

# CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 30/Nov/2017

CERTIFICATE NUMBER : 11903932JD01A



5248

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



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APPROVED SIGNATORY

A handwritten signature in black ink, appearing to read 'N. Mirza'.

Naseer Mirza

## Customer :

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

## Equipment Details:

|                    |                                                                              |                  |             |
|--------------------|------------------------------------------------------------------------------|------------------|-------------|
| Description:       | Dipole Validation Kit                                                        | Date of Receipt: | 20/Nov/2017 |
| Manufacturer:      | Speag                                                                        |                  |             |
| Type/Model Number: | D750V3                                                                       |                  |             |
| Serial Number:     | 1071                                                                         |                  |             |
| Calibration Date:  | 21/Nov/2017                                                                  |                  |             |
| Calibrated By:     | Chanthu Thevarajah<br>Laboratory Engineer                                    |                  |             |
| Signature:         | A handwritten signature in blue ink, appearing to read 'Chanthu Thevarajah'. |                  |             |

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.

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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) |
|------------|------------------------------|----------------------|---------------|------------|-----------------------|------------------------|
| A2546      | Data Acquisition Electronics | SPEAG                | DAE4          | 1435       | 10 Feb 2017           | 12                     |
| A2545      | Probe                        | SPEAG                | ES3DV4        | 3395       | 04 May 2017           | 12                     |
| A2765      | Dipole                       | SPEAG                | D750V3        | 1147       | 21 Sep 2017           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi               | ART 100850-01 | 0001       | Cal as part of System | 12                     |
| M1855      | Power Sensor                 | Rhode & Schwarz      | NRP-Z51       | 103246     | 08 Nov 2017           | 12                     |
| M1015      | Network Analyser             | Agilent Technologies | 8753ES        | US39172406 | 10 Oct 2017           | 12                     |
| PRE0151154 | Network Analyser             | Rhode & Schwarz      | ZND8          | 100151     | 22 Nov 2016           | 24                     |
| PRE0151877 | Calibration Kit              | Rhode & Schwarz      | Z135          | 102947-Bt  | 02 Dec 2016           | 12                     |
| M1838      | Signal Generator             | Rhode & Schwarz      | SME06         | 831377/005 | 30 Mars 2017          | 12                     |

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### 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:  | 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 | 20.5°C      | 21.0°C | $\epsilon_r$ | 41.96        | 41.94          | ± 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  | 2.16 W/Kg          | 8.59 W/Kg            | ± 17.57%        |
|                 | SAR averaged over 10g | 1.44 W/Kg          | 5.73 W/Kg            | ± 17.32%        |

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

| Simulant Liquid | Parameter   | Measured Level                  | Uncertainty (%)                    |
|-----------------|-------------|---------------------------------|------------------------------------|
| Head            | Impedance   | 46.312 $\Omega$ 2.22 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 26.76                           | ± 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        | 54.53          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 0.96         | 0.96           | ± 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  | 2.14 W/Kg          | 8.52 W/Kg            | ± 18.06%        |
|                 | SAR averaged over 10g | 1.43 W/Kg          | 5.69 W/Kg            | ± 17.44%        |

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

| Simulant Liquid | Parameter   | Measured Level                 | Uncertainty (%)                    |
|-----------------|-------------|--------------------------------|------------------------------------|
| Body            | Impedance   | 52.11 $\Omega$ 4.88 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 26.35                          | ± 2.03 dB                          |

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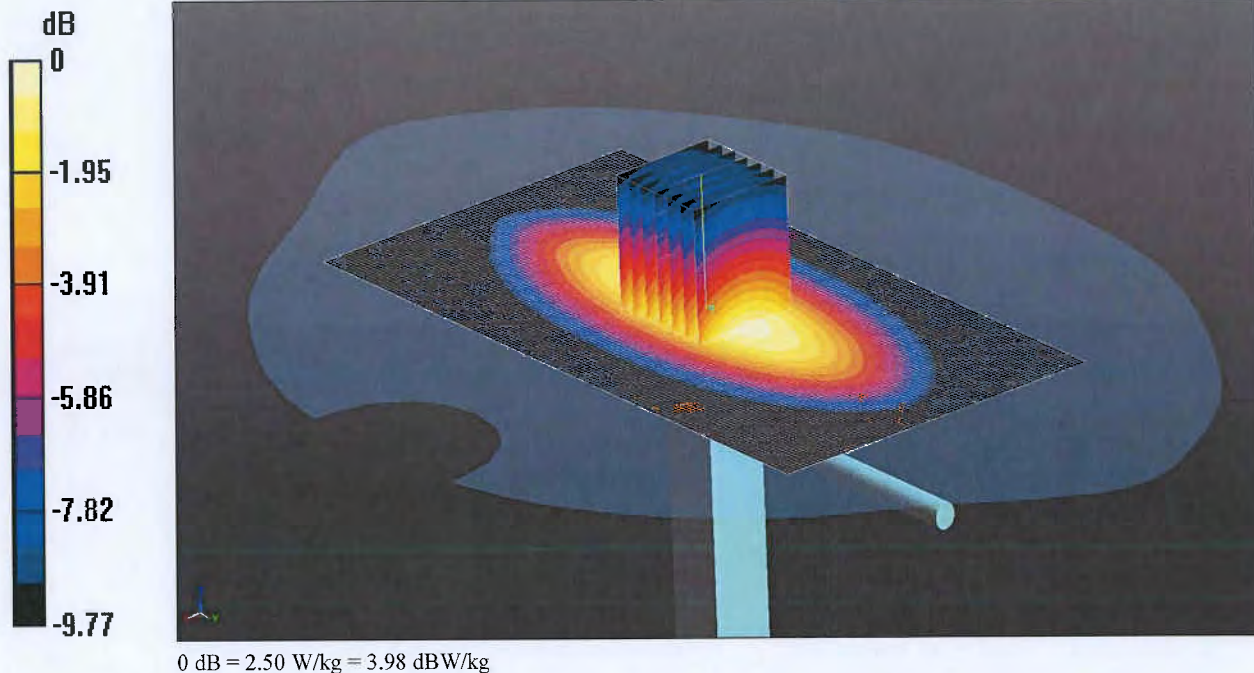
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: Dipole 750 MHz SN:1047; Type: D750V3; Serial: D750V3 - SN:1071



Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1

Medium: 750,835,900,1800,1900 MHz HSL Medium parameters used:  $f = 750$  MHz;  $\sigma = 0.914$  S/m;  $\epsilon_r = 41.936$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3995; ConvF(10.57, 10.57, 10.57); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (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=15mm, Pin=250mW 2 2 2 2/Area Scan (81x151x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 2.50 W/kg

**Configuration/d=15mm, Pin=250mW 2 2 2 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 50.49 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 3.18 W/kg

**SAR(1 g) = 2.16 W/kg; SAR(10 g) = 1.44 W/kg**

Maximum value of SAR (measured) = 2.50 W/kg

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

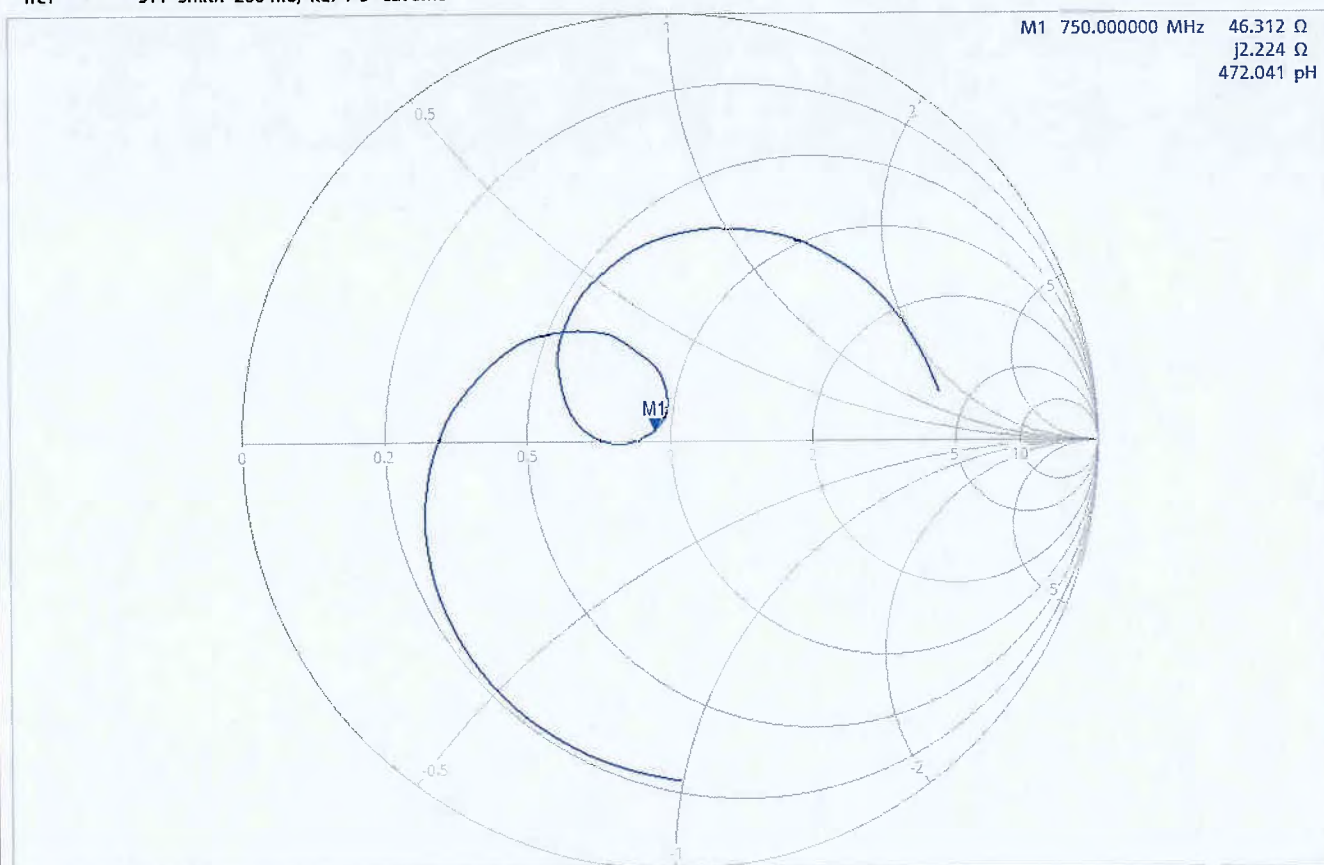


11/28/2017 3:29:06 PM  
1326.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal Smo

1

M1 750.000000 MHz 46.312  $\Omega$   
j2.224  $\Omega$   
472.041 pF



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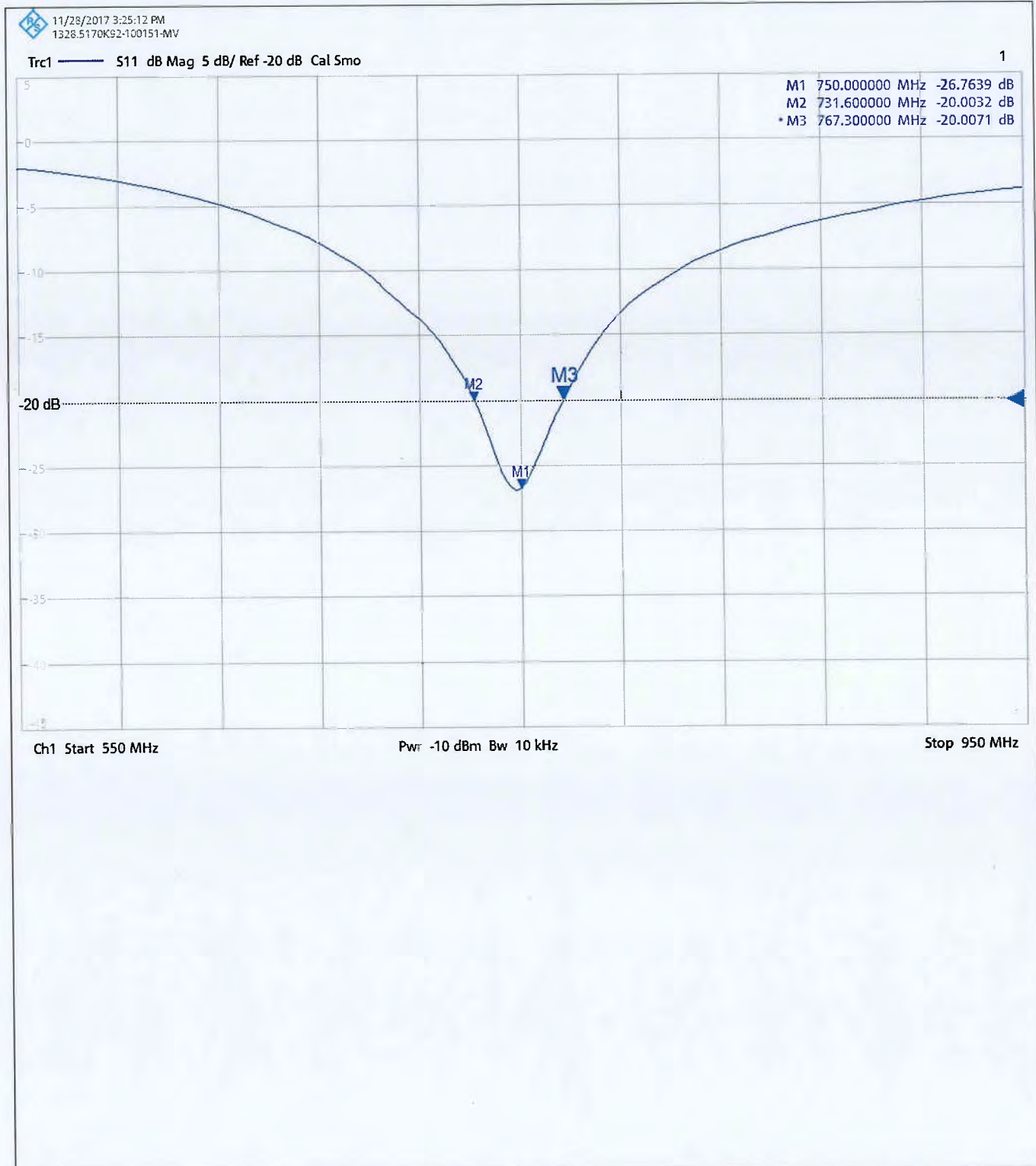
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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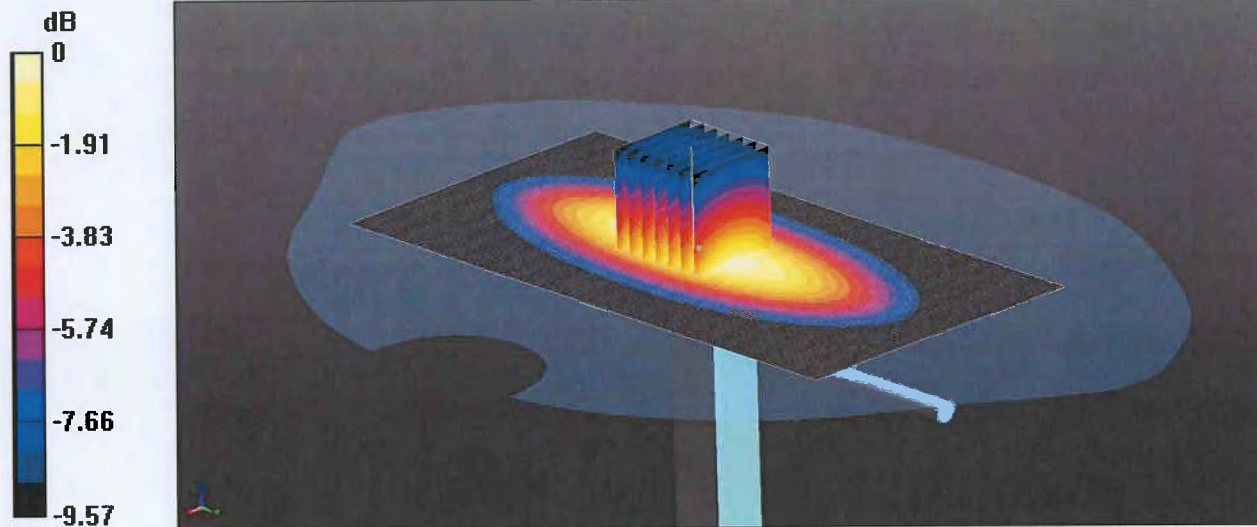
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 750 MHz; Type: D750V3; Serial: D750V3 - SN:1011



