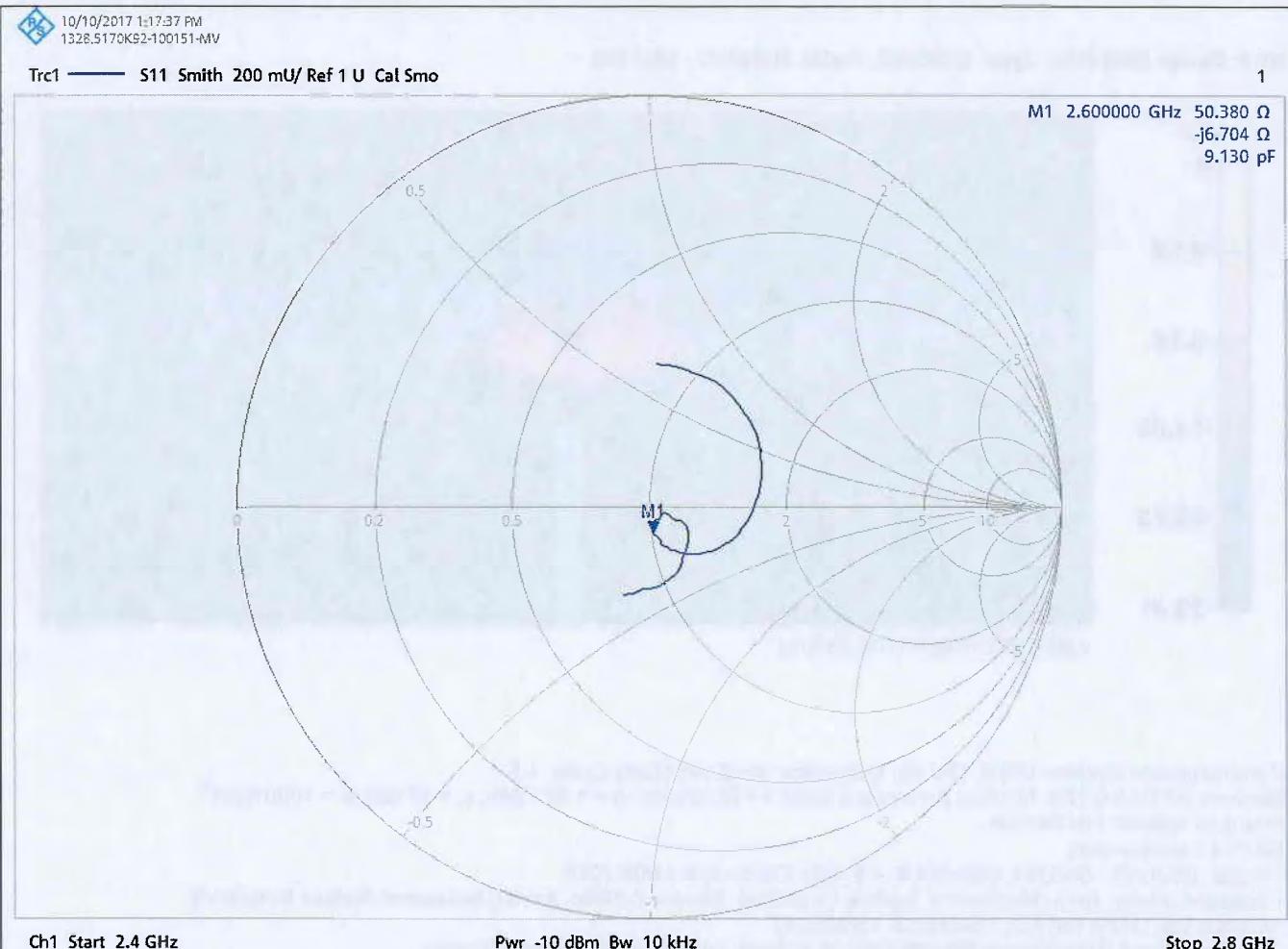
ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01E

Page 6 of 10

Impedance Measurement Plot for Head Stimulating Liquid (HSL)



