

# CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 23/May/2017

CERTIFICATE NUMBER : 11762345JD01A



5248

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**APPROVED SIGNATORY**

.....  
Naseer Mirza

## Customer :

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

## Equipment Details:

|                    |                                           |                  |             |
|--------------------|-------------------------------------------|------------------|-------------|
| Description:       | Dipole Validation Kit                     | Date of Receipt: | 09/May/2017 |
| Manufacturer:      | Speag                                     |                  |             |
| Type/Model Number: | D750V3                                    |                  |             |
| Serial Number:     | 1024                                      |                  |             |
| Calibration Date:  | 12/May/2017                               |                  |             |
| Calibrated By:     | Chanthu Thevarajah<br>Laboratory Engineer |                  |             |

Signature:

.....

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

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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) |
|------------|------------------------------|----------------------|---------------|------------|-----------------------|------------------------|
| A2110      | Data Acquisition Electronics | SPEAG                | DAE4          | 431        | 18 Nov 2016           | 12                     |
| A2587      | Probe                        | SPEAG                | ES3DV3        | 3341       | 29 Aug 2016           | 12                     |
| A1985      | Dipole                       | SPEAG                | D750V3        | 1011       | 14 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  | 09 May 2017           | 12                     |
| M1768      | Signal Generator             | Rhode & Schwarz      | SME06         | 837633/001 | 08 Nov 2016           | 12                     |

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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: RX90L |
| Robot Serial Number:     | F00/SD89A1/A/01                            |
| DASY Version:            | DASY 4 (v4.7.80)                           |
| Phantom:                 | Flat section of SAM Twin Phantom           |
| Distance Dipole Centre:  | 15 mm (with spacer)                        |
| Frequency:               | 750 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            | 750             | 21.0 °C   | 21.0 °C | 21.0°C      | 21.0°C | $\epsilon_r$ | 41.96        | 41.29          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 0.89         | 0.91           | ± 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  | 2.13 W/Kg          | <b>8.47 W/Kg</b>     | ± 17.57%        |
|                 | SAR averaged over 10g | 1.39 W/Kg          | <b>5.53 W/Kg</b>     | ± 17.32%        |

### Antenna Parameters – Head Simulating Liquid (HSL)

| Simulant Liquid | Parameter   | Measured Level                 | Uncertainty (%)                    |
|-----------------|-------------|--------------------------------|------------------------------------|
| Head            | Impedance   | 47.67 $\Omega$ 2.80 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 28.12                          | ± 2.03 dB                          |

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### 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            | 750             | 21.0 °C   | 21.0 °C | 21.0°C      | 21.0°C | $\epsilon_r$ | 55.55        | 53.75          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 0.96         | 0.97           | ± 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  | 2.16 W/Kg          | <b>8.59 W/Kg</b>     | ± 18.06%        |
|                 | SAR averaged over 10g | 1.42 W/Kg          | <b>5.65 W/Kg</b>     | ± 17.44%        |

### Antenna Parameters – Body Simulating Liquid (MSL)

| Simulant Liquid | Parameter   | Measured Level                 | Uncertainty (%)                    |
|-----------------|-------------|--------------------------------|------------------------------------|
| Body            | Impedance   | 51.39 $\Omega$ 3.87 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 28.60                          | ± 2.03 dB                          |

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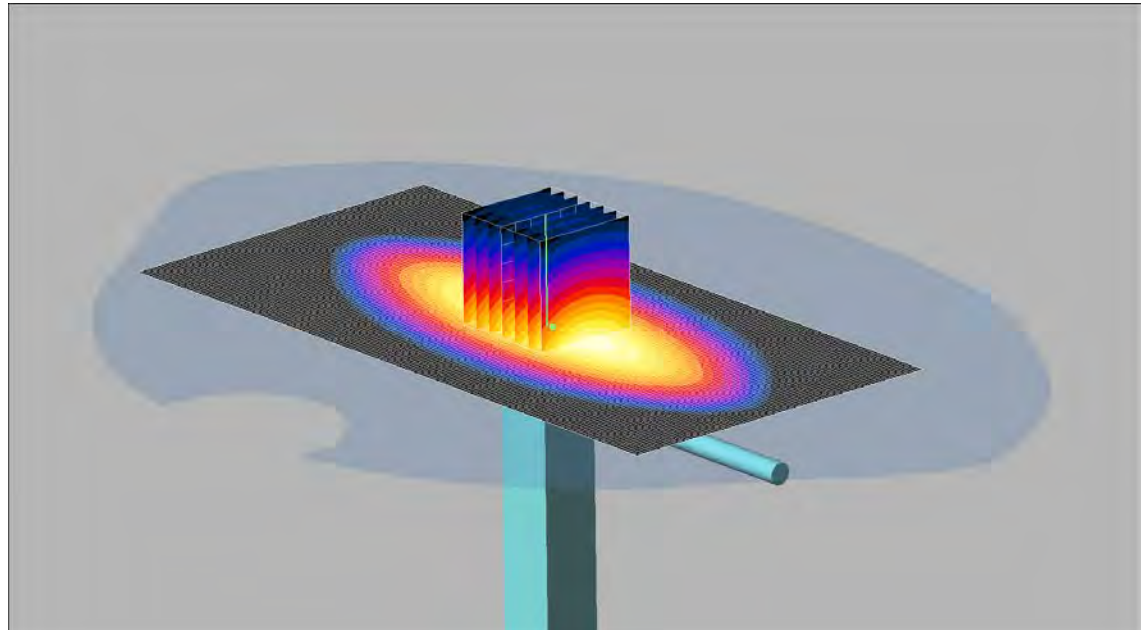
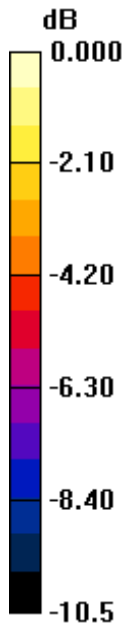
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: Dipole 750 MHz SN:1101; Type: D750V3; Serial: D750V3 - SN:1024



0 dB = 2.48mW/g

Communication System: CW 750; Frequency: 750 MHz; Duty Cycle: 1:1

Medium: 750 MHz HSL Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.91$  mho/m;  $\epsilon_r = 41.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(6.53, 6.53, 6.53);

- Sensor-Surface: 3mm (Mechanical Surface Detection)

- Electronics: DAE4 Sn431; Calibrated: 18/11/2016

- Phantom: SAM 12a (Site 57); Type: SAM 4.0; Serial: TP:1020

- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**d=15mm, Pin=250mW/Area Scan (81x161x1):** Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 2.52 mW/g