0 dB = 2.29 W/kg = 3.60 dBW/kg

Communication System: UID 0, CW; Frequency: 750 MHz; Duty Cycle: 1:1

Medium: MSL(750,835,900,1800,1900,5G) Medium parameters used:  $f = 750 \text{ MHz}$ ;  $\sigma = 0.96 \text{ S/m}$ ;  $\epsilon_r = 54.527$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3995; ConvF(10.33, 10.33, 10.33); Calibrated: 04/05/2017;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

**Configuration/d=15mm, Pin=250mW 2/Area Scan (81x151x1):** Interpolated grid:  $dx=1.200 \text{ mm}$ ,  $dy=1.200 \text{ mm}$

Maximum value of SAR (interpolated) = 2.29 W/kg

**Configuration/d=15mm, Pin=250mW 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 48.67 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 3.12 W/kg

**SAR(1 g) = 2.14 W/kg; SAR(10 g) = 1.43 W/kg**

Maximum value of SAR (measured) = 2.29 W/kg

# CERTIFICATE OF CALIBRATION

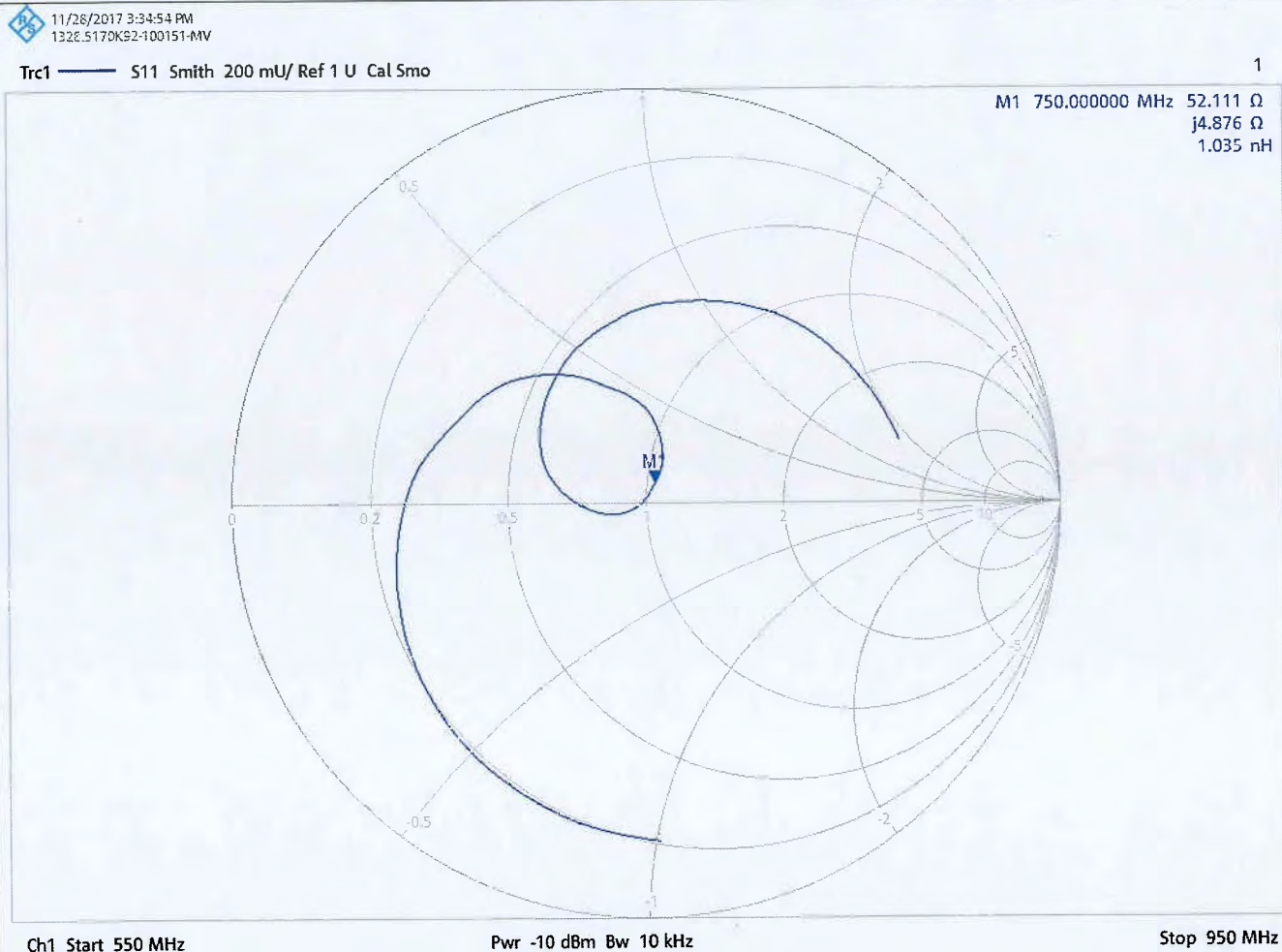
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### Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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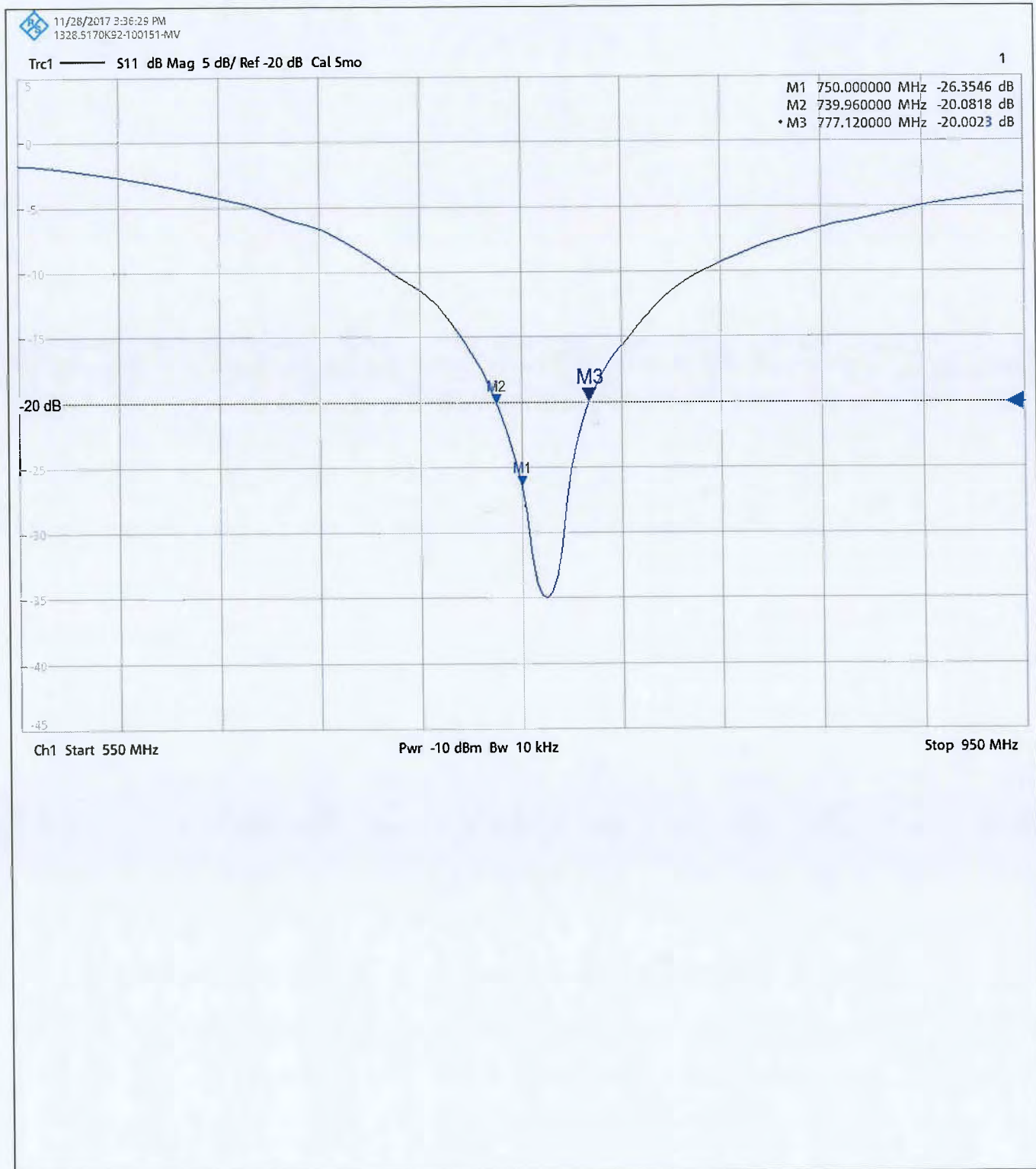
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### Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



**Calibration Certificate Label:**

|                                                                                   |                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903932JD01A</p> <p>Instrument ID: 1071</p> <p>Calibration Date: 21/Nov/2017</p> <p>Calibration Due Date:</p> |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                   |                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903932JD01A</p> <p>Instrument ID: 1071</p> <p>Calibration Date: 21/Nov/2017</p> <p>Calibration Due Date:</p> |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                     |                                                                                                                                                                                         |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903932JD01A</p> <p>Instrument ID: 1071</p> <p>Calibration Date: 21/Nov/2017</p> <p>Calibration Due Date:</p> |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|



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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: **D835V2-4d142\_Oct17**

## CALIBRATION CERTIFICATE

Object **D835V2 - SN:4d142**

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

Calibration date: **October 12, 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  $(22 \pm 3)^{\circ}\text{C}$  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         | 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-May-17 (No. EX3-7349_May17)  | May-18                |
| 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-17) | In house check: Oct-18 |

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

Issued: October 13, 2017

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Accreditation No.: **SCS 0108**

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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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- 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                  | V52.10.0    |
| Extrapolation                | Advanced Extrapolation |             |
| Phantom                      | Modular Flat Phantom   |             |
| Distance Dipole Center - TSL | 15 mm                  | with Spacer |
| Zoom Scan Resolution         | dx, dy, dz = 5 mm      |             |
| Frequency                    | 835 MHz $\pm$ 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 | 40.7 $\pm$ 6 % | 0.92 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 | 2.46 W/kg                    |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | 9.64 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 | 1.58 W/kg                    |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | 6.22 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 | 54.4 $\pm$ 6 % | 1.01 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 | 2.49 W/kg                    |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | 9.63 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 | 1.61 W/kg                    |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | 6.27 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 | 50.8 $\Omega$ - 3.4 j $\Omega$ |
| Return Loss                          | - 29.3 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 47.1 $\Omega$ - 6.0 j $\Omega$ |
| Return Loss                          | - 23.3 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.392 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 |

## DASY5 Validation Report for Head TSL

Date: 12.10.2017

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

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.07, 10.07, 10.07); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

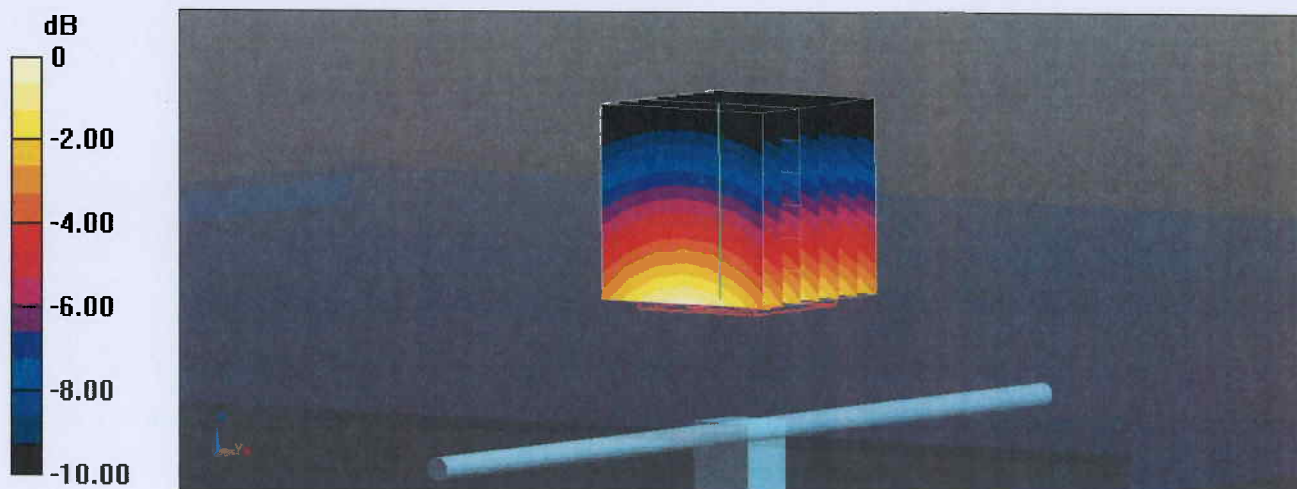
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