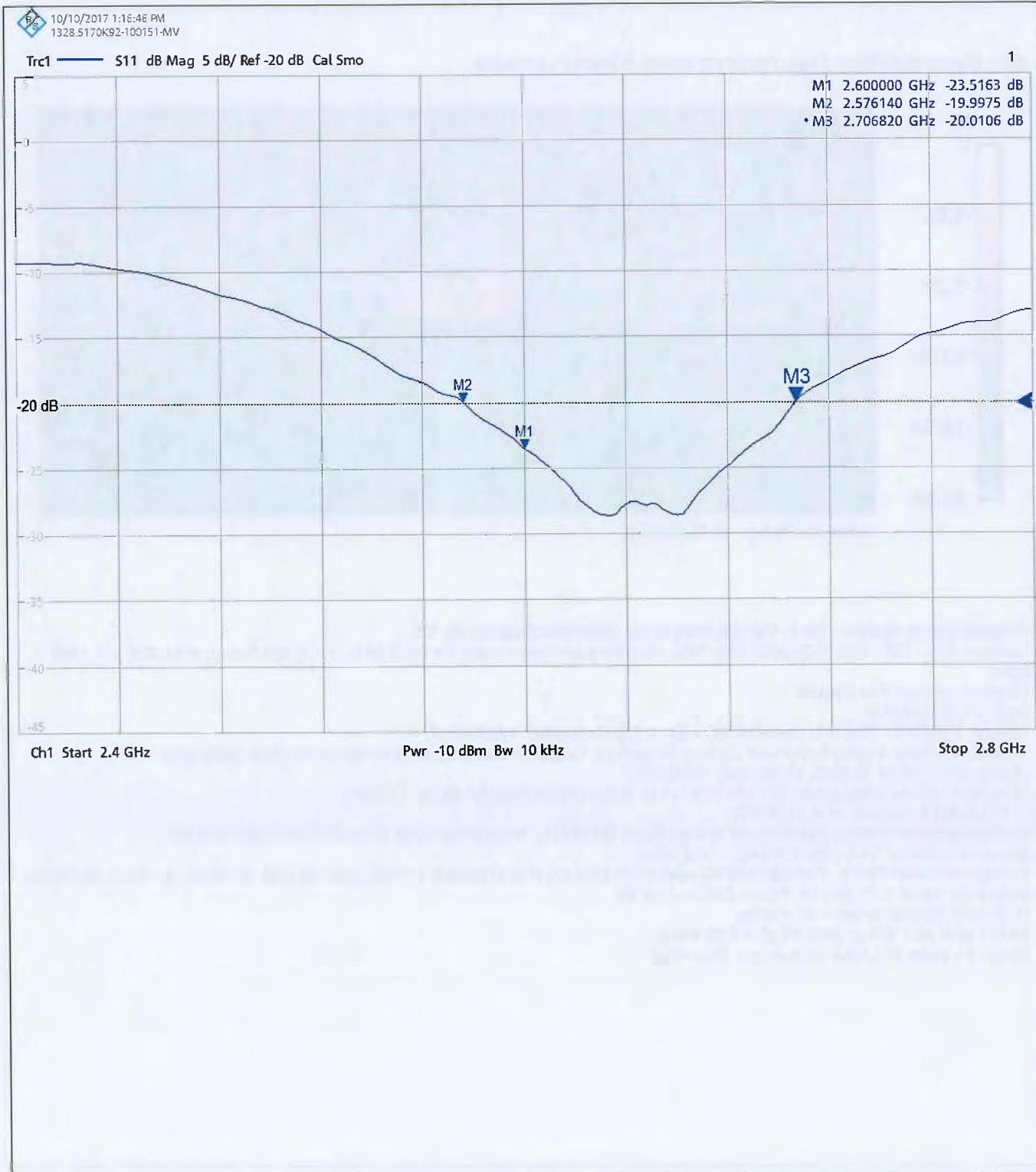
CERTIFICATE OF CALIBRATION ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01E