**d=15mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 55.4 V/m; Power Drift = -0.238 dB

Peak SAR (extrapolated) = 3.15 W/kg

**SAR(1 g) = 2.13 mW/g; SAR(10 g) = 1.39 mW/g**

Maximum value of SAR (measured) = 2.48 mW/g

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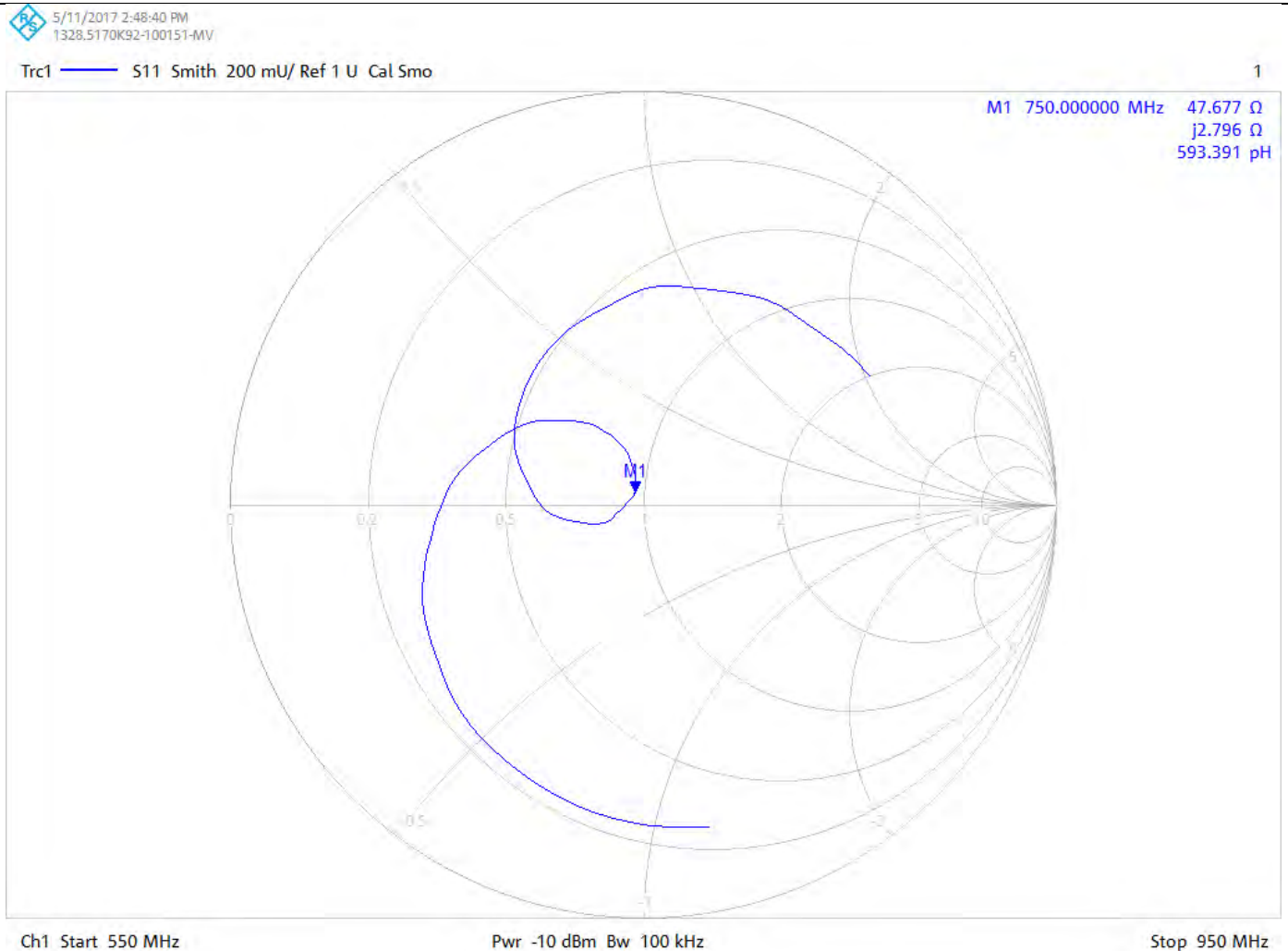
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### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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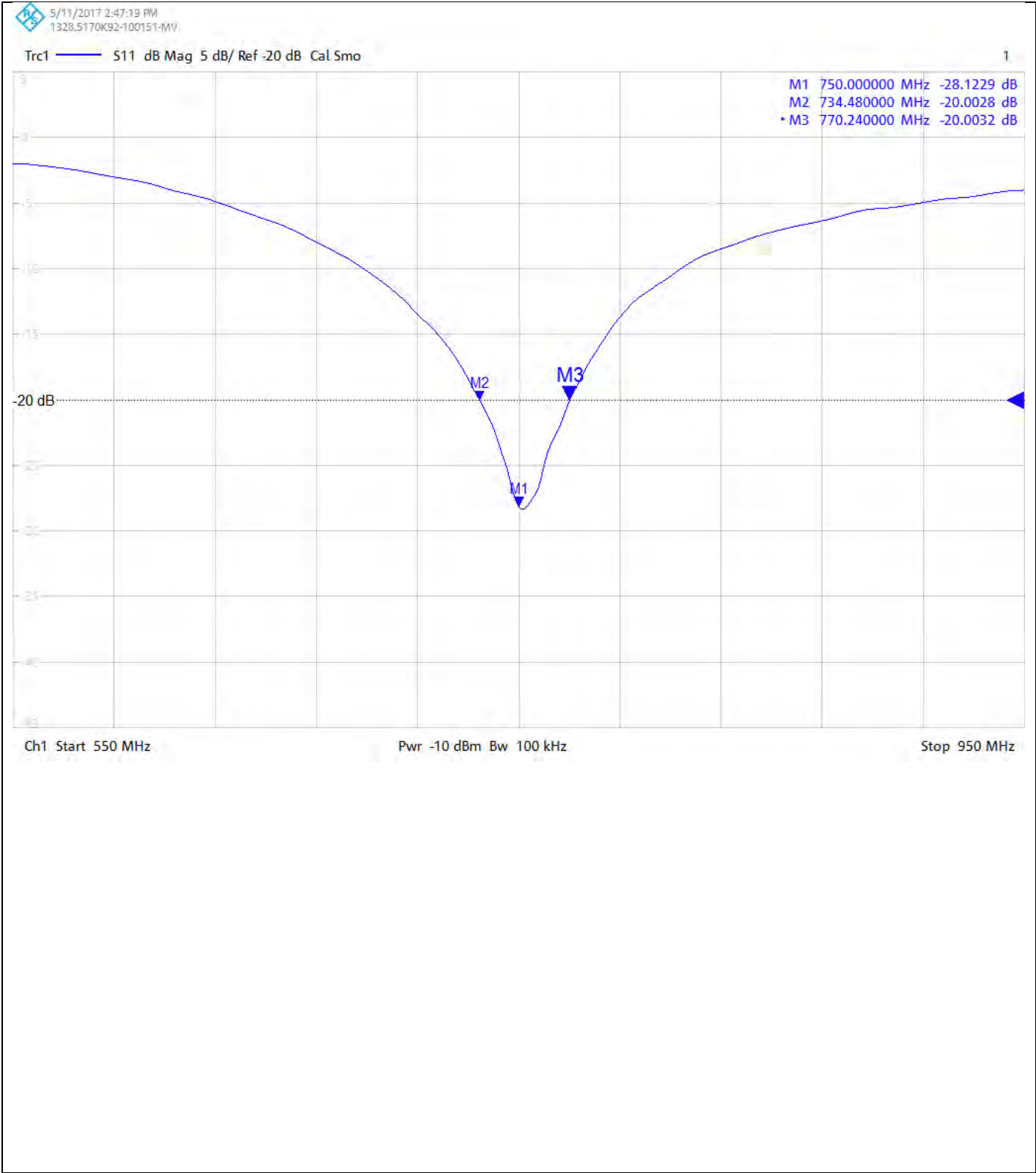
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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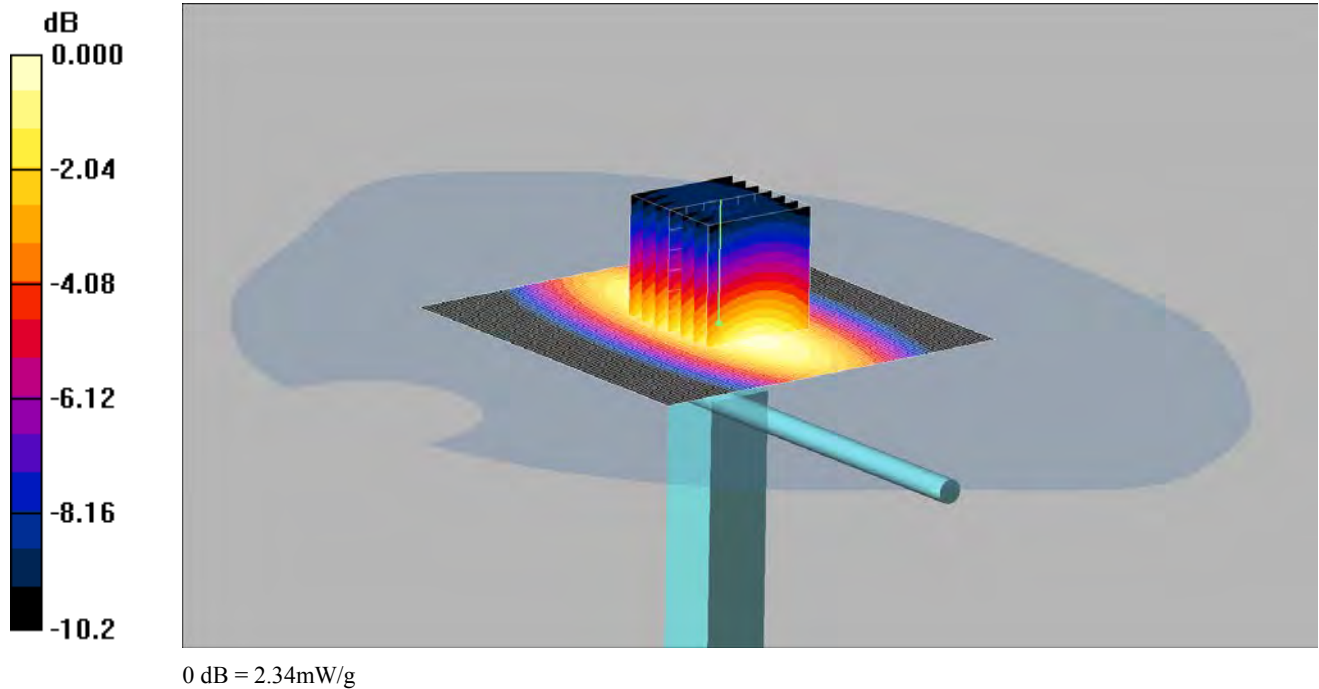
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1024