Reference Value = 63.04 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 3.87 W/kg

**SAR(1 g) = 2.46 W/kg; SAR(10 g) = 1.58 W/kg**

Maximum value of SAR (measured) = 3.37 W/kg

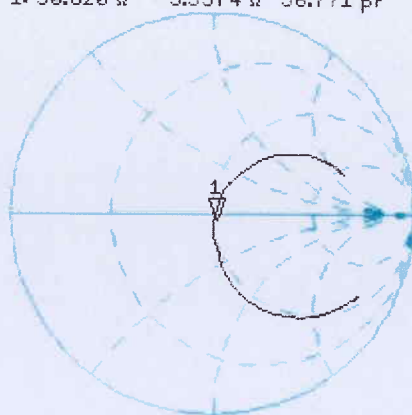


0 dB = 3.37 W/kg = 5.28 dBW/kg

# Impedance Measurement Plot for Head TSL

12 Oct 2017 14:25:42  
 CH1 S11 1 U FS 1: 50.820  $\Omega$  -3.3574  $\Omega$  56.771 pF 835.000 000 MHz

\*  
 Del  
 CA



Avg  
 16

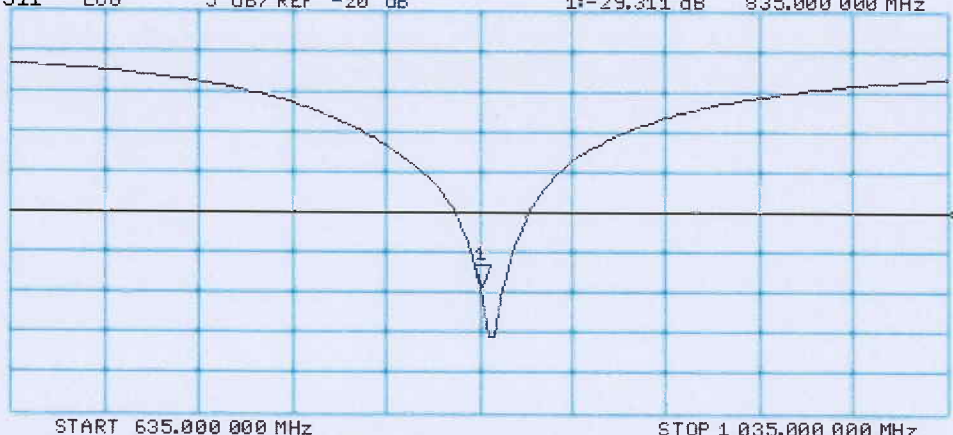
H1d

CH2 S11 LOG 5 dB/REF -20 dB 1: -29.311 dB 835.000 000 MHz

CA

Avg  
 16

H1d



START 635.000 000 MHz

STOP 1 035.000 000 MHz

## DASY5 Validation Report for Body TSL

Date: 12.10.2017

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:  $f = 835 \text{ MHz}$ ;  $\sigma = 1.01 \text{ S/m}$ ;  $\epsilon_r = 54.4$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(10.2, 10.2, 10.2); Calibrated: 31.05.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 28.03.2017
- Phantom: Flat Phantom 4.9 (Back); Type: QD 00R P49 AA; Serial: 1005
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

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

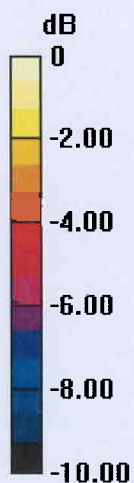
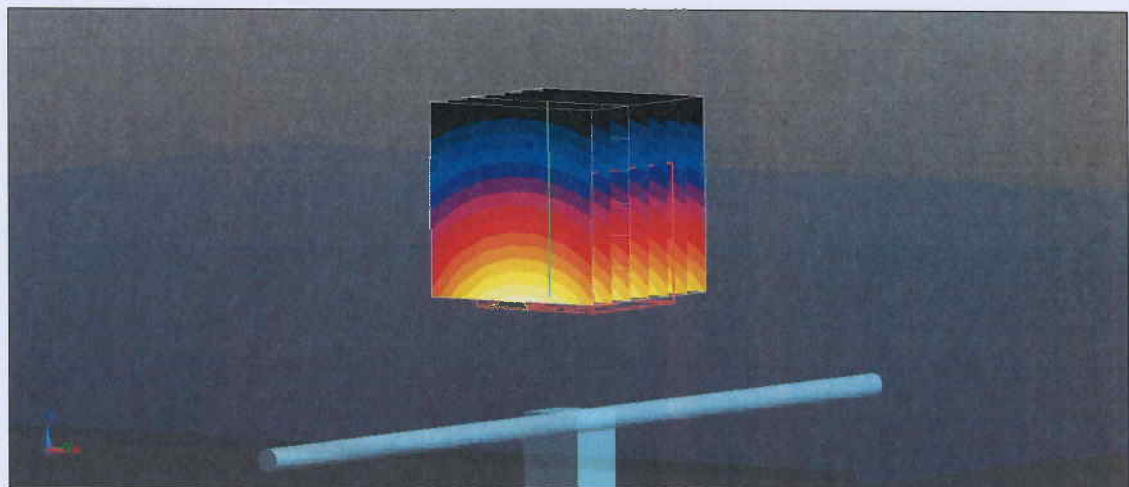
Measurement grid:  $dx=5\text{mm}$ ,  $dy=5\text{mm}$ ,  $dz=5\text{mm}$

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

Peak SAR (extrapolated) = 3.83 W/kg

**SAR(1 g) = 2.49 W/kg; SAR(10 g) = 1.61 W/kg**

Maximum value of SAR (measured) = 3.33 W/kg



0 dB = 3.33 W/kg = 5.22 dBW/kg

# Impedance Measurement Plot for Body TSL

12 Oct 2017 13:06:15  
CH1 S11 1 U FS 1: 47.109  $\Omega$  -5.9531  $\Omega$  32.018 pF 835.000 000 MHz

\*

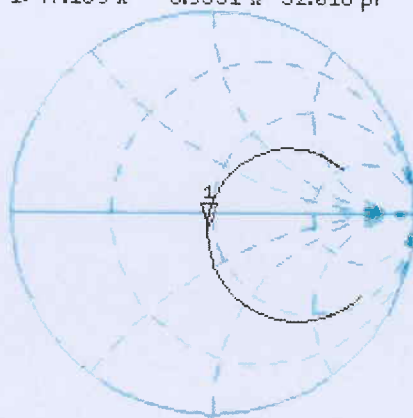
Del

CA

Avg

16

H1d



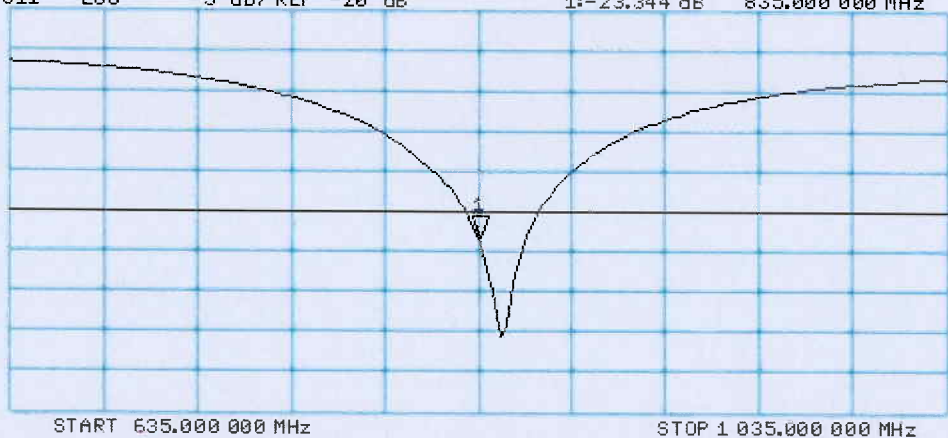
CH2 S11 LOG 5 dB/REF -20 dB 1: -23.344 dB 835.000 000 MHz

CA

Avg

16

H1d



## 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 <sup>3</sup> (1 g) of Head TSL | Condition          |                                 |
|-------------------------------------------------------|--------------------|---------------------------------|
| SAR (average measured)                                | 250 mW input power | 2.34 W/kg                       |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>9.05 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 | 1.53 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>5.97 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 (average measured)                                | 250 mW input power | 2.45 W/kg                       |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>9.50 W/kg ± 17.5 % (k=2)</b> |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                 |
|---------------------------------------------------------|--------------------|---------------------------------|
| SAR (average measured)                                  | 250 mW input power | 1.63 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>6.36 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 (average measured)                                | 250 mW input power | 2.32 W/kg                       |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>9.03 W/kg ± 17.5 % (k=2)</b> |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                 |
|---------------------------------------------------------|--------------------|---------------------------------|
| SAR (average measured)                                  | 250 mW input power | 1.55 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>6.08 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 (average measured)                                | 250 mW input power | 1.99 W/kg                       |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>7.73 W/kg ± 17.5 % (k=2)</b> |

| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                 |
|---------------------------------------------------------|--------------------|---------------------------------|
| SAR (average measured)                                  | 250 mW input power | 1.33 W/kg                       |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>5.18 W/kg ± 16.9 % (k=2)</b> |

# CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 29/Nov/2017      CERTIFICATE NUMBER : 11903932JD01B



**5248**

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**

A handwritten signature in black ink, appearing to read 'N. Mirza'.

Naseer Mirza

## Customer :

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

## Equipment Details:

|                    |                                           |                  |             |
|--------------------|-------------------------------------------|------------------|-------------|
| Description:       | Dipole Validation Kit                     | Date of Receipt: | 20/Nov/2017 |
| Manufacturer:      | Speag                                     |                  |             |
| Type/Model Number: | D835V2                                    |                  |             |
| Serial Number:     | 4d002                                     |                  |             |
| Calibration Date:  | 21/Nov/2017                               |                  |             |
| Calibrated By:     | Chanthu Thevarajah<br>Laboratory Engineer |                  |             |

Signature:

A handwritten signature in blue ink, appearing to read 'Chanthu Thevarajah'.

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.

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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) |
|------------|------------------------------|----------------------|---------------|------------|-----------------------|------------------------|
| A2546      | Data Acquisition Electronics | SPEAG                | DAE4          | 1435       | 10 Feb 2017           | 12                     |
| A2545      | Probe                        | SPEAG                | ES3DV4        | 3395       | 04 May 2017           | 12                     |
| PRE0159049 | Dipole                       | SPEAG                | D835V2        | 438        | 28 April 2017         | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi               | ART 100850-01 | 0001       | Cal as part of System | 12                     |
| M1855      | Power Sensor                 | Rhode & Schwarz      | NRP-Z51       | 103246     | 08 Nov 2017           | 12                     |
| M1015      | Network Analyser             | Agilent Technologies | 8753ES        | US39172406 | 10 Oct 2017           | 12                     |
| PRE0151154 | Network Analyser             | Rhode & Schwarz      | ZND8          | 100151     | 22 Nov 2016           | 24                     |
| PRE0151877 | Calibration Kit              | Rhode & Schwarz      | Z135          | 102947-Bt  | 02 Dec 2016           | 12                     |
| M1838      | Signal Generator             | Rhode & Schwarz      | SME06         | 831377/005 | 30 Mars 2017          | 12                     |

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### 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:  | 15 mm (with spacer)                        |
| Frequency:               | 835 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            | 835             | 21.0 °C   | 21.0 °C | 20.5°C      | 21.0°C | $\epsilon_r$ | 41.50        | 41.73          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 0.90         | 0.94           | ± 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  | 2.58 W/Kg          | 10.27 W/Kg           | ± 17.57%        |
|                 | SAR averaged over 10g | 1.70 W/Kg          | 6.76 W/Kg            | ± 17.32%        |

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

| Simulant Liquid | Parameter   | Measured Level                  | Uncertainty (%)                    |
|-----------------|-------------|---------------------------------|------------------------------------|
| Head            | Impedance   | 47.692 $\Omega$ 1.64 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 30.74                           | ± 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            | 835             | 21.0 °C   | 21.0 °C | 21.0°C      | 21.0°C | $\epsilon_r$ | 55.20        | 54.37          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 0.97         | 0.99           | ± 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  | 2.57 W/Kg          | 10.23 W/Kg           | ± 18.06%        |
|                 | SAR averaged over 10g | 1.71 W/Kg          | 6.80 W/Kg            | ± 17.44%        |

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

| Simulant Liquid | Parameter   | Measured Level                 | Uncertainty (%)                    |
|-----------------|-------------|--------------------------------|------------------------------------|
| Body            | Impedance   | 46.15 $\Omega$ 5.05 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 24.49                          | ± 2.03 dB                          |