Page 7 of 10

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

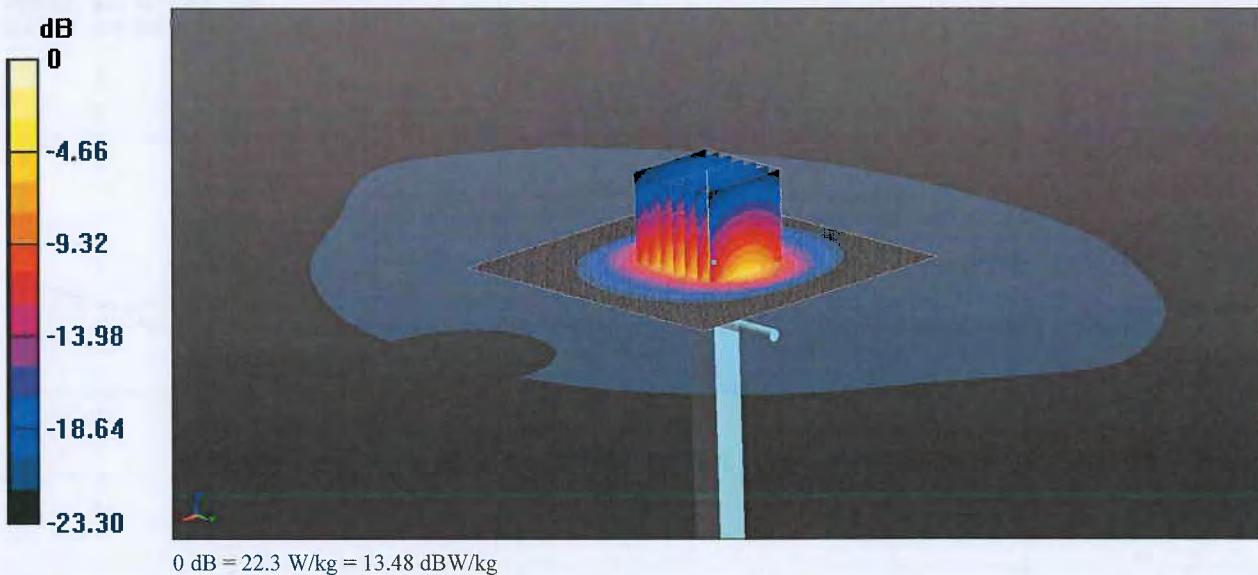
CERTIFICATE
NUMBER :
11903941JD01E

UKAS Accredited Calibration Laboratory No. 5248

Page 8 of 10

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1006



Communication System: UID 0, CW (0); Frequency: 2600 MHz; Duty Cycle: 1:1
Medium: 900, 1750, 1800, 1900, 2600 MHz MSL Medium parameters used: $f = 2600$ MHz; $\sigma = 2.189$ S/m; $\epsilon_r = 51.388$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(4.32, 4.32, 4.32); Calibrated: 14/08/2017;
- Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW 2/Area Scan (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 16.2 W/kg

Configuration/d=10mm, Pin=250mW 2/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 87.50 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 31.4 W/kg

SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.28 W/kg

Maximum value of SAR (measured) = 22.3 W/kg

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01E

Page 9 of 10

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01E

Page 10 of 10

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

| | |
|---|--|
|  5248 | UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date: |
|---|--|

| | |
|---|--|
|  5248 | UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date: |
|---|--|

| | |
|--|--|
|  5248 | UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date: |
|--|--|



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 **UL CCS USA**

Certificate No: **D5GHzV2-1138_Oct17**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1138**

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

Calibration date: **October 26, 2017**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|-----------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP | SN: 104778 | 04-Apr-17 (No. 217-02521/02522) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103244 | 04-Apr-17 (No. 217-02521) | Apr-18 |
| Power sensor NRP-Z91 | SN: 103245 | 04-Apr-17 (No. 217-02522) | Apr-18 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 07-Apr-17 (No. 217-02528) | Apr-18 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 07-Apr-17 (No. 217-02529) | Apr-18 |
| Reference Probe EX3DV4 | SN: 3503 | 31-Dec-16 (No. EX3-3503_Dec16) | Dec-17 |
| DAE4 | SN: 601 | 28-Mar-17 (No. DAE4-601_Mar17) | Mar-18 |
| DAE4 | SN: 781 | 13-Jul-17 (No. DAE4-781_Jul17) | Jul-18 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Power meter EPM-442A | SN: GB37480704 | 07-Oct-16 (No. 217-02222) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: US37292783 | 07-Oct-16 (No. 217-02222) | In house check: Oct-18 |
| Power sensor HP 8481A | SN: MY41092317 | 07-Oct-16 (No. 217-02223) | In house check: Oct-18 |
| RF generator R&S SMT-06 | SN: 100972 | 15-Jun-15 (in house check Oct-16) | In house check: Oct-18 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-17) | In house check: Oct-18 |

| Calibrated by: | Name | Function | Signature |
|----------------|----------------|-----------------------|-----------|
| | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: October 26, 2017