Communication System: CW; Frequency: 750 MHz; Duty Cycle: 1:1

Medium: 750 MHz MSL Medium parameters used:  $f = 750 \text{ MHz}$ ;  $\sigma = 0.97 \text{ mho/m}$ ;  $\epsilon_r = 53.8$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(6.51, 6.51, 6.51);

- Sensor-Surface: 4mm (Mechanical Surface Detection)

- Electronics: DAE4 Sn431; Calibrated: 18/11/2016

- Phantom: SAM 12a (Site 57); Type: SAM 4.0; Serial: TP:1020

- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

**d=15mm, Pin=250mW/Area Scan (81x81x1):** Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 2.33 mW/g

**d=15mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 49.3 V/m; Power Drift = 0.106 dB

Peak SAR (extrapolated) = 3.23 W/kg

**SAR(1 g) = 2.16 mW/g; SAR(10 g) = 1.42 mW/g**

Maximum value of SAR (measured) = 2.34 mW/g



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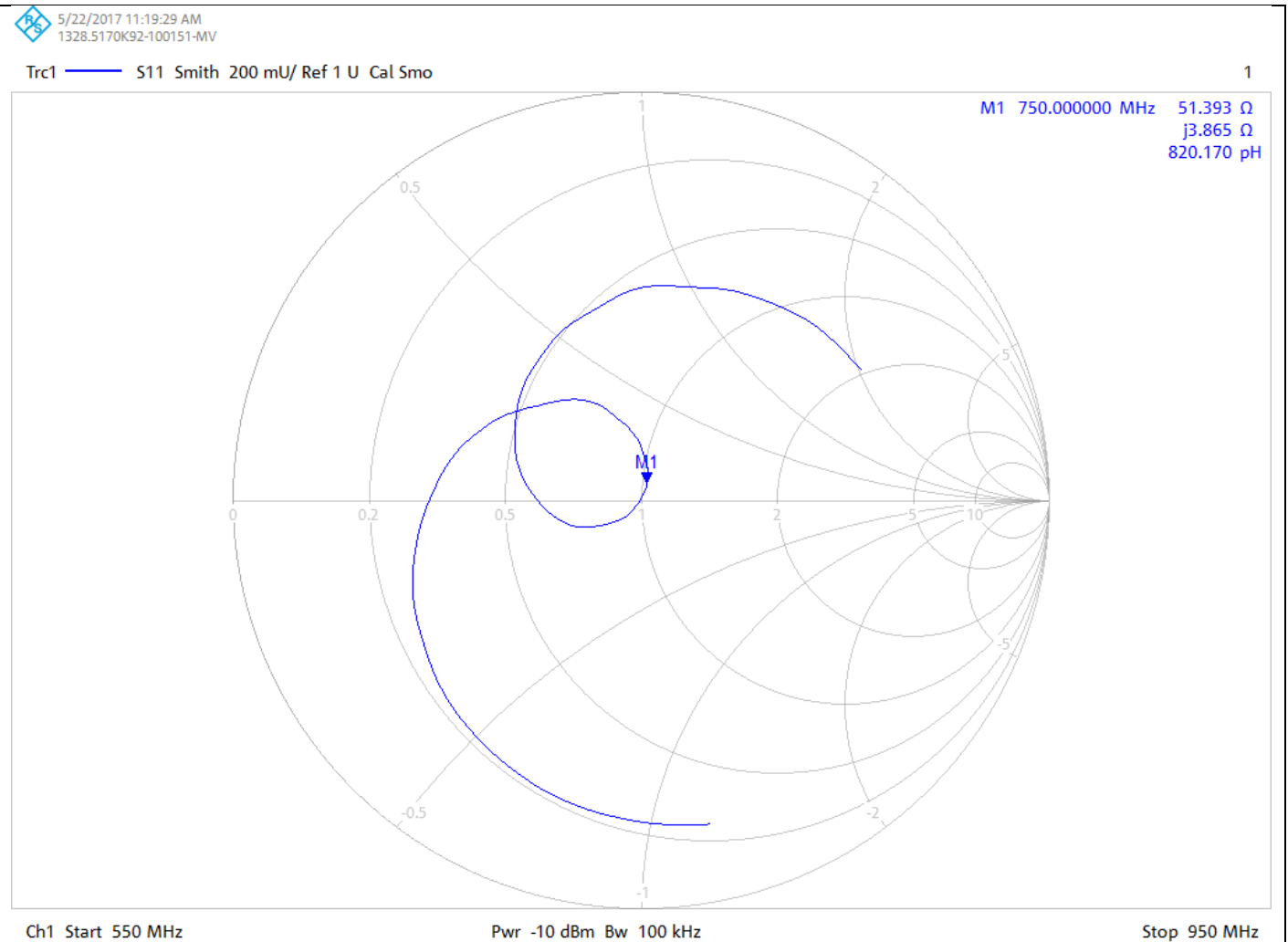
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### Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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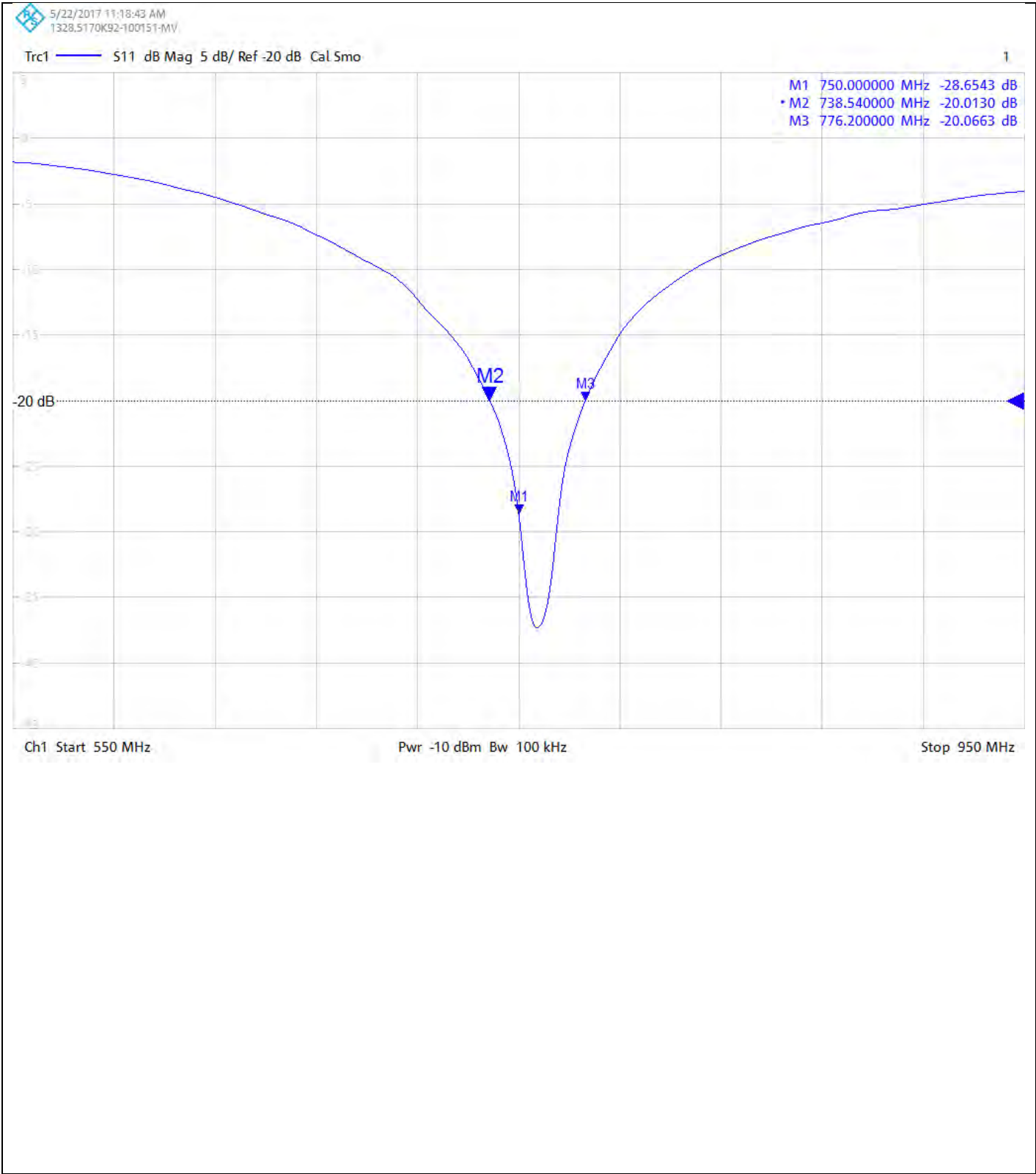
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### Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