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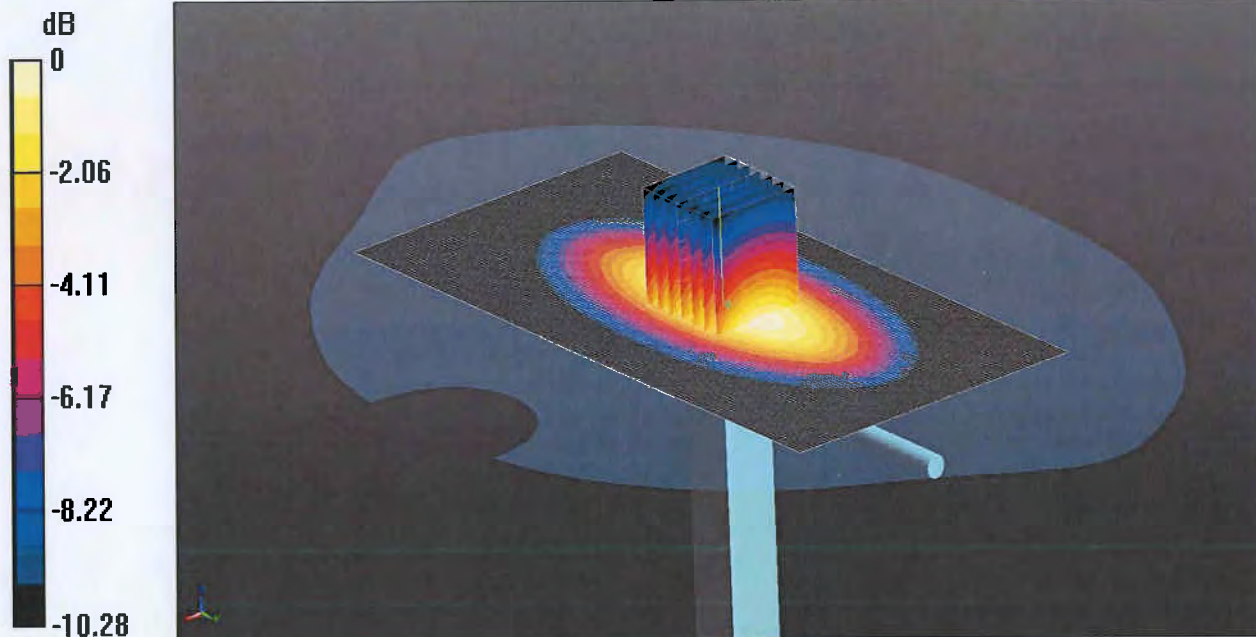
CERTIFICATE  
NUMBER :  
11903932JD01B

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

DUT: Dipole 835 MHz ; Type: D835V2; Serial: D7835V2 - SN:4d003



0 dB = 2.99 W/kg = 4.76 dBW/kg

Communication System: UID 0, CW 835; Frequency: 835 MHz; Duty Cycle: 1:1

Medium: 750,835,900,1800,1900 MHz HSL Medium parameters used (interpolated):  $f = 835$  MHz;  $\sigma = 0.944$  S/m;  $\epsilon_r = 41.726$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3995; ConvF(10.16, 10.16, 10.16); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (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=15mm, Pin=250mW 3 2/Area Scan (81x161x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 3.00 W/kg

**Configuration/d=15mm, Pin=250mW 3 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 56.77 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 3.83 W/kg

**SAR(1 g) = 2.58 W/kg; SAR(10 g) = 1.7 W/kg**

Maximum value of SAR (measured) = 2.99 W/kg

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NUMBER :  
11903932JD01B

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

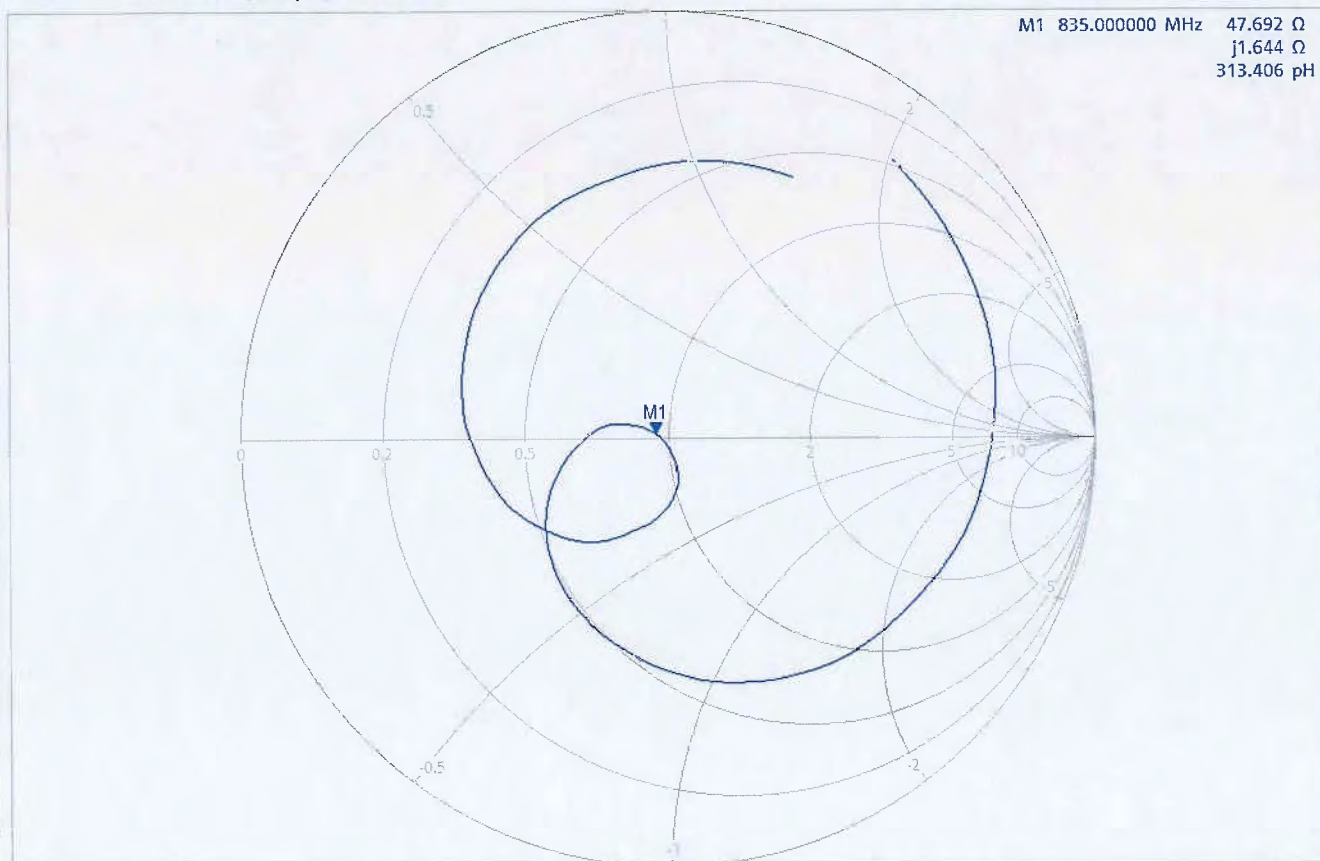


11/28/2017 1:32:28 PM  
1326.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal Smo

1

M1 835.000000 MHz 47.692  $\Omega$   
j1.644  $\Omega$   
313.406 pH



Ch1 Start 635 MHz

Pwr -10 dBm Bw 10 kHz

Stop 1.035 GHz

# CERTIFICATE OF CALIBRATION

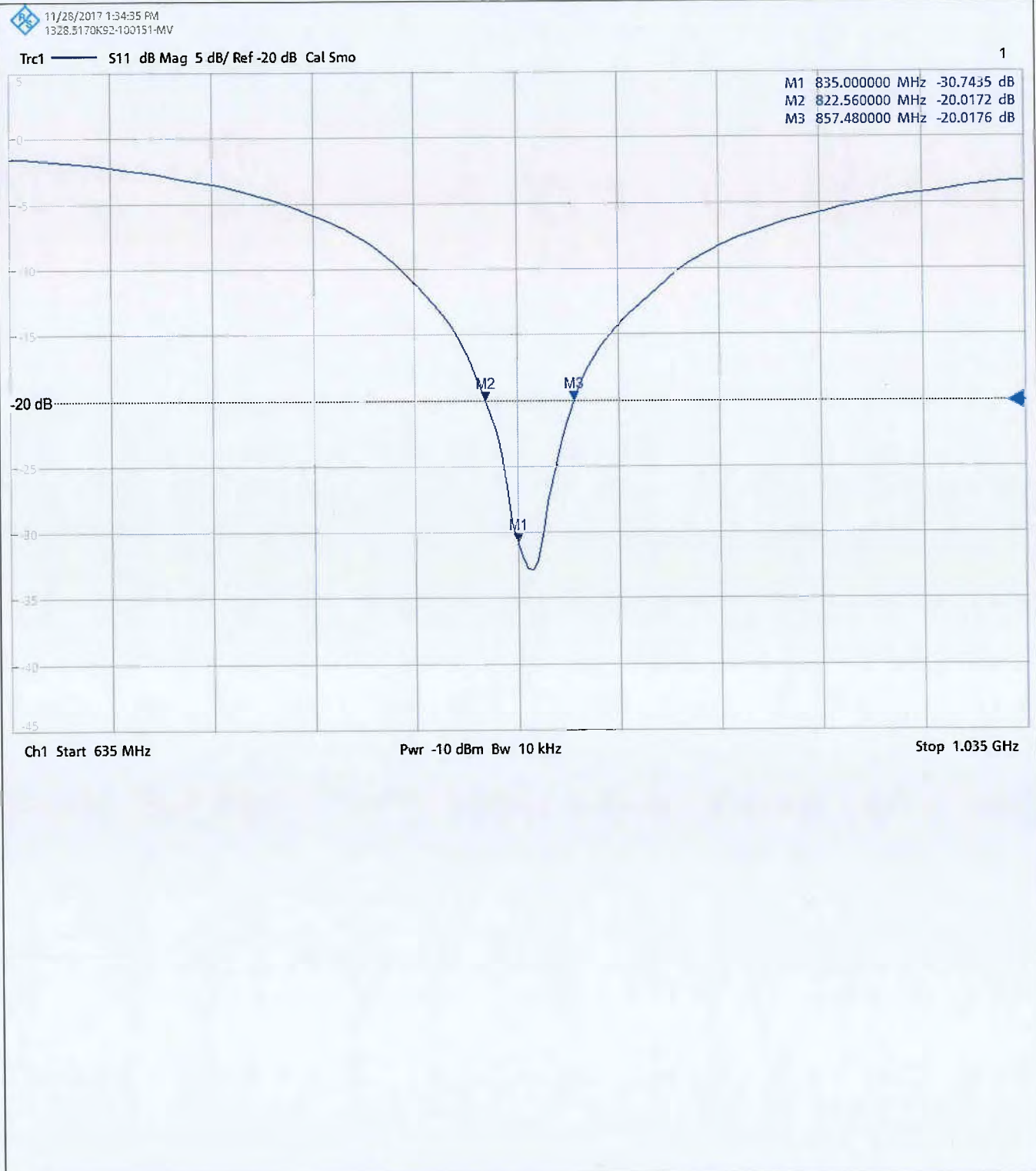
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NUMBER :  
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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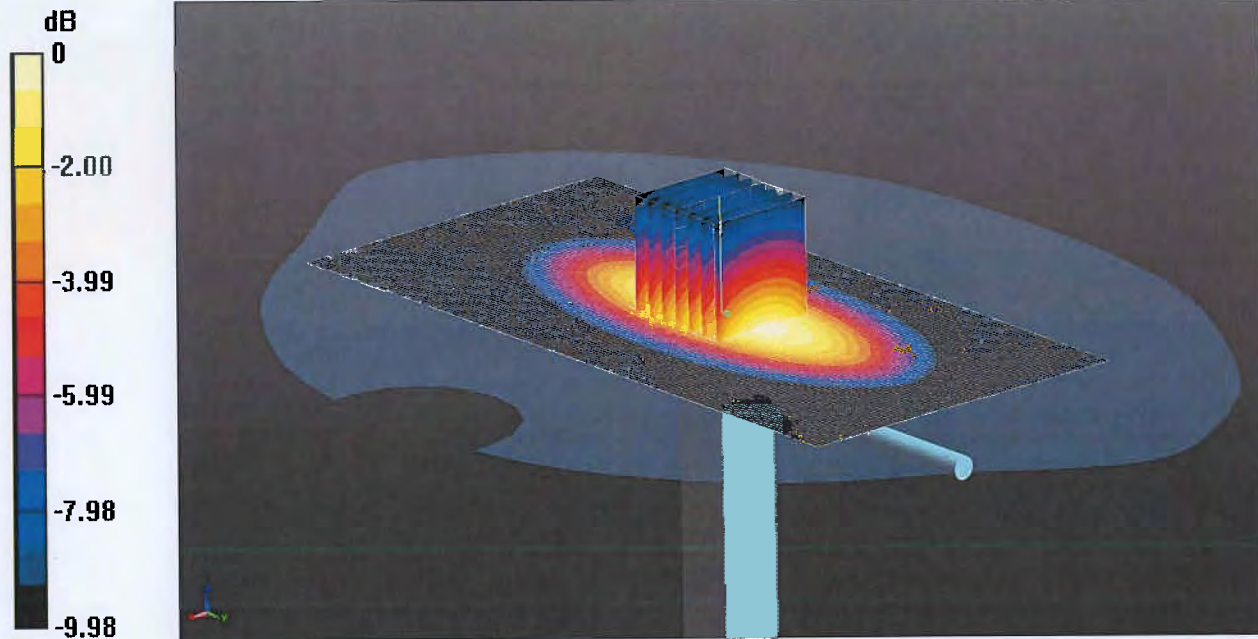
UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE  
NUMBER :  
11903932JD01B

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

DUT: Dipole 835 MHz ; Type: D835V2; Serial: D835V2 - 4d002



Communication System: UID 0, CW 835; Frequency: 835 MHz; Duty Cycle: 1:1

Medium: MSL(750,835,900,1800,1900,5G) Medium parameters used (interpolated):  $f = 835$  MHz;  $\sigma = 0.992$  S/m;  $\epsilon_r = 54.368$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3995; ConvF(10.09, 10.09, 10.09); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

**Configuration/d=15mm, Pin=250mW 2 2/Area Scan (81x161x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 2.99 W/kg

**Configuration/d=15mm, Pin=250mW 2 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 55.21 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 3.78 W/kg