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

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

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

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

Measurement Conditions

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

| | | |
|-------------------------------------|--|----------------------------------|
| DASY Version | DASY5 | |
| Extrapolation | Advanced Extrapolation | |
| Phantom | Modular Flat Phantom V5.0 | |
| Distance Dipole Center - TSL | 10 mm | with Spacer |
| Zoom Scan Resolution | $dx, dy = 4.0 \text{ mm}, dz = 1.4 \text{ mm}$ | Graded Ratio = 1.4 (Z direction) |
| Frequency | 5200 MHz $\pm 1 \text{ MHz}$ 5600 MHz $\pm 1 \text{ MHz}$ 5800 MHz $\pm 1 \text{ MHz}$ | |

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 ± 0.2) °C | 36.1 ± 6 % | 4.50 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C | ---- | ---- |

SAR result with Head TSL at 5200 MHz

| | | |
|---|--------------------|------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR measured | 100 mW input power | 7.77 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 77.7 W/kg ± 19.9 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR measured | 100 mW input power | 2.22 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 22.2 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 | 35.5 ± 6 % | 4.90 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 | 8.33 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 83.2 W/kg ± 19.9 % (k=2) |
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR measured | 100 mW input power | 2.37 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 | 35.3 ± 6 % | 5.11 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 | 7.98 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 79.7 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|--------------------------|
| SAR measured | 100 mW input power | 2.27 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 22.7 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 % | 5.44 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 | 7.40 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 73.4 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|--------------------------|
| SAR measured | 100 mW input power | 2.08 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 20.6 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 | 46.3 ± 6 % | 5.97 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 | 8.01 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 79.5 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 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 | 46.0 ± 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 cm ³ (1 g) of Body TSL | Condition | |
|---|--------------------|--------------------------|
| SAR measured | 100 mW input power | 7.74 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 76.8 W/kg ± 19.9 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Body TSL | condition | |
|---|--------------------|--------------------------|
| SAR measured | 100 mW input power | 2.15 W/kg |
| SAR for nominal Body TSL parameters | normalized to 1W | 21.3 W/kg ± 19.5 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 49.0 Ω - 8.1 $j\Omega$ |
| Return Loss | - 21.7 dB |

Antenna Parameters with Head TSL at 5600 MHz

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 56.1 Ω - 1.8 $j\Omega$ |
| Return Loss | - 24.4 dB |

Antenna Parameters with Head TSL at 5800 MHz

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 54.7 Ω - 2.1 $j\Omega$ |
| Return Loss | - 26.1 dB |

Antenna Parameters with Body TSL at 5200 MHz

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 50.4 Ω - 7.4 $j\Omega$ |
| Return Loss | - 22.7 dB |

Antenna Parameters with Body TSL at 5600 MHz

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 57.9 Ω - 1.7 $j\Omega$ |
| Return Loss | - 22.6 dB |

Antenna Parameters with Body TSL at 5800 MHz

| | |
|--------------------------------------|-------------------------------|
| Impedance, transformed to feed point | 54.9 Ω - 2.2 $j\Omega$ |
| Return Loss | - 25.9 dB |

General Antenna Parameters and Design

| | |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.203 ns |
|----------------------------------|----------|

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

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

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

Additional EUT Data

| | |
|-----------------|--------------|
| Manufactured by | SPEAG |
| Manufactured on | May 07, 2012 |

DASY5 Validation Report for Head TSL

Date: 26.10.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1138

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

Medium parameters used: $f = 5200 \text{ MHz}$; $\sigma = 4.5 \text{ S/m}$; $\epsilon_r = 36.1$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5600 \text{ MHz}$; $\sigma = 4.9 \text{ S/m}$; $\epsilon_r = 35.5$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5800 \text{ MHz}$; $\sigma = 5.11 \text{ S/m}$; $\epsilon_r = 35.3$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.76, 5.76, 5.76); Calibrated: 31.12.2016, ConvF(5.09, 5.09, 5.09); Calibrated: 31.12.2016, ConvF(5.01, 5.01, 5.01); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn781; Calibrated: 13.07.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 69.15 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 27.6 W/kg