**Calibration Certificate Label:**

|                                                                                                                        |                                                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>UKAS<br/>CALIBRATION<br/>5248</p> | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11762345JD01A</p> <p>Instrument ID: 1024</p> <p>Calibration Date: 12/May/2017</p> <p>Calibration Due Date:</p> |
|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                        |                                                                                                                                                                                         |
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|------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                                          |                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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|--------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



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Client **UL CCS USA**

Certificate No: **D835V2-4d142\_Sep16**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN:4d142**

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

Calibration date: **September 22, 2016**

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 ( $22 \pm 3$ )°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           | 15-Jun-16 (No. EX3-7349_Jun16)  | Jun-17                |
| DAE4                        | SN: 601            | 30-Dec-15 (No. DAE4-601_Dec15)  | Dec-16                |

| Secondary Standards       | ID #           | Check Date (in house)             | Scheduled Check        |
|---------------------------|----------------|-----------------------------------|------------------------|
| Power meter EPM-442A      | SN: GB37480704 | 07-Oct-15 (No. 217-02222)         | In house check: Oct-16 |
| Power sensor HP 8481A     | SN: US37292783 | 07-Oct-15 (No. 217-02222)         | In house check: Oct-16 |
| Power sensor HP 8481A     | SN: MY41092317 | 07-Oct-15 (No. 217-02223)         | In house check: Oct-16 |
| RF generator R&S SMT-06   | SN: 100972     | 15-Jun-15 (in house check Jun-15) | In house check: Oct-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

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

Issued: September 23, 2016

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**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 | 15 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5.0 mm    |             |
| Frequency                    | 835 MHz $\pm$ 1 MHz    |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 41.5           | 0.90 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 40.8 $\pm$ 6 % | 0.94 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 2.41 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 9.30 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 1.56 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 6.07 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             | 55.2           | 0.97 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 55.7 $\pm$ 6 % | 1.00 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 2.38 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 9.32 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 1.57 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 6.18 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 | 50.5 $\Omega$ - 6.1 j $\Omega$ |
| Return Loss                          | - 24.4 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 46.2 $\Omega$ - 8.6 j $\Omega$ |
| Return Loss                          | - 20.2 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.389 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 27, 2012 |



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

### Measurement Conditions

DASY system configuration, as far as not given on page 1 and 3.

|         |                  |                             |
|---------|------------------|-----------------------------|
| Phantom | SAM Head Phantom | For usage with cSAR3DV1-R/L |
|---------|------------------|-----------------------------|

### SAR result with SAM Head (Top)

| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                                |
|-------------------------------------------------------|--------------------|--------------------------------|
| SAR measured                                          | 250 mW input power | 2.40 W/kg                      |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>9.26W/kg ± 17.5 % (k=2)</b> |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                 |
|---------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                            | 250 mW input power | 1.59 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>6.18 W/kg ± 16.9 % (k=2)</b> |

### SAR result with SAM Head (Mouth)

| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                                 |
|-------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                          | 250 mW input power | 2.53 W/kg                       |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>9.76 W/kg ± 17.5 % (k=2)</b> |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                 |
|---------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                            | 250 mW input power | 1.66 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>6.45 W/kg ± 16.9 % (k=2)</b> |

### SAR result with SAM Head (Neck)

| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                                 |
|-------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                          | 250 mW input power | 2.38 W/kg                       |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>9.19 W/kg ± 17.5 % (k=2)</b> |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                 |
|---------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                            | 250 mW input power | 1.61 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>6.26 W/kg ± 16.9 % (k=2)</b> |

### SAR result with SAM Head (Ear)

| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                                 |
|-------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                          | 250 mW input power | 2.00 W/kg                       |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>7.72 W/kg ± 17.5 % (k=2)</b> |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                 |
|---------------------------------------------------------|--------------------|---------------------------------|
| SAR measured                                            | 250 mW input power | 1.35 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>5.25 W/kg ± 16.9 % (k=2)</b> |



## DASY5 Validation Report for Head TSL

Date: 19.09.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN:4d142**

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

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 0.94 \text{ S/m}$ ;  $\epsilon_r = 40.8$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.72, 9.72, 9.72); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

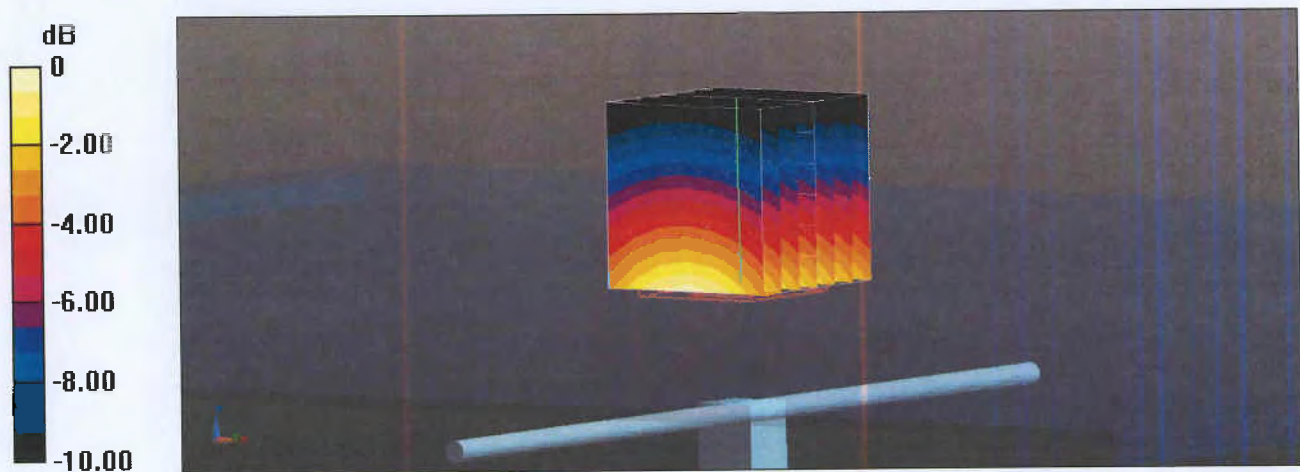
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 61.62 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.62 W/kg