**SAR(1 g) = 2.57 W/kg; SAR(10 g) = 1.71 W/kg**

Maximum value of SAR (measured) = 2.97 W/kg

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

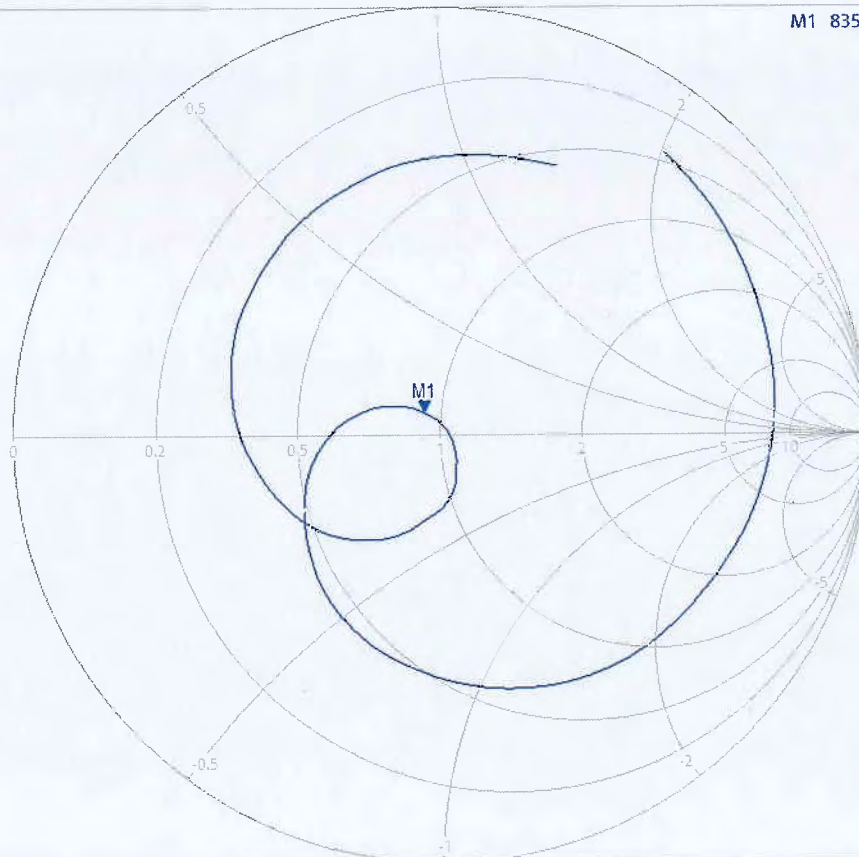


11/28/2017 1:28:03 PM  
1328.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal Smo

1

M1 835.000000 MHz 46.153  $\Omega$   
j5.050  $\Omega$   
962.581 pF



Ch1 Start 635 MHz

Pwr -10 dBm Bw 10 kHz

Stop 1.035 GHz

# CERTIFICATE OF CALIBRATION

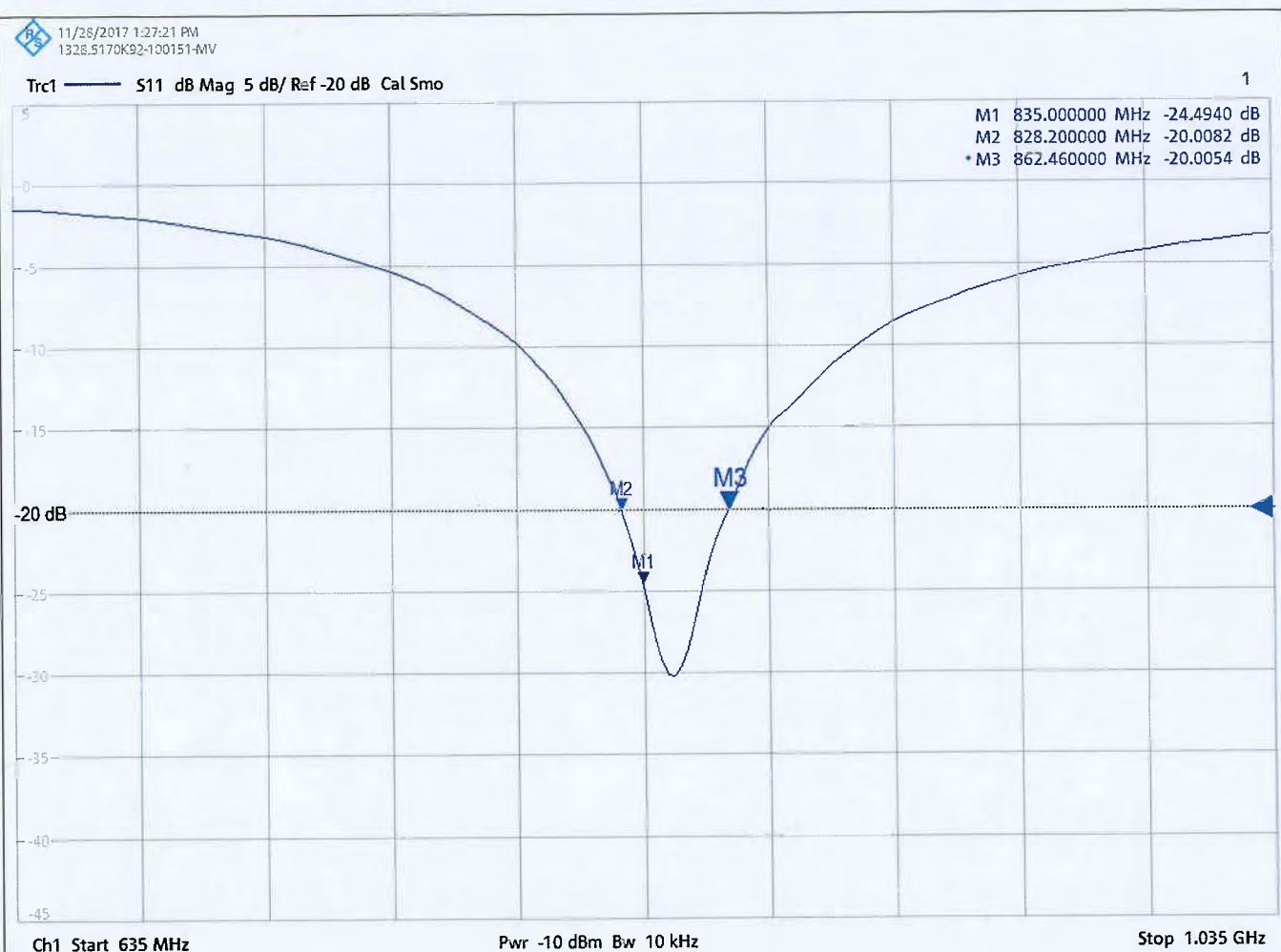
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CERTIFICATE  
NUMBER :  
11903932JD01B

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



**Calibration Certificate Label:**

|                                                                                               |                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>5248</p> | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903932JD01B</p> <p>Instrument ID: 4d002</p> <p>Calibration Date: 21/Nov/2017</p> <p>Calibration Due Date:</p> |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                               |                                                                                                                                                                                          |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>5248</p> | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903932JD01B</p> <p>Instrument ID: 4d002</p> <p>Calibration Date: 21/Nov/2017</p> <p>Calibration Due Date:</p> |
|-----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                |                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>5248</p> | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903932JD01B</p> <p>Instrument ID: 4d002</p> <p>Calibration Date: 21/Nov/2017</p> <p>Calibration Due Date:</p> |
|------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

# CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

DATE OF ISSUE: 29/Nov/2017

CERTIFICATE NUMBER : 11903932JD01C



5248

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

A handwritten signature in black ink, appearing to read 'N. Mirza'.

Naseer Mirza

## Customer :

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

## Equipment Details:

|                    |                                                                               |                  |             |
|--------------------|-------------------------------------------------------------------------------|------------------|-------------|
| Description:       | Dipole Validation Kit                                                         | Date of Receipt: | 20/Nov/2017 |
| Manufacturer:      | Speag                                                                         |                  |             |
| Type/Model Number: | D900V2                                                                        |                  |             |
| Serial Number:     | 108                                                                           |                  |             |
| Calibration Date:  | 22/Nov/2017                                                                   |                  |             |
| Calibrated By:     | Chanthu Thevarajah<br>Laboratory Engineer                                     |                  |             |
| Signature:         | A handwritten signature in black ink, appearing to read 'Chanthu Thevarajah'. |                  |             |

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.

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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) |
|------------|------------------------------|----------------------|---------------|------------|-----------------------|------------------------|
| A2546      | Data Acquisition Electronics | SPEAG                | DAE4          | 1435       | 10 Feb 2017           | 12                     |
| A2545      | Probe                        | SPEAG                | ES3DV4        | 3395       | 04 May 2017           | 12                     |
| A2588      | Dipole                       | SPEAG                | D900V2        | 1d168      | 21 Sep 2017           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi               | ART 100850-01 | 0001       | Cal as part of System | 12                     |
| M1855      | Power Sensor                 | Rhode & Schwarz      | NRP-Z51       | 103246     | 08 Nov 2017           | 12                     |
| M1015      | Network Analyser             | Agilent Technologies | 8753ES        | US39172406 | 10 Oct 2017           | 12                     |
| PRE0151154 | Network Analyser             | Rhode & Schwarz      | ZND8          | 100151     | 22 Nov 2016           | 24                     |
| PRE0151877 | Calibration Kit              | Rhode & Schwarz      | Z135          | 102947-Bt  | 02 Dec 2016           | 12                     |
| M1838      | Signal Generator             | Rhode & Schwarz      | SME06         | 831377/005 | 30 Mars 2017          | 12                     |

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### 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:  | 15 mm (with spacer)                        |
| Frequency:               | 900 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            | 900             | 21.0 °C   | 21.0 °C | 20.5°C      | 21.0°C | $\epsilon_r$ | 41.50        | 41.56          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 0.97         | 0.97           | ± 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  | 2.69 W/Kg          | 10.70 W/Kg           | ± 17.57%        |
|                 | SAR averaged over 10g | 1.73 W/Kg          | 6.88 W/Kg            | ± 17.32%        |

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

| Simulant Liquid | Parameter   | Measured Level                  | Uncertainty (%)                    |
|-----------------|-------------|---------------------------------|------------------------------------|
| Head            | Impedance   | 50.666 $\Omega$ 4.46 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 27.83                           | ± 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            | 900             | 21.0 °C   | 21.0 °C | 21.0°C      | 21.0°C | $\epsilon_r$ | 55.00        | 54.24          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 1.05         | 1.02           | ± 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  | 2.73 W/Kg          | 10.86 W/Kg           | ± 18.06%        |
|                 | SAR averaged over 10g | 1.80 W/Kg          | 7.16 W/Kg            | ± 17.44%        |

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

| Simulant Liquid | Parameter   | Measured Level                | Uncertainty (%)                   |
|-----------------|-------------|-------------------------------|-----------------------------------|
| Body            | Impedance   | 53.72 $\Omega$ 8.72 $j\Omega$ | ± 0.28 $\Omega$ ± 0.044 $j\Omega$ |
|                 | Return Loss | 21.25                         | ± 2.03 dB                         |

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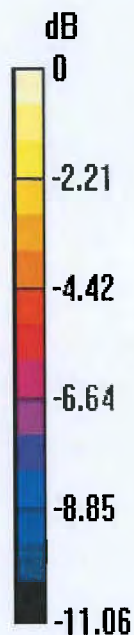
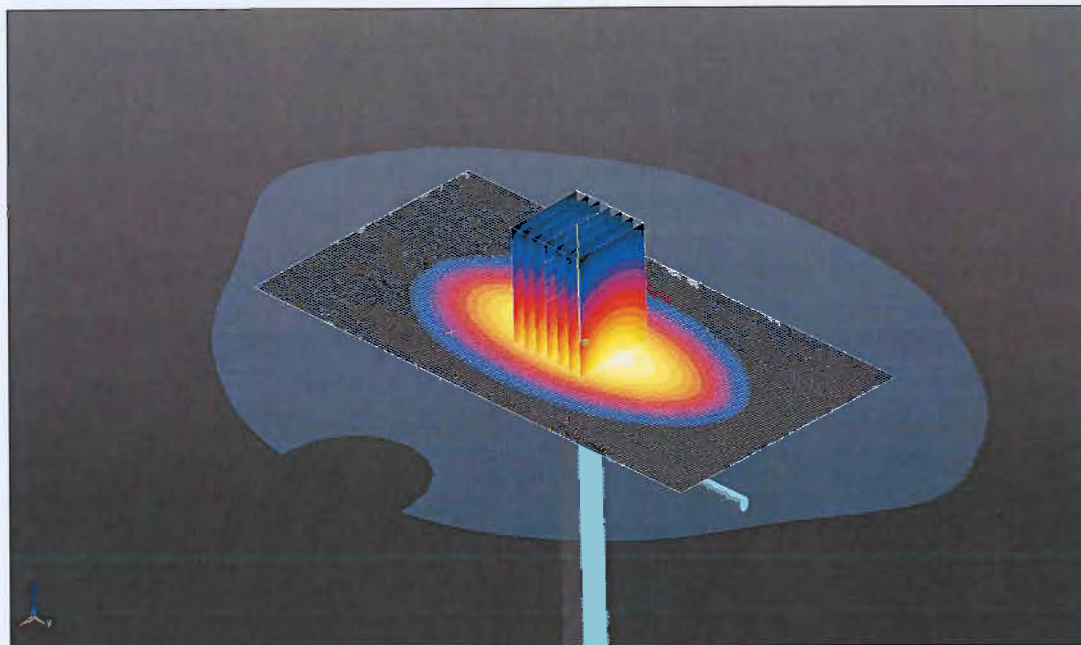
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: Dipole 900 MHz; SN: 108; Type: D900V2; Serial: SN108



0 dB = 3.15 W/kg = 4.98 dBW/kg

Communication System: UID 0, CW (0); Frequency: 900 MHz; Duty Cycle: 1:1

Medium: 750,835,900,1800,1900 MHz HSL Medium parameters used:  $f = 900$  MHz;  $\sigma = 0.967$  S/m;  $\epsilon_r = 41.565$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3995; ConvF(10.1, 10.1, 10.1); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (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=15mm, Pin=250mW 2 2/Area Scan (81x161x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 3.17 W/kg

**Configuration/d=15mm, Pin=250mW 2 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 57.39 V/m; Power Drift = 0.00 dB