SAR(1 g) = 7.77 W/kg; SAR(10 g) = 2.22 W/kg

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

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 70.42 V/m; Power Drift = -0.09 dB

Peak SAR (extrapolated) = 31.7 W/kg

SAR(1 g) = 8.33 W/kg; SAR(10 g) = 2.37 W/kg

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

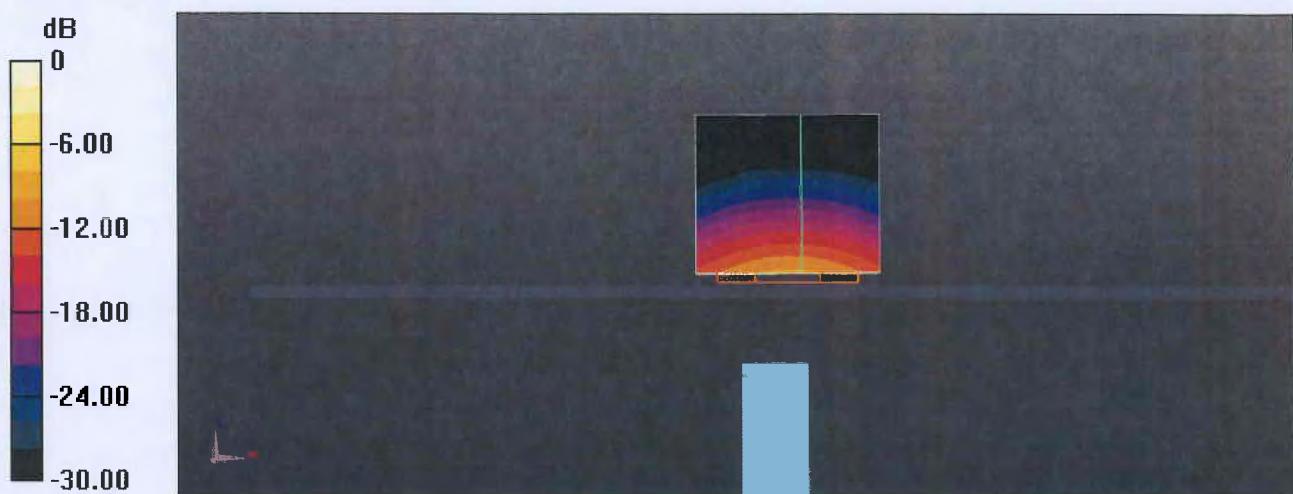
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 68.10 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 31.5 W/kg