**SAR(1 g) = 2.41 W/kg; SAR(10 g) = 1.56 W/kg**

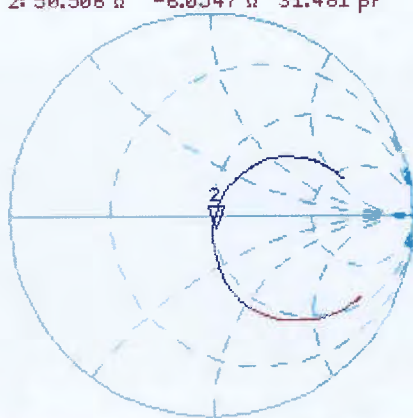
Maximum value of SAR (measured) = 3.22 W/kg



# Impedance Measurement Plot for Head TSL

19 Sep 2016 12:09:13  
CH1 S11 1 U FS 2: 50.506  $\Omega$  -6.0547  $\Omega$  31.481 pF 835.000 000 MHz

\*  
Del  
CA



Avg  
16

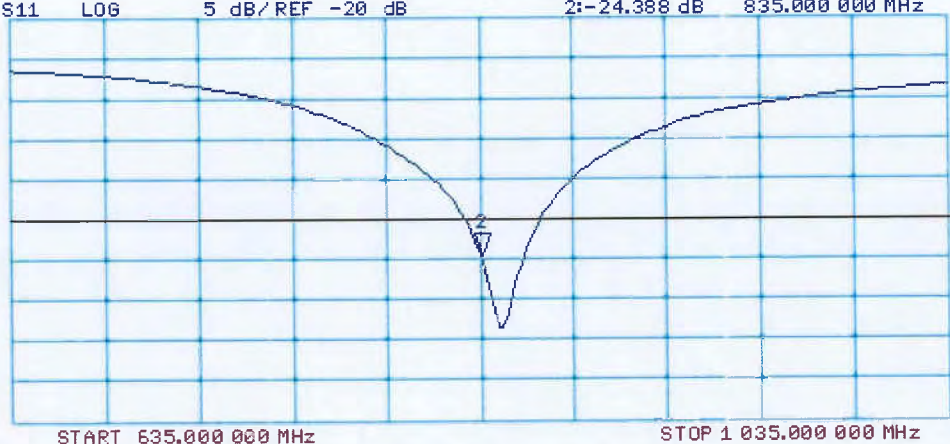
H1d

CH2 S11 LOG 5 dB/REF -20 dB 2:-24.388 dB 835.000 000 MHz

CA

Avg  
16

H1d





Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d142**

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

Medium parameters used:  $f = 835 \text{ MHz}$ ;  $\sigma = 1 \text{ S/m}$ ;  $\epsilon_r = 55.7$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.73, 9.73, 9.73); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 4.9L; Type: QD000P49AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

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

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

Reference Value = 59.27 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.43 W/kg

**SAR(1 g) = 2.38 W/kg; SAR(10 g) = 1.57 W/kg**

Maximum value of SAR (measured) = 3.11 W/kg



0 dB = 3.11 W/kg = 4.93 dBW/kg

# Impedance Measurement Plot for Body TSL

12 Sep 2016 10:59:17  
 CH1 S11 1 U FS 1: 46.160  $\Omega$  -8.6035  $\Omega$  22.154 pF 835.000 000 MHz

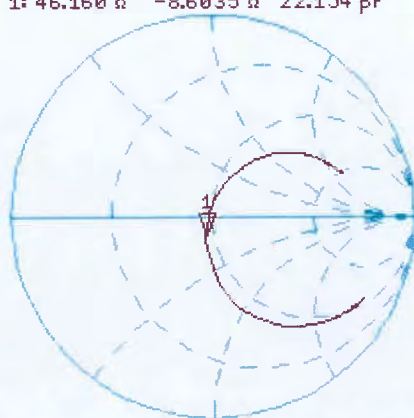
\*

De1

CA

Avg  
16

H1d

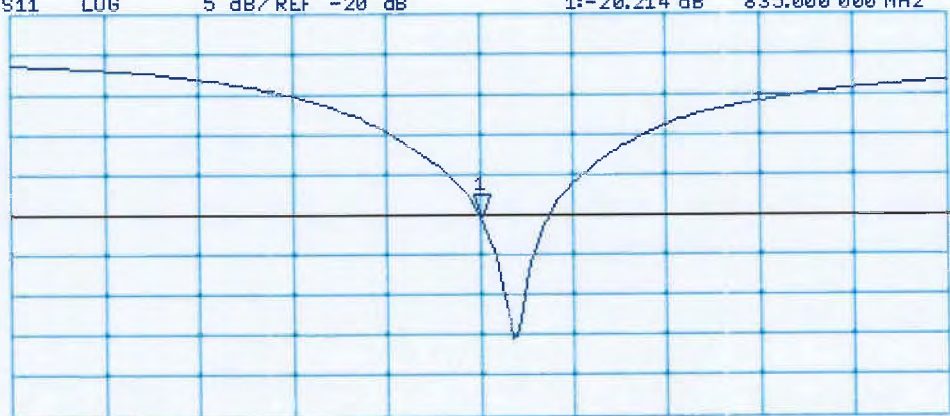


CH2 S11 LOG 5 dB/REF -20 dB 1:-20.214 dB 835.000 000 MHz

CA

Avg  
16

H1d



START 635.000 000 MHz

STOP 1 035.000 000 MHz

## DASY5 Validation Report for SAM Head

Date: 22.09.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN: 4d142**

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

Medium parameters used:  $f = 835$  MHz;  $\sigma = 0.95$  S/m;  $\epsilon_r = 42.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.72, 9.72, 9.72); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: SAM Head
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7372)

**SAM Head/Top/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 60.83 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.53 W/kg

**SAR(1 g) = 2.40 W/kg; SAR(10 g) = 1.59 W/kg**

Maximum value of SAR (measured) = 3.16 W/kg

**SAM Head/Mouth/Zoom Scan (7x8x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 58.70 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 3.92 W/kg

**SAR(1 g) = 2.53 W/kg; SAR(10 g) = 1.66 W/kg**

Maximum value of SAR (measured) = 3.53 W/kg

**SAM Head/Neck/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 59.26 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 3.35 W/kg