Peak SAR (extrapolated) = 4.11 W/kg

**SAR(1 g) = 2.69 W/kg; SAR(10 g) = 1.73 W/kg**

Maximum value of SAR (measured) = 3.15 W/kg

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

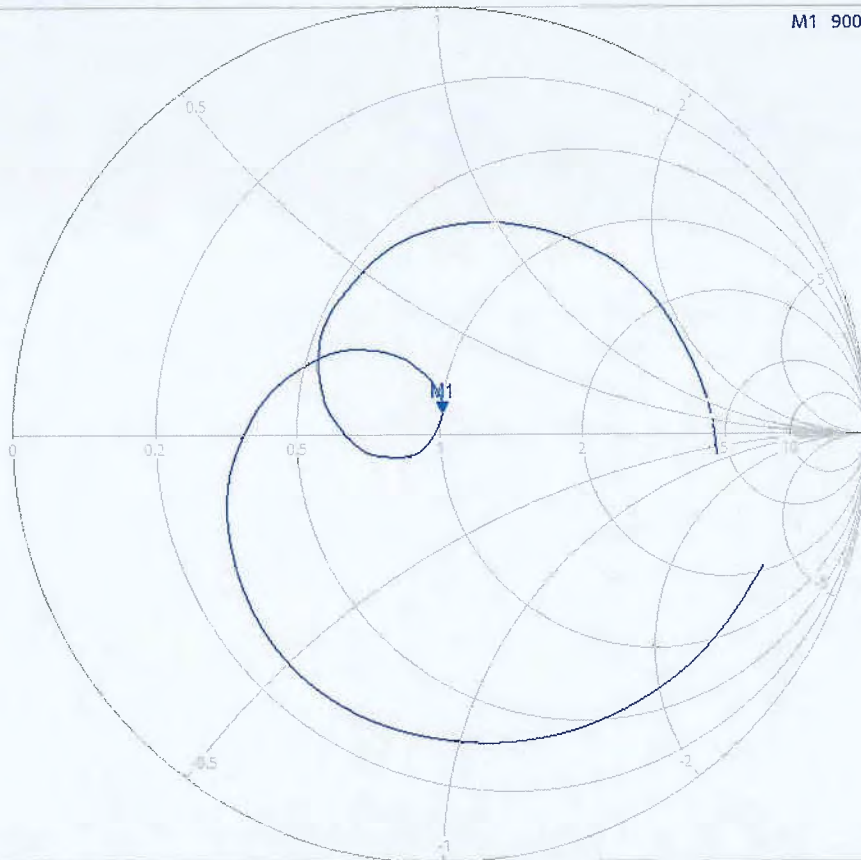


11/28/2017 1:55:22 PM  
1328.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal Smo

1

M1 900.000000 MHz 50.666  $\Omega$   
j4.458  $\Omega$   
788.363 pH



Ch1 Start 700 MHz

Pwr -10 dBm Bw 10 kHz

Stop 1.1 GHz

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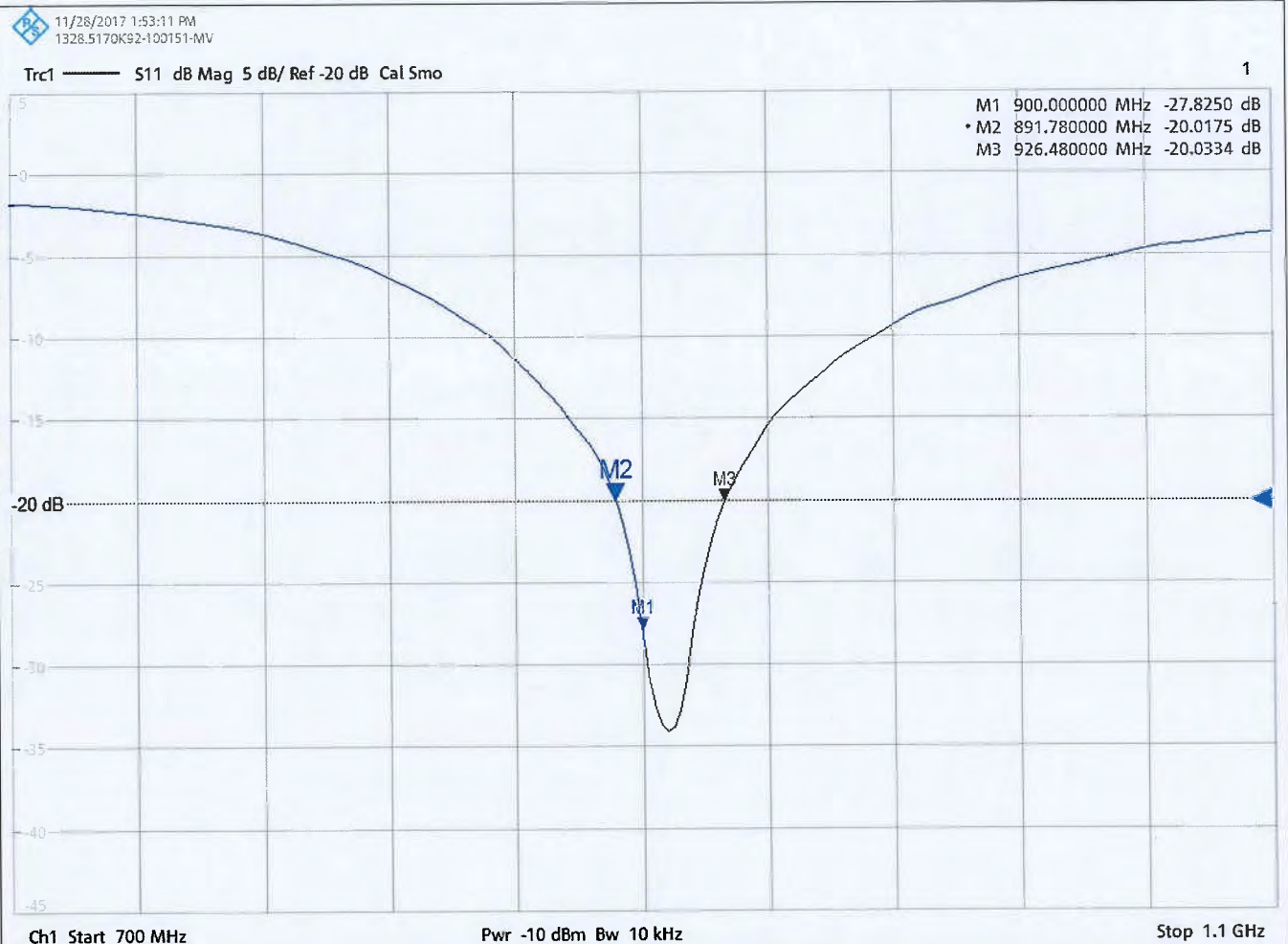
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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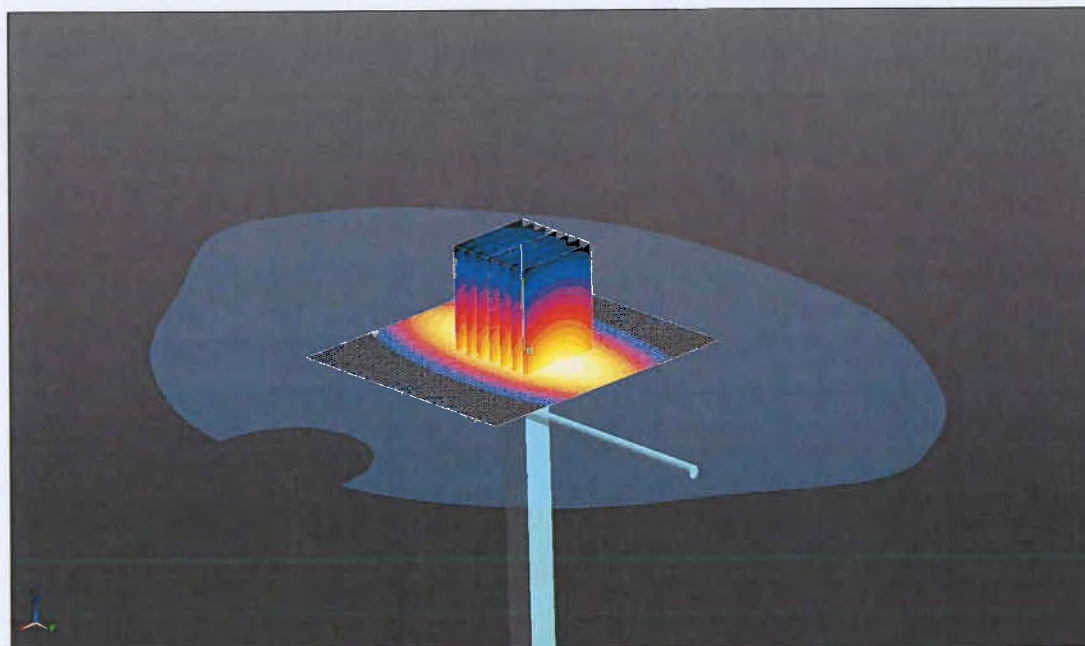
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 900 MHz; SN: 108; Type: D900V2; Serial: SN108



0 dB = 2.94 W/kg = 4.68 dBW/kg

Communication System: UID 0, CW (0); Frequency: 900 MHz; Duty Cycle: 1:1

Medium: MSL(750,835,900,1800,1900,5G) Medium parameters used:  $f = 900$  MHz;  $\sigma = 1.018$  S/m;  $\epsilon_r = 54.24$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3995; ConvF(9.81, 9.81, 9.81); Calibrated: 04/05/2017;

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

- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017

- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:xxxx

- ; SEMCAD X Version 14.6.10 (7372)

**SAR/d=15mm, Pin=250 mW, dist=10.0mm (ET-Probe)/Area Scan (81x71x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 3.21 W/kg

**SAR/d=15mm, Pin=250 mW, dist=10.0mm (ET-Probe)/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 58.69 V/m; Power Drift = -0.77 dB

Peak SAR (extrapolated) = 4.04 W/kg

**SAR(1 g) = 2.73 W/kg; SAR(10 g) = 1.8 W/kg**

Maximum value of SAR (measured) = 2.94 W/kg

# CERTIFICATE OF CALIBRATION

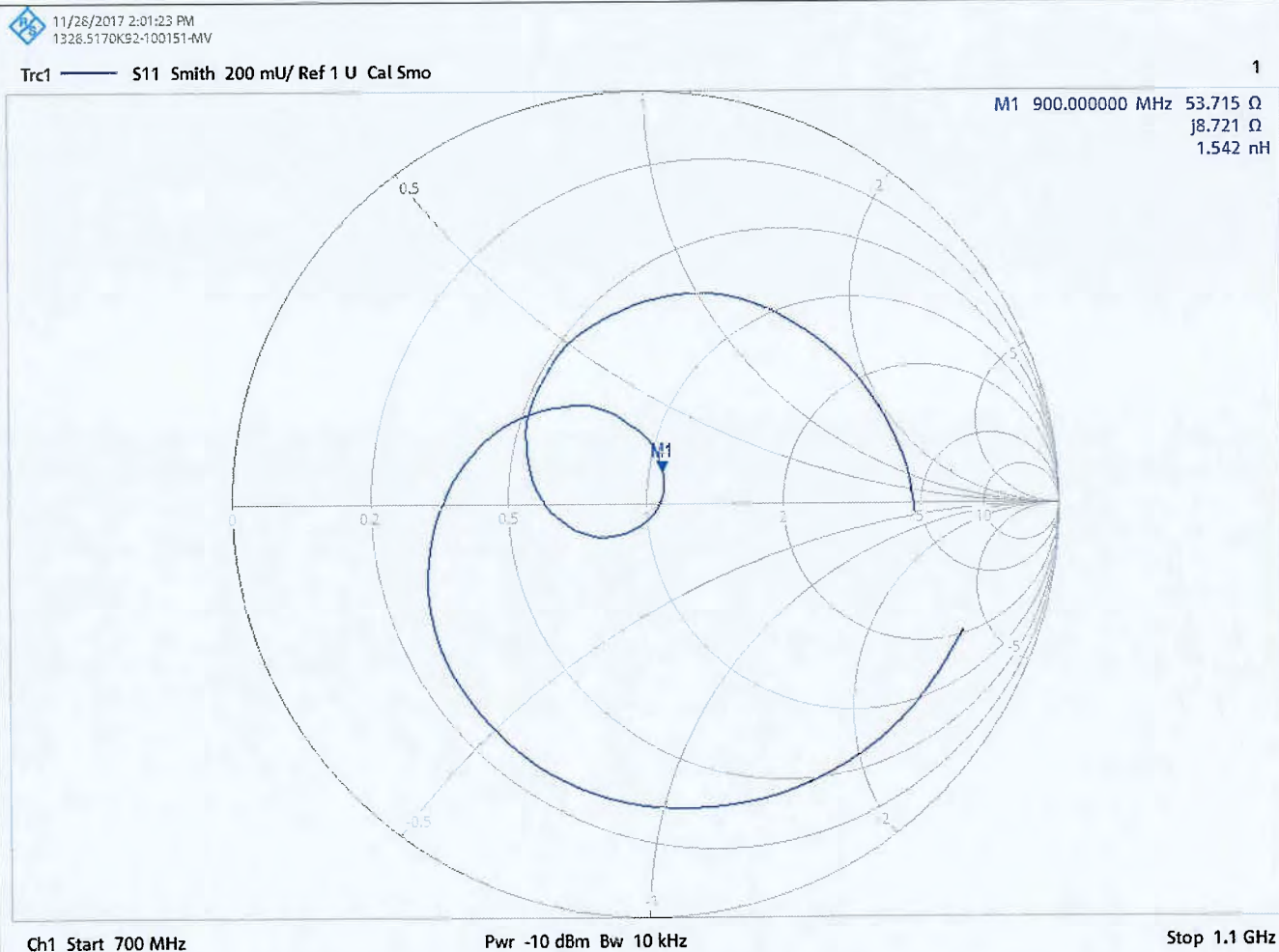
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### Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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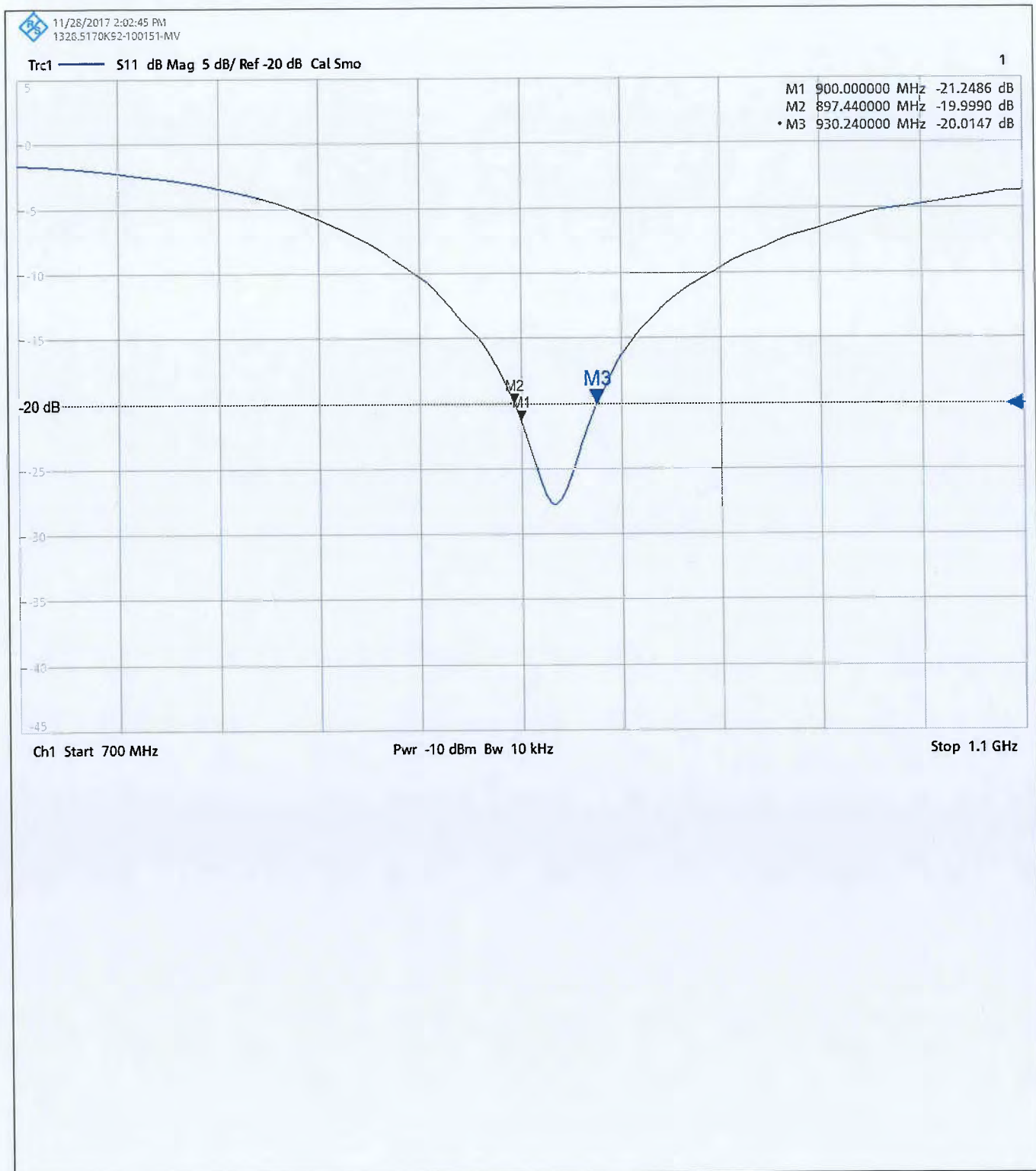
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### Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