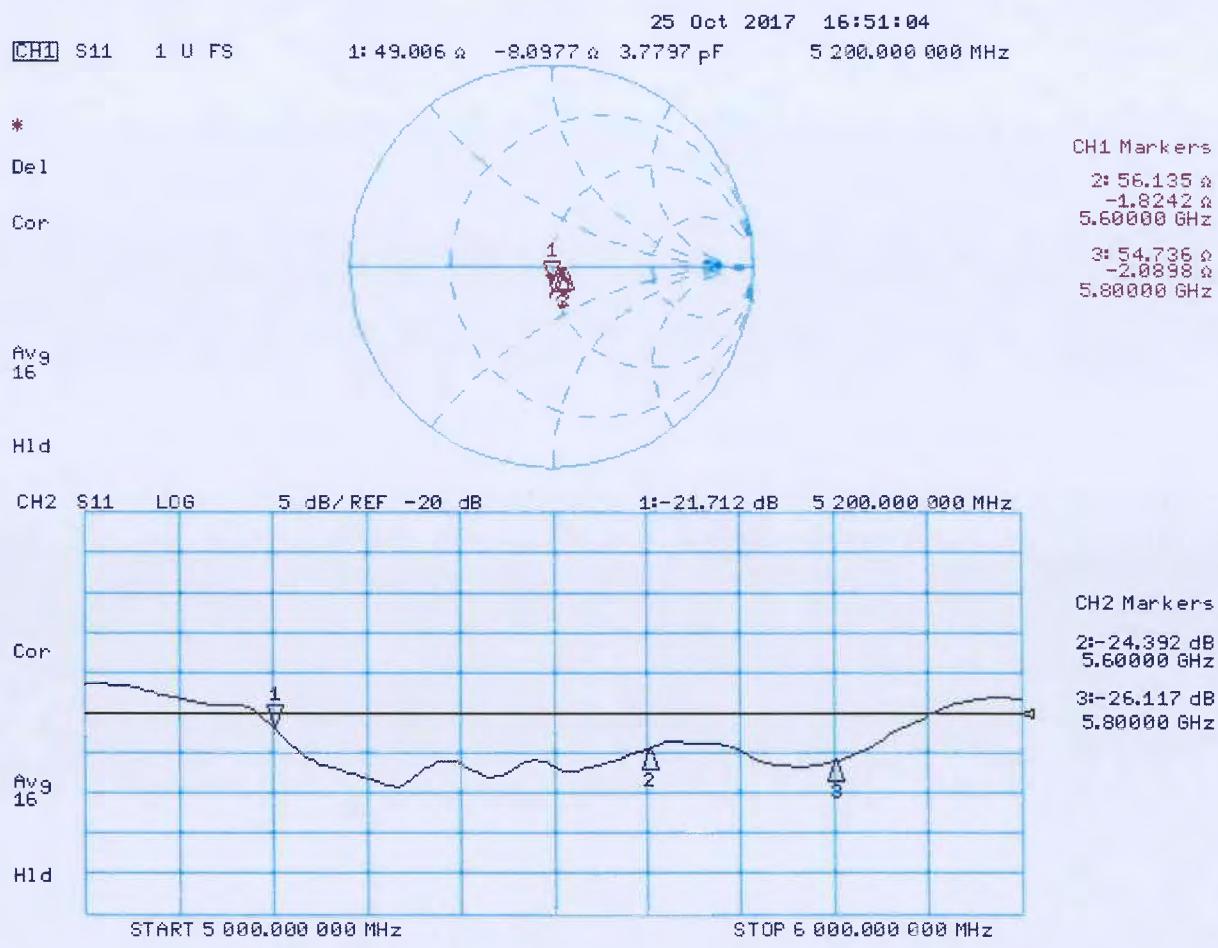
SAR(1 g) = 7.98 W/kg; SAR(10 g) = 2.27 W/kg

Maximum value of SAR (measured) = 18.7 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: 25.10.2017

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1138

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

Medium parameters used: $f = 5200 \text{ MHz}$; $\sigma = 5.44 \text{ S/m}$; $\epsilon_r = 47.1$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5600 \text{ MHz}$; $\sigma = 5.97 \text{ S/m}$; $\epsilon_r = 46.3$; $\rho = 1000 \text{ kg/m}^3$,

Medium parameters used: $f = 5800 \text{ MHz}$; $\sigma = 6.25 \text{ S/m}$; $\epsilon_r = 46$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.29, 5.29, 5.29); Calibrated: 31.12.2016, ConvF(4.57, 4.57, 4.57); Calibrated: 31.12.2016, ConvF(4.48, 4.48, 4.48); Calibrated: 31.12.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 63.83 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 27.9 W/kg

SAR(1 g) = 7.4 W/kg; SAR(10 g) = 2.08 W/kg

Maximum value of SAR (measured) = 16.8 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 64.58 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 33.3 W/kg