**SAR(1 g) = 2.38 W/kg; SAR(10 g) = 1.61 W/kg**

Maximum value of SAR (measured) = 3.05 W/kg

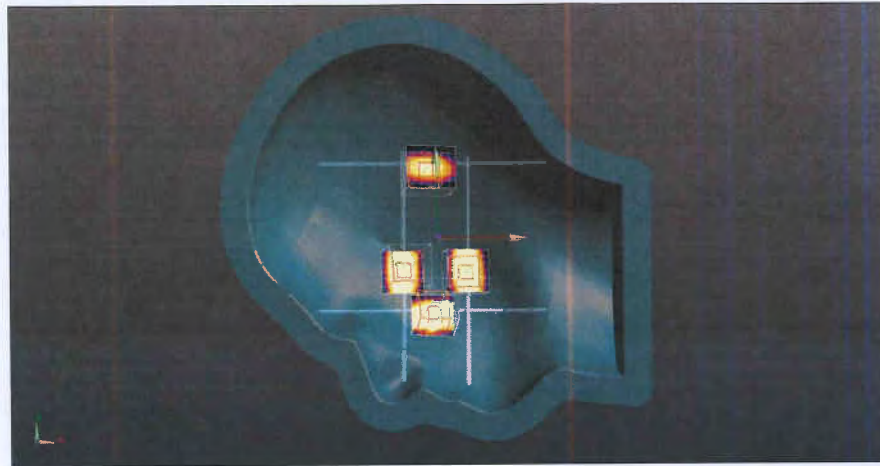
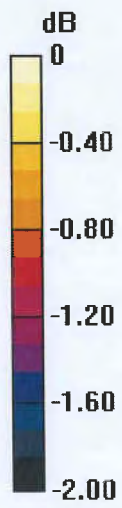
**SAM Head/Ear/Zoom Scan (8x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 54.45 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 2.83 W/kg

**SAR(1 g) = 2 W/kg; SAR(10 g) = 1.35 W/kg**

Maximum value of SAR (measured) = 2.55 W/kg



0 dB = 2.55 W/kg = 4.07 dBW/kg





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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: **D1750V2-1053\_Aug16**

## CALIBRATION CERTIFICATE

Object **D1750V2 - SN:1053**

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

Calibration date: **August 16, 2016**

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 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           | 15-Jun-16 (No. EX3-7349_Jun16)  | Jun-17                |
| DAE4                        | SN: 601            | 30-Dec-15 (No. DAE4-601_Dec15)  | Dec-16                |

| Secondary Standards       | ID #           | Check Date (in house)             | Scheduled Check        |
|---------------------------|----------------|-----------------------------------|------------------------|
| Power meter EPM-442A      | SN: GB37480704 | 07-Oct-15 (No. 217-02222)         | In house check: Oct-16 |
| Power sensor HP 8481A     | SN: US37292783 | 07-Oct-15 (No. 217-02222)         | In house check: Oct-16 |
| Power sensor HP 8481A     | SN: MY41092317 | 07-Oct-15 (No. 217-02223)         | In house check: Oct-16 |
| RF generator R&S SMT-06   | SN: 100972     | 15-Jun-15 (in house check Jun-15) | In house check: Oct-16 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

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

Issued: August 16, 2016

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                    | 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 | 40.3 $\pm$ 6 % | 1.37 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 9.34 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 37.4 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 4.93 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 19.7 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 | 53.1 $\pm$ 6 % | 1.49 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 9.36 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 37.4 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 4.94 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 19.7 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 | 49.6 $\Omega$ + 0.3 j $\Omega$ |
| Return Loss                          | - 46.3 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 46.2 $\Omega$ - 2.1 j $\Omega$ |
| Return Loss                          | - 26.9 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.219 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: 16.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1053**

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

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.37$  S/m;  $\epsilon_r = 40.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.46, 8.46, 8.46); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; 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:

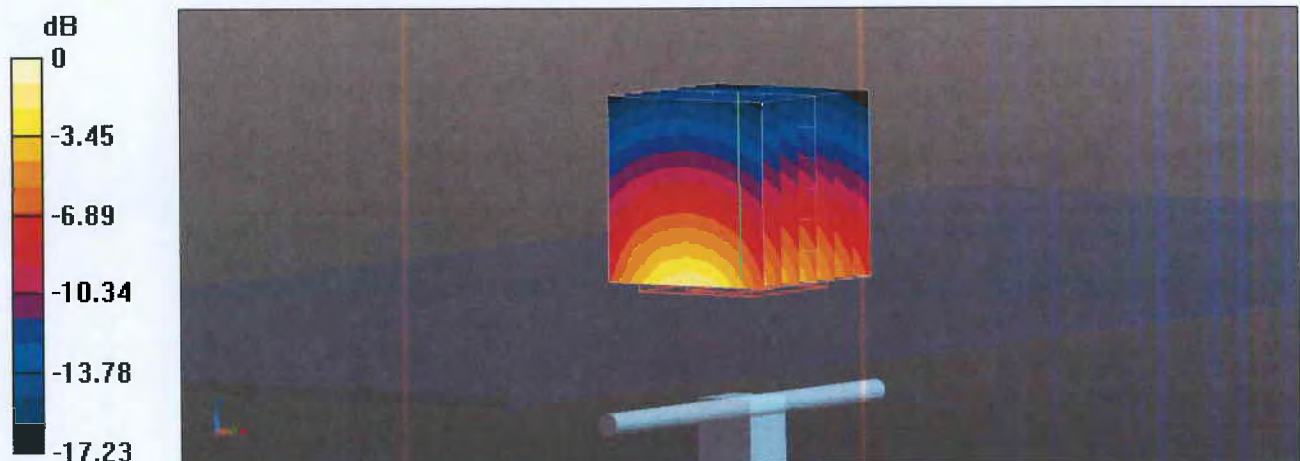
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 106.4 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 17.4 W/kg

**SAR(1 g) = 9.34 W/kg; SAR(10 g) = 4.93 W/kg**

Maximum value of SAR (measured) = 14.4 W/kg



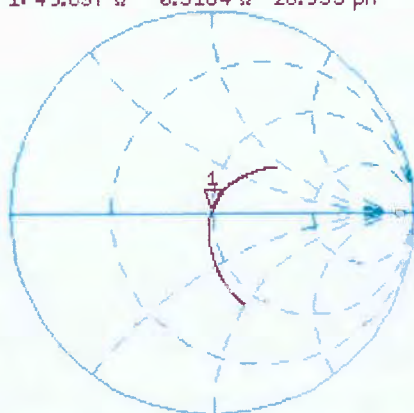
0 dB = 14.4 W/kg = 11.58 dBW/kg



# Impedance Measurement Plot for Head TSL

16 Aug 2016 13:22:53  
 CH1 S11 1 U FS 1: 49.637  $\Omega$  0.3184  $\Omega$  28.953  $\mu\text{H}$  1 750.000 000 MHz

\*  
 Del  
 CA



Avg  
 16

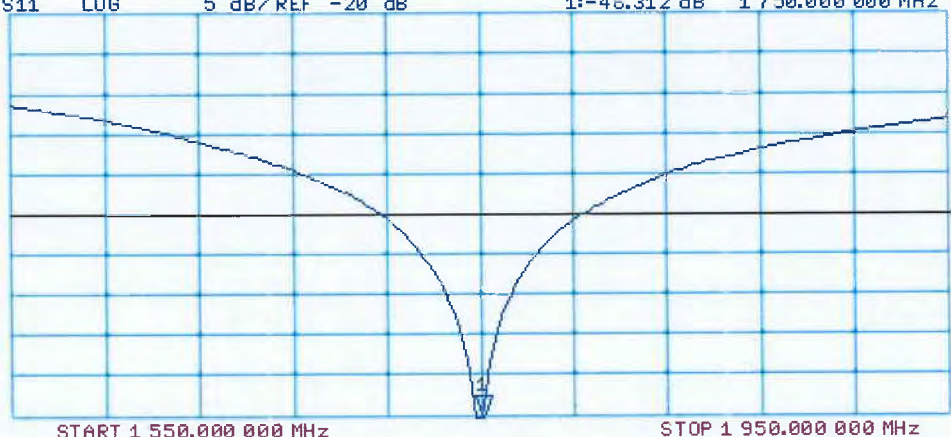
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -46.312 dB 1 750.000 000 MHz

CA

Avg  
 16

H1d



START 1 550.000 000 MHz

STOP 1 950.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 15.08.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1750 MHz; Type: D1750V2; Serial: D1750V2 - SN:1053**

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

Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.49$  S/m;  $\epsilon_r = 53.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.25, 8.25, 8.25); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; 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:**