**Calibration Certificate Label:**

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

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

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

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ISSUED BY **UL VS LTD**

DATE OF ISSUE: 18/Sep/2017

CERTIFICATE NUMBER : 11903949JD01B



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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



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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: | 24/Aug/2017 |
| Manufacturer:      | SPEAG                                     |                  |             |
| Type/Model Number: | D1750V2                                   |                  |             |
| Serial Number:     | 1053                                      |                  |             |
| Calibration Date:  | 24/Aug/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%

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.

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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                     |
| A2436      | Probe                        | SPEAG                | ES3DV3        | 3335       | 28 July 2017          | 12                     |
| A2077      | Probe                        | SPEAG                | EX3DV4        | 3814       | 30 Sep 2016           | 12                     |
| A1236      | Dipole                       | SPEAG                | 1800V2        | 2d009      | 09 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                     |
| 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:  | 10 mm (with spacer)                        |
| Frequency:               | 1750 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            | 1750            | 22.6 °C   | 22.5 °C | 22.5°C      | 22.5°C | $\epsilon_r$ | 40.10        | 38.82          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 1.37         | 1.36           | ± 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  | 9.91 W/Kg          | <b>39.45 W/Kg</b>    | ± 17.57%        |
|                 | SAR averaged over 10g | 5.17 W/Kg          | <b>20.58 W/Kg</b>    | ± 17.32%        |

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

| Simulant Liquid | Parameter   | Measured Level                   | Uncertainty (%)                    |
|-----------------|-------------|----------------------------------|------------------------------------|
| Head            | Impedance   | 46.781 $\Omega$ -0.22 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 28.74                            | ± 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            | 1750            | 22.0 °C   | 22.0 °C | 21.5°C      | 22.0°C | $\epsilon_r$ | 53.40        | 51.51          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 1.49         | 1.47           | ± 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  | 8.15 W/Kg          | <b>32.44 W/Kg</b>    | ± 18.06%        |
|                 | SAR averaged over 10g | 4.35 W/Kg          | <b>17.31 W/Kg</b>    | ± 17.44%        |

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

| Simulant Liquid | Parameter   | Measured Level                 | Uncertainty (%)                    |
|-----------------|-------------|--------------------------------|------------------------------------|
| Body            | Impedance   | 45.96 $\Omega$ 2.84 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 24.77                          | ± 2.03 dB                          |

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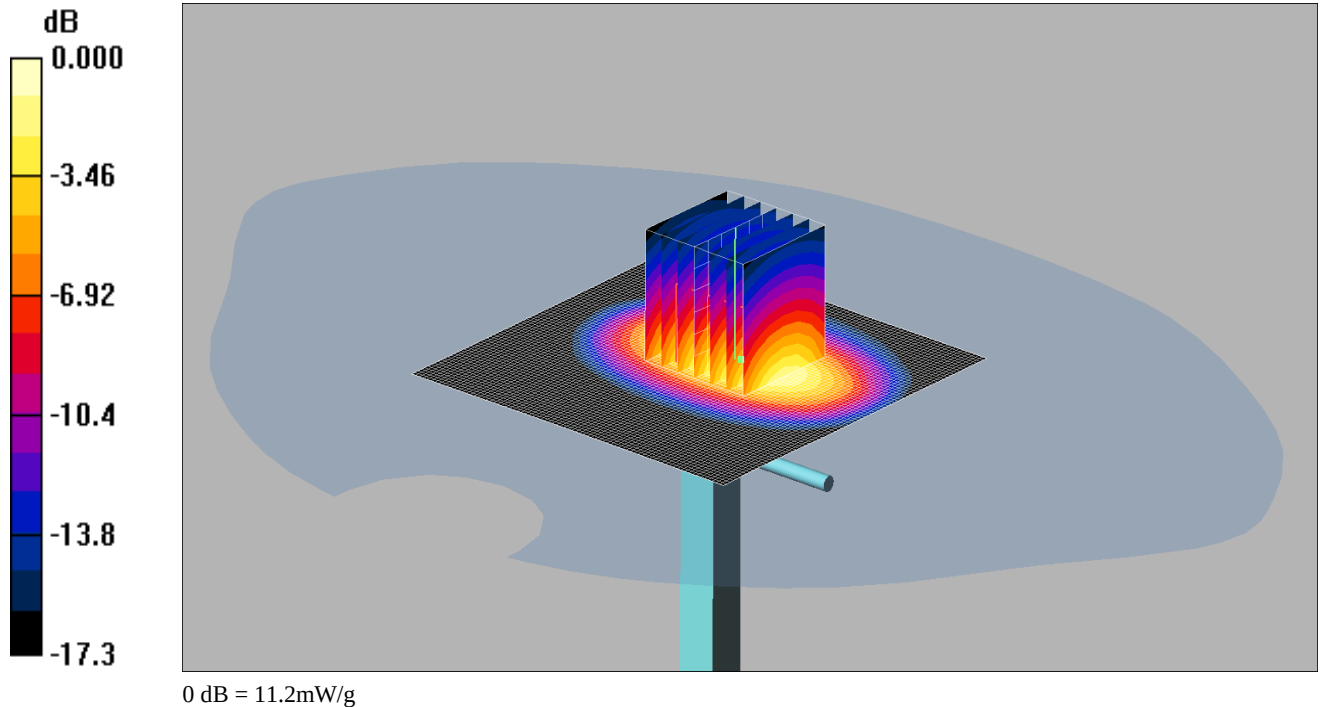
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1750V2 – SN1053; Type: D1750V2; Serial: SN1053



Communication System: CW; Frequency: 1750 MHz; Duty Cycle: 1:1

Medium: 1750MHz HSL Medium parameters used:  $f = 1750 \text{ MHz}$ ;  $\sigma = 1.37 \text{ mho/m}$ ;  $\epsilon_r = 38.8$ ;  $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3335; ConvF(5.51, 5.51, 5.51);

- 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=10mm, Pin=250mW/Area Scan (81x81x1):** Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 11.2 mW/g

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

Reference Value = 78.3 V/m; Power Drift = 0.078 dB

Peak SAR (extrapolated) = 18.5 W/kg

**SAR(1 g) = 9.91 mW/g; SAR(10 g) = 5.17 mW/g**

Maximum value of SAR (measured) = 11.2 mW/g

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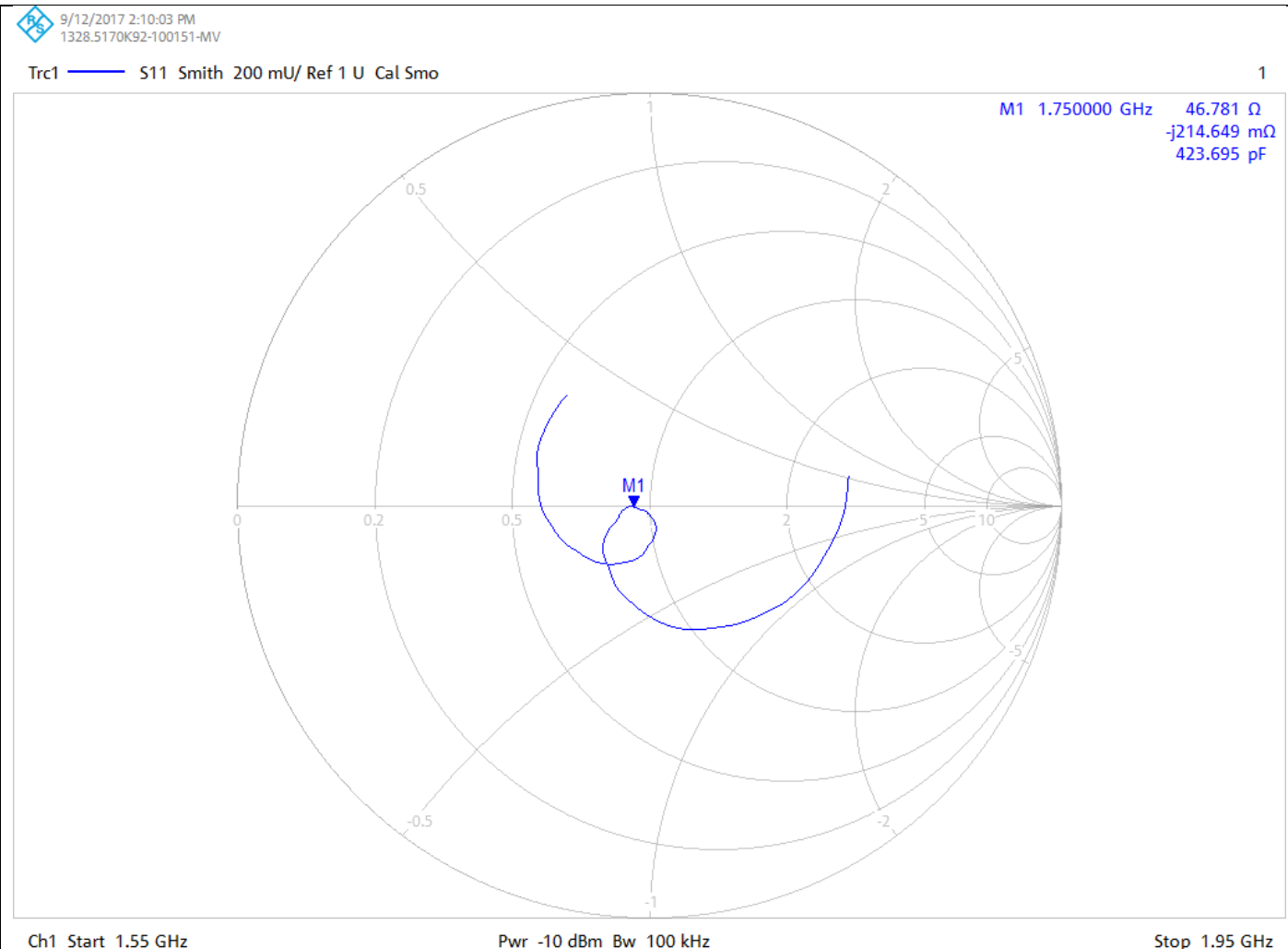
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### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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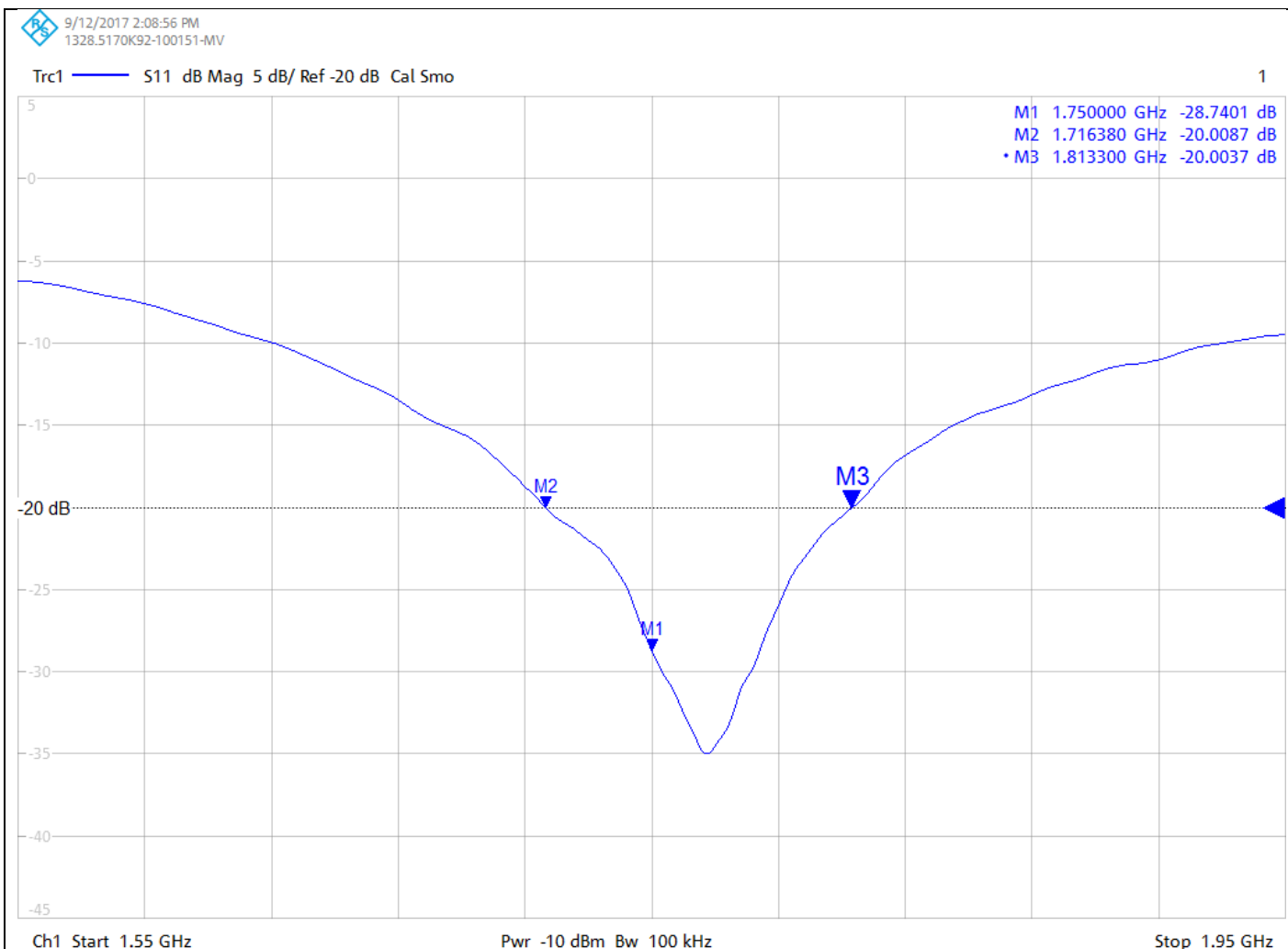
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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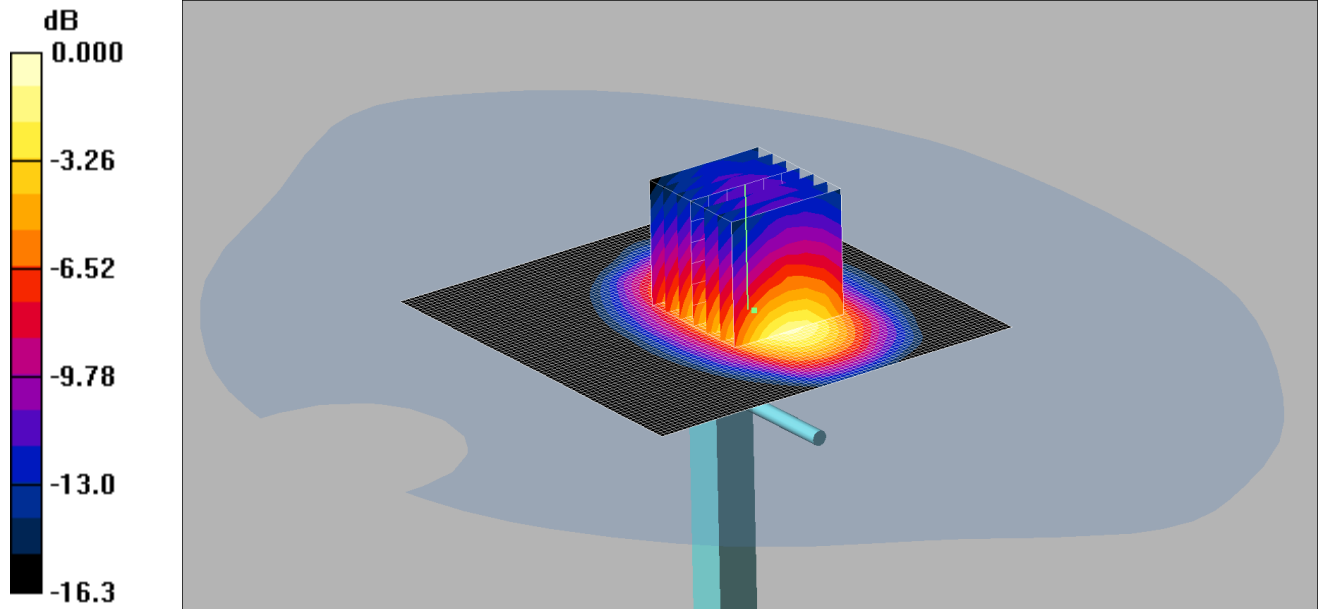
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D1750V2 - SN1053; Type: D1750V2; Serial: SN1053



0 dB = 9.02mW/g

Communication System: CW; Frequency: 1750 MHz; Duty Cycle: 1:1  
Medium: 1750 Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.47$  mho/m;  $\epsilon_r = 51.5$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3814; ConvF(7.8, 7.8, 7.8);

- 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=10mm, Pin=250mW 2 2 2/Area Scan (81x81x1):** Measurement grid: dx=12mm, dy=12mm

Maximum value of SAR (interpolated) = 9.60 mW/g

**d=10mm, Pin=250mW 2 2 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 65.5 V/m; Power Drift = -0.119 dB

Peak SAR (extrapolated) = 14.7 W/kg

**SAR(1 g) = 8.15 mW/g; SAR(10 g) = 4.35 mW/g**

Maximum value of SAR (measured) = 9.02 mW/g

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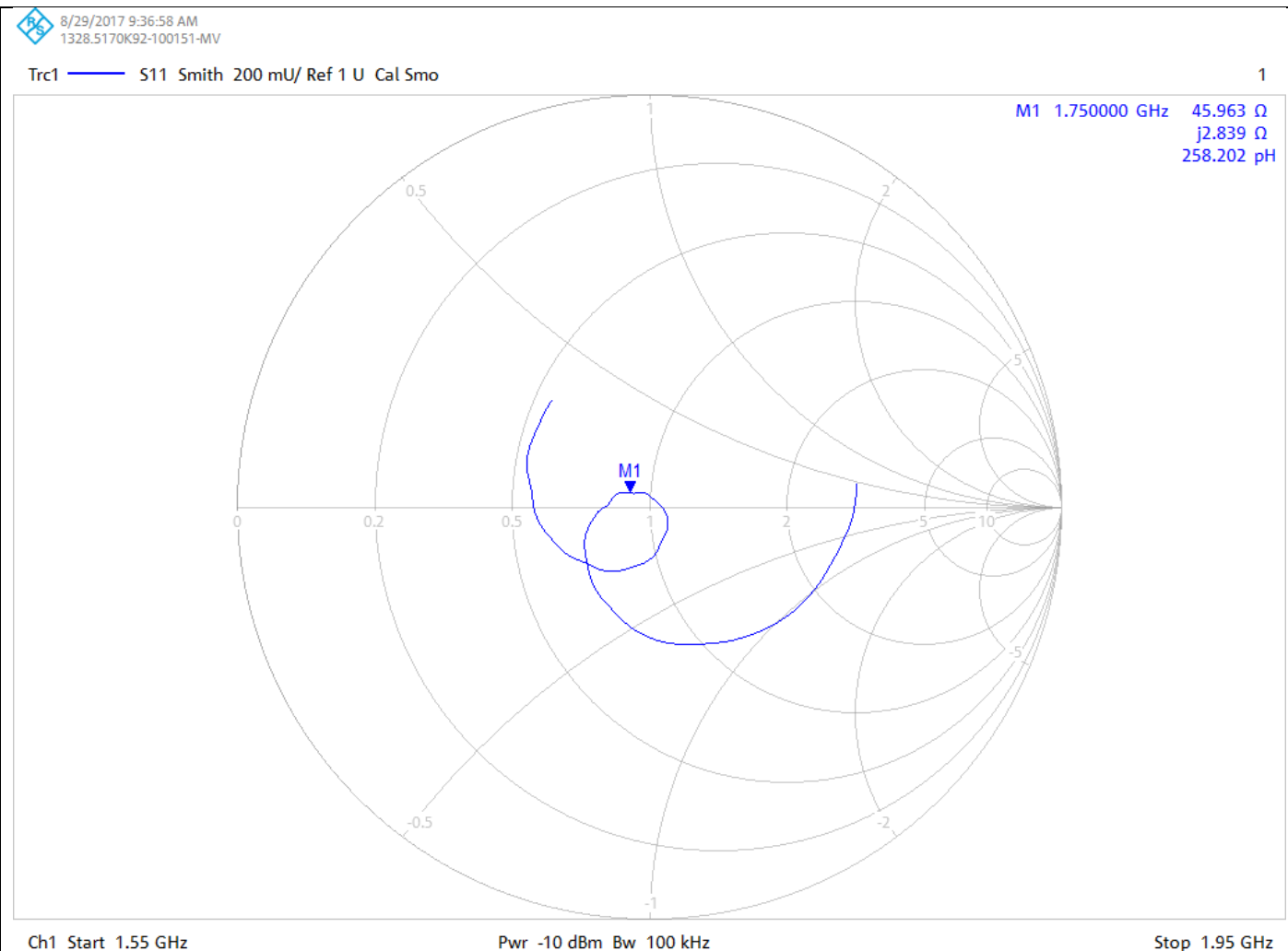
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### Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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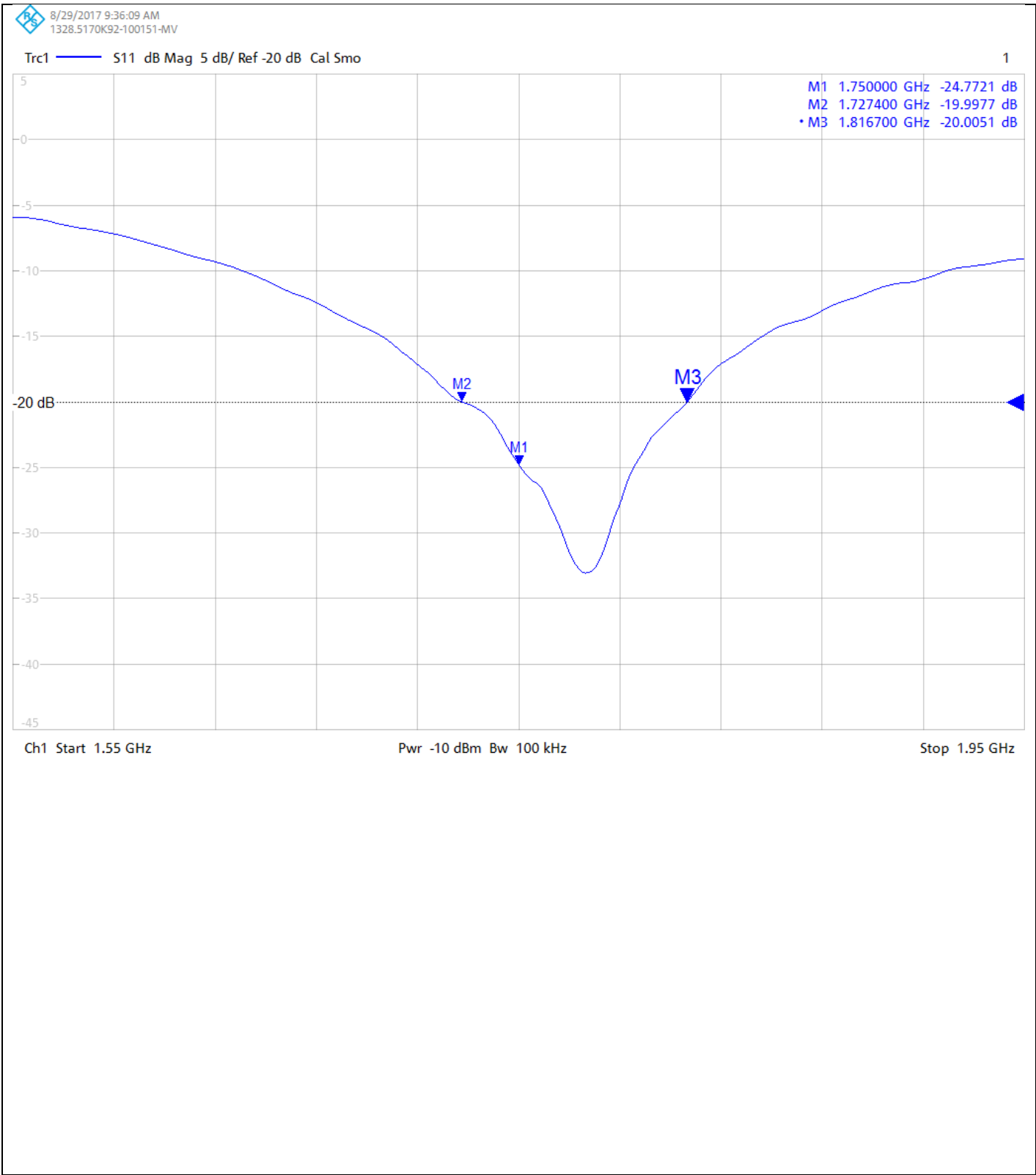
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11903949JD01B

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



**Calibration Certificate Label:**

|                                                                                   |                                                                                                                                                                                         |
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|  | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903949JD01B</p> <p>Instrument ID: 1053</p> <p>Calibration Date: 24/Aug/2017</p> <p>Calibration Due Date:</p> |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                   |                                                                                                                                                                                         |
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|                                                                                     |                                                                                                                                                                                         |
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|  | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903949JD01B</p> <p>Instrument ID: 1053</p> <p>Calibration Date: 24/Aug/2017</p> <p>Calibration Due Date:</p> |
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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



APPROVED SIGNATORY

Naseer Mirza

## Customer :

UL VS Ltd  
Pavilion A, Ashwood Park, Ashwood Way  
Basingstoke, RG23 8BG, England

## Equipment Details:

|                    |                                           |                  |             |
|--------------------|-------------------------------------------|------------------|-------------|
| Description:       | Dipole Validation Kit                     | Date of Receipt: | 29/Sep/2017 |
| Manufacturer:      | Speag                                     |                  |             |
| Type/Model Number: | D1750V2                                   |                  |             |
| Serial Number:     | 1077                                      |                  |             |
| Calibration Date:  | 05/Oct/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%

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.

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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) |
|------------|------------------------------|----------------------|---------------|-------------|-----------------------|------------------------|
| A2546      | Data Acquisition Electronics | SPEAG                | DAE4          | 1435        | 10 Feb 2017           | 12                     |
| A2587      | Probe                        | SPEAG                | ES3DV3        | 3341        | 14 Aug 2017           | 12                     |
| A1236      | Dipole                       | SPEAG                | D1800V2       | 2d009       | 09 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                     |

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### 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:               | 