SAR(1 g) = 8.01 W/kg; SAR(10 g) = 2.25 W/kg

Maximum value of SAR (measured) = 19.0 W/kg

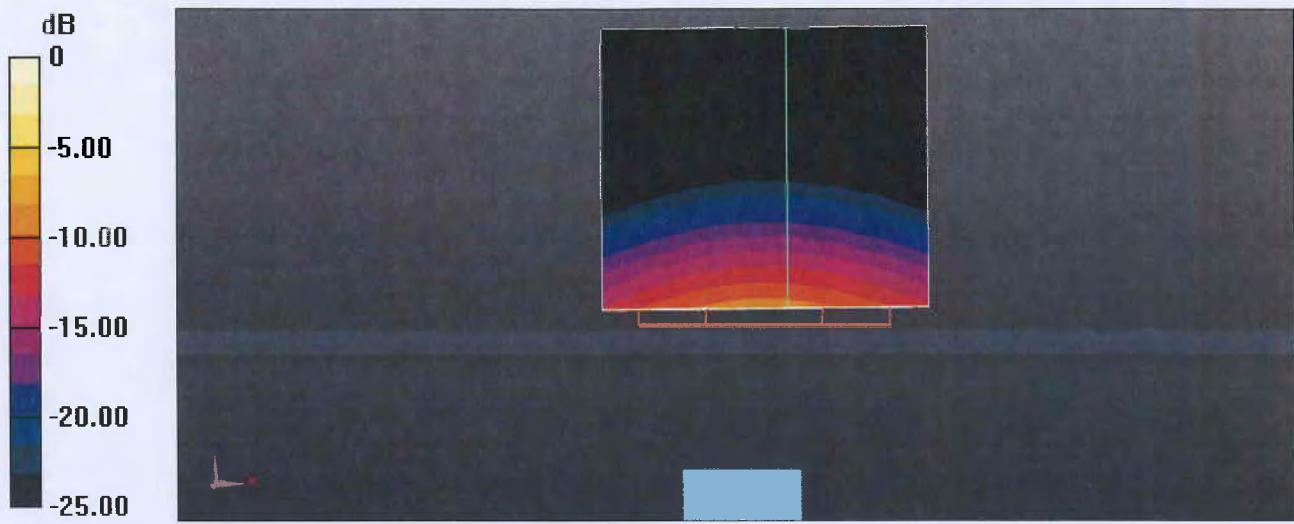
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=1.4\text{mm}$

Reference Value = 62.86 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 34.2 W/kg

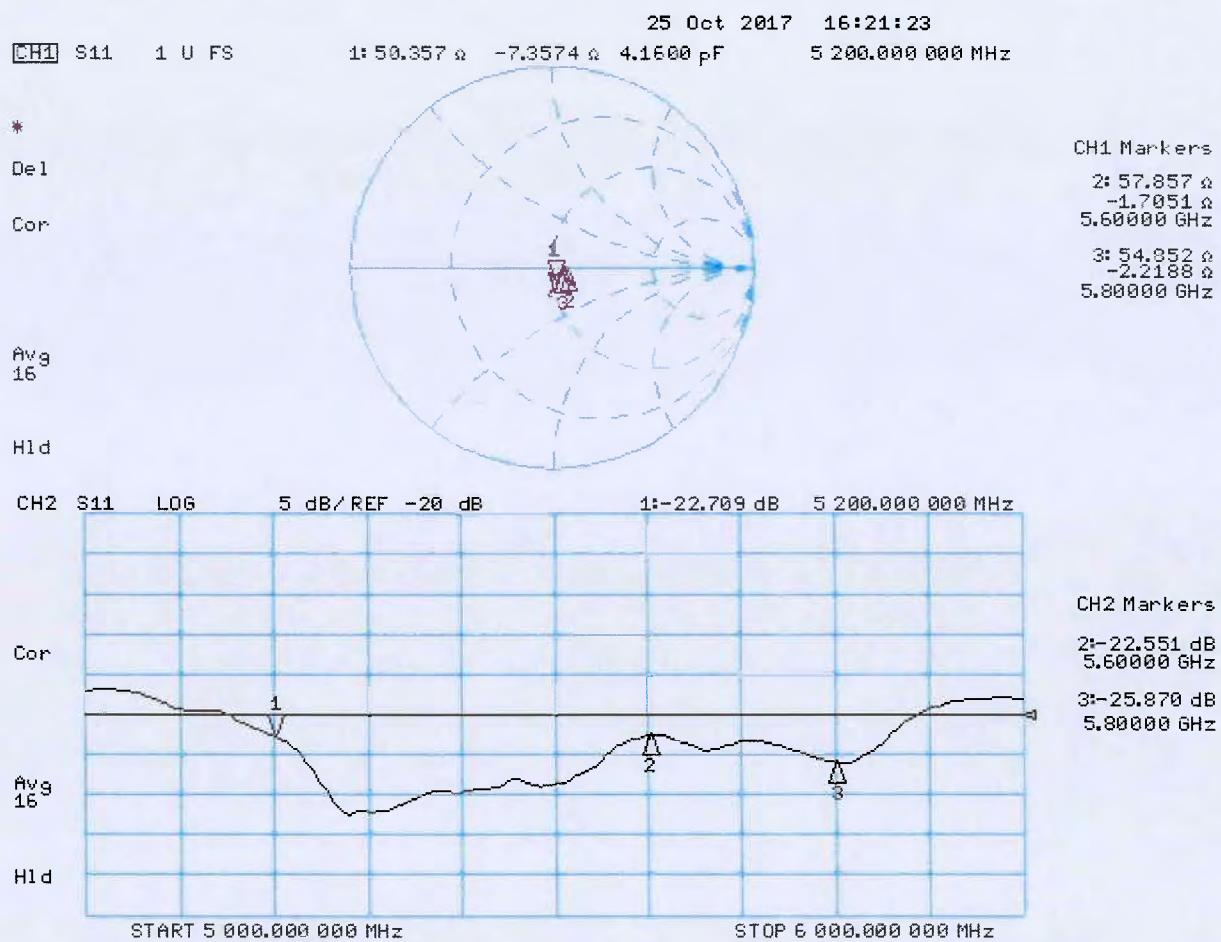
SAR(1 g) = 7.74 W/kg; SAR(10 g) = 2.15 W/kg