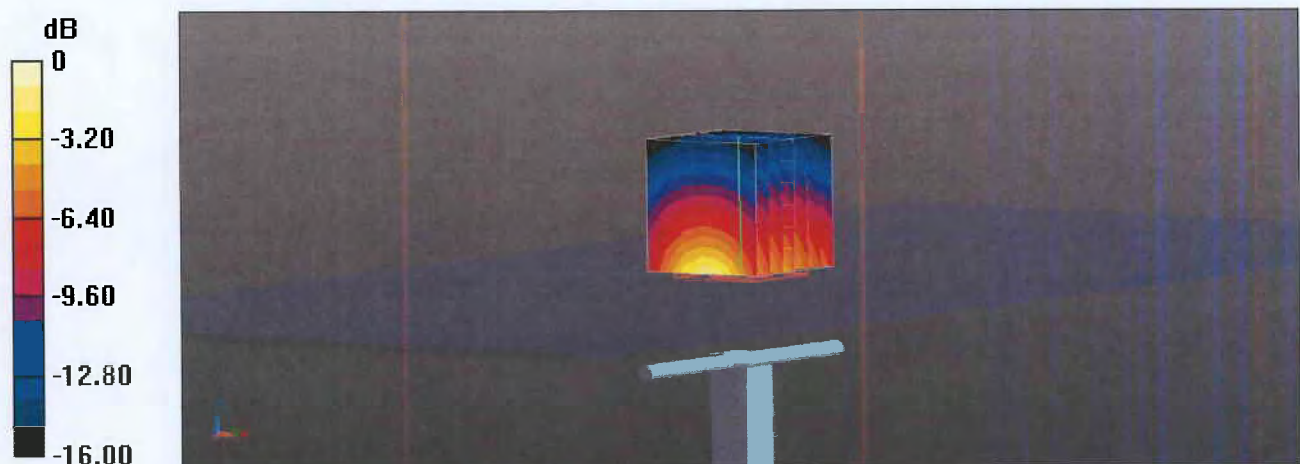
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 101.8 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 16.7 W/kg

**SAR(1 g) = 9.36 W/kg; SAR(10 g) = 4.94 W/kg**

Maximum value of SAR (measured) = 14.1 W/kg



0 dB = 14.1 W/kg = 11.49 dBW/kg

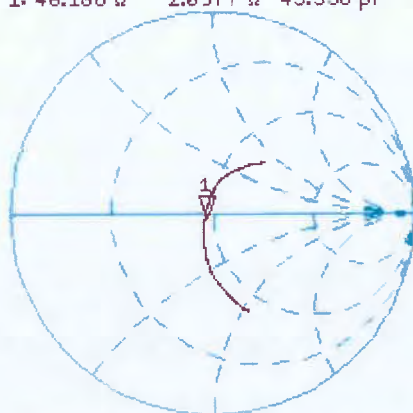
# Impedance Measurement Plot for Body TSL

15 Aug 2016 16:32:27  
 CH1 S11 1 U FS 1: 46.188  $\Omega$  -2.0977  $\Omega$  43.356 pF 1 750.000 000 MHz

\*  
 Del  
 CA

Avg  
 16

H1d

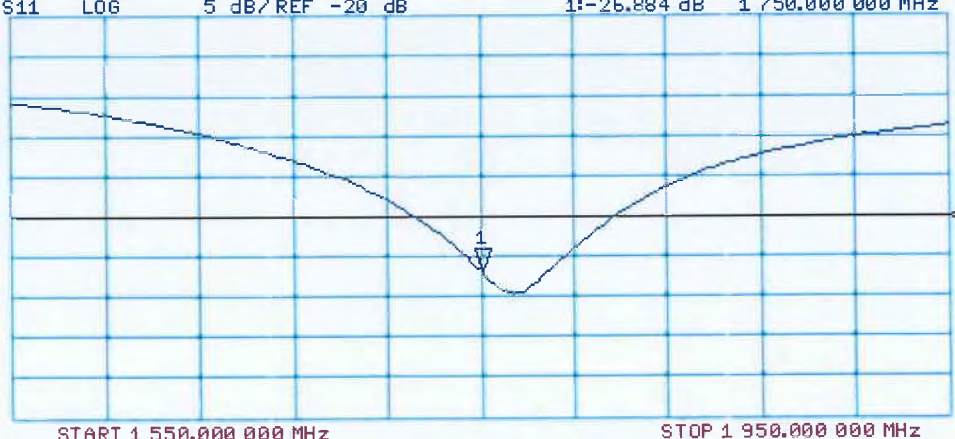


CH2 S11 LOG 5 dB/REF -20 dB 1: -26.884 dB 1 750.000 000 MHz

CA

Avg  
 16

H1d



START 1 550.000 000 MHz

STOP 1 950.000 000 MHz





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Accreditation No.: **SCS 0108**

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Multilateral Agreement for the recognition of calibration certificates

Client **UL CCS USA**

Certificate No: **D1900V2-5d043\_Nov16**

## CALIBRATION CERTIFICATE

Object **D1900V2 - SN:5d043**

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

Calibration date: **November 09, 2016**

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 ( $22 \pm 3$ )°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           | 15-Jun-16 (No. EX3-7349_Jun16)  | Jun-17                |
| DAE4                        | SN: 601            | 30-Dec-15 (No. DAE4-601_Dec15)  | Dec-16                |

| 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 |

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

Issued: November 10, 2016

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 | 40.6 $\pm$ 6 % | 1.39 mho/m $\pm$ 6 % |
| Head TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Head TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 9.92 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 40.0 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 5.19 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 20.9 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             | 53.3           | 1.52 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 53.0 $\pm$ 6 % | 1.46 mho/m $\pm$ 6 % |
| Body TSL temperature change during test | < 0.5 °C            | ----           | ----                 |

## SAR result with Body TSL

|                                                       |                    |                              |
|-------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 1 cm <sup>3</sup> (1 g) of Body TSL | Condition          |                              |
| SAR measured                                          | 250 mW input power | 9.55 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 39.1 W/kg $\pm$ 17.0 % (k=2) |

|                                                         |                    |                              |
|---------------------------------------------------------|--------------------|------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                              |
| SAR measured                                            | 250 mW input power | 5.10 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 20.7 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 | 51.5 $\Omega$ + 3.5 j $\Omega$ |
| Return Loss                          | - 28.6 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 46.1 $\Omega$ + 4.7 j $\Omega$ |
| Return Loss                          | - 24.0 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.194 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 16, 2003 |



## DASY5 Validation Report for Head TSL

Date: 09.11.2016

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d043**

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

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.39$  S/m;  $\epsilon_r = 40.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.99, 7.99, 7.99); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7331)

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

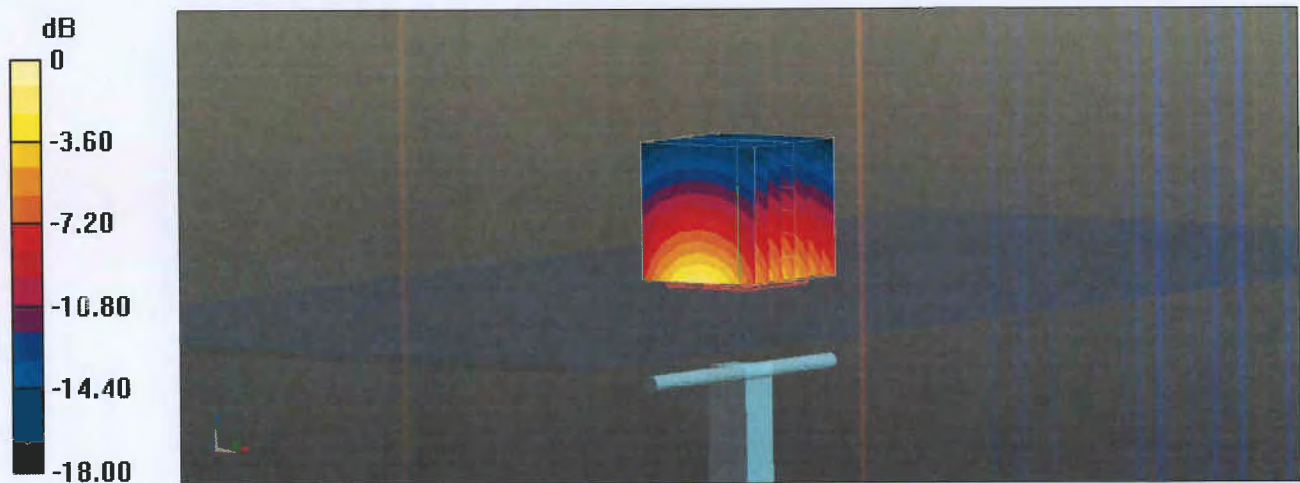
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 108.3 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 18.7 W/kg