Maximum value of SAR (measured) = 18.9 W/kg



0 dB = 18.9 W/kg = 12.76 dBW/kg

Impedance Measurement Plot for Body TSL



Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Conditions (f=5200 MHz)

| | | |
|---------|------------------|-----------------------------|
| Phantom | SAM Head Phantom | For usage with cSAR3DV2-R/L |
|---------|------------------|-----------------------------|

SAR result with SAM Head (Top)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 8.42 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 83.9 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR measured | 100 mW input power | 2.43 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 24.2 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Mouth)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 8.89 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 88.6 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR (average measured) | 100 mW input power | 2.58 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 25.7 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Neck)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 8.50 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 84.5 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR (average measured) | 100 mW input power | 2.41 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 23.9 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Ear)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 5.42 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 54.0 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR (average measured) | 100 mW input power | 1.85 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 18.4 W/kg ± 19.9 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Conditions (f=5600 MHz)

| | | |
|---------|------------------|-----------------------------|
| Phantom | SAM Head Phantom | For usage with cSAR3DV2-R/L |
|---------|------------------|-----------------------------|

SAR result with SAM Head (Top)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 9.18 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 91.1 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR measured | 100 mW input power | 2.60 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 25.7 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Mouth)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 9.37 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 93.0 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR (average measured) | 100 mW input power | 2.69 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 26.6 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Neck)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 8.80 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 87.4 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR (average measured) | 100 mW input power | 2.40 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 23.8 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Ear)

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 1 cm³ (1 g) of Head TSL | Condition | |
| SAR (average measured) | 100 mW input power | 6.28 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 62.3 W/kg ± 20.3 % (k=2) |

| | | |
|---|--------------------|---------------------------------|
| SAR averaged over 10 cm³ (10 g) of Head TSL | condition | |
| SAR (average measured) | 100 mW input power | 2.10 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 20.8 W/kg ± 19.9 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Evaluation Conditions (f=5800 MHz)

| | | |
|---------|------------------|-----------------------------|
| Phantom | SAM Head Phantom | For usage with cSAR3DV2-R/L |
|---------|------------------|-----------------------------|

SAR result with SAM Head (Top)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR (average measured) | 100 mW input power | 8.32 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 82.8 W/kg ± 20.3 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR measured | 100 mW input power | 2.36 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 23.4 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Mouth)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR (average measured) | 100 mW input power | 9.10 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 90.6 W/kg ± 20.3 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR (average measured) | 100 mW input power | 2.60 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 25.9 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Neck)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR (average measured) | 100 mW input power | 8.25 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 81.7 W/kg ± 20.3 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR (average measured) | 100 mW input power | 2.31 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 22.8 W/kg ± 19.9 % (k=2) |

SAR result with SAM Head (Ear)

| SAR averaged over 1 cm ³ (1 g) of Head TSL | Condition | |
|---|--------------------|---------------------------------|
| SAR (average measured) | 100 mW input power | 5.81 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 57.7 W/kg ± 20.3 % (k=2) |

| SAR averaged over 10 cm ³ (10 g) of Head TSL | condition | |
|---|--------------------|---------------------------------|
| SAR (average measured) | 100 mW input power | 1.95 W/kg |
| SAR for nominal Head TSL parameters | normalized to 1W | 19.3 W/kg ± 19.9 % (k=2) |