**SAR(1 g) = 9.92 W/kg; SAR(10 g) = 5.19 W/kg**

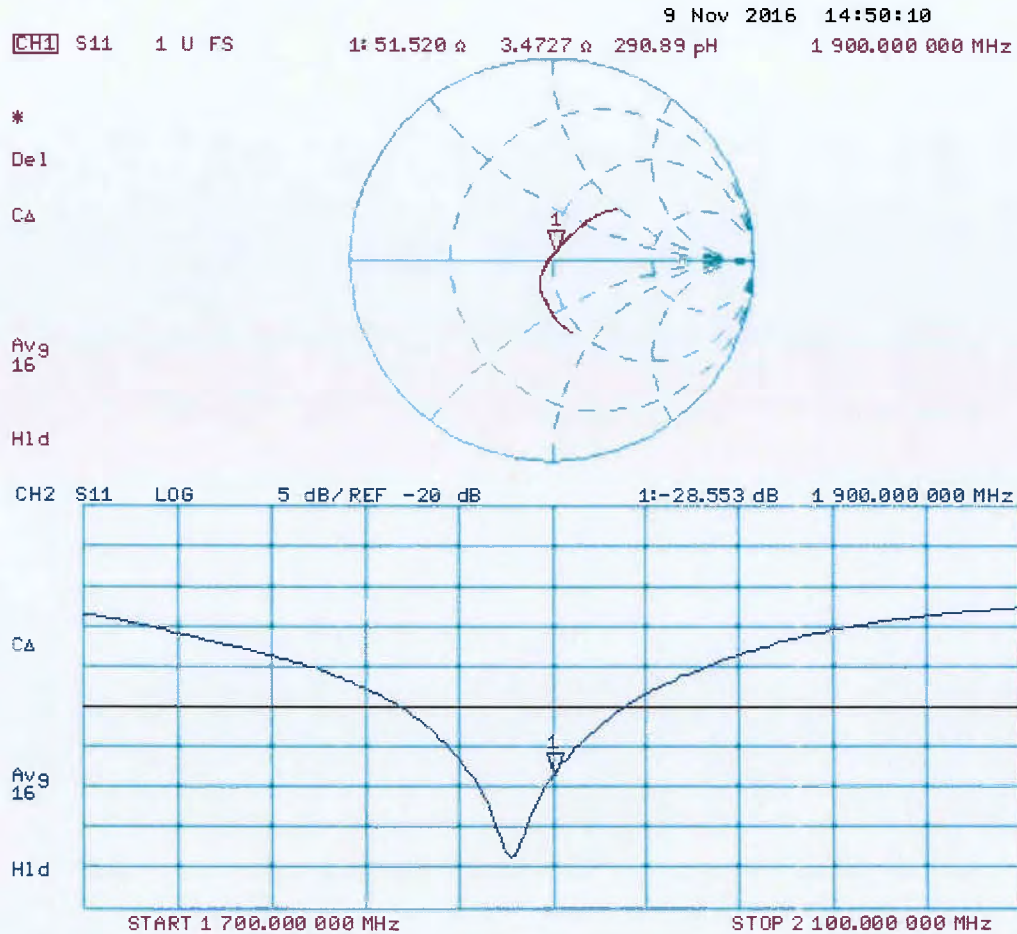
Maximum value of SAR (measured) = 15.5 W/kg



0 dB = 15.5 W/kg = 11.90 dBW/kg



# Impedance Measurement Plot for Head TSL



Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN:5d043**

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

Medium parameters used:  $f = 1900$  MHz;  $\sigma = 1.46$  S/m;  $\epsilon_r = 53$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.03, 8.03, 8.03); Calibrated: 15.06.2016;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.12.2015
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7331)

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

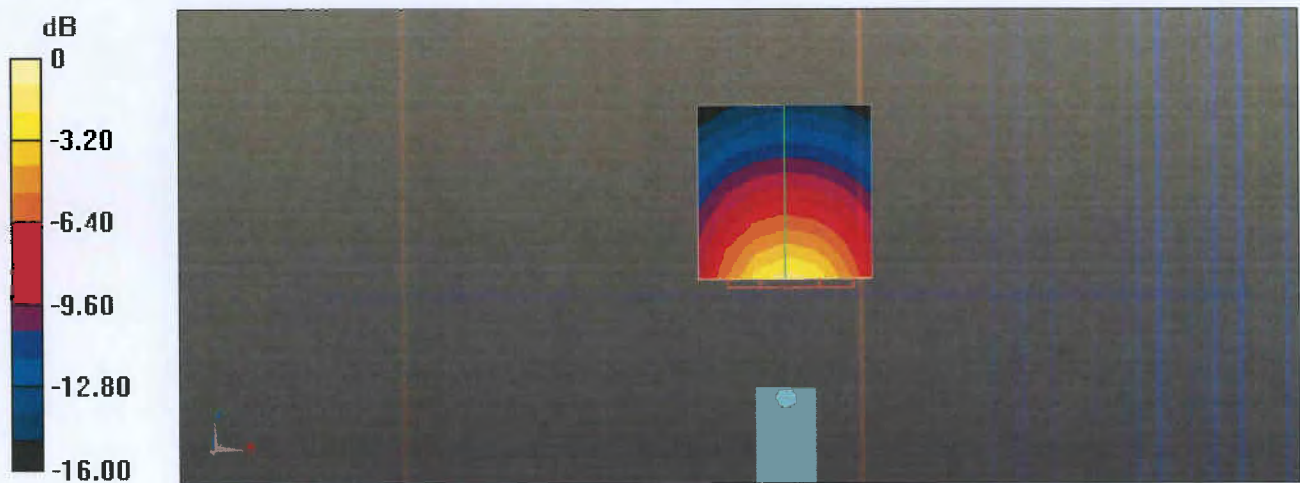
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 103.7 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 16.5 W/kg

**SAR(1 g) = 9.55 W/kg; SAR(10 g) = 5.1 W/kg**

Maximum value of SAR (measured) = 14.2 W/kg

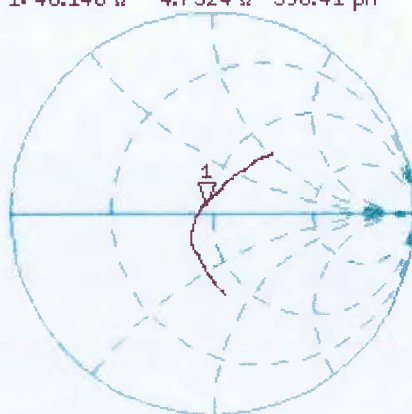


0 dB = 14.2 W/kg = 11.52 dBW/kg

# Impedance Measurement Plot for Body TSL

9 Nov 2016 14:49:12  
CH1 S11 1 U FS 1: 46.148  $\Omega$  4.7324  $\Omega$  396.41 pF 1 900.000 000 MHz

\*  
De1  
CA



Avg  
16

H1d

CH2 S11 LOG 5 dB/REF -20 dB 1:-23.962 dB 1 900.000 000 MHz

CA

Avg  
16

H1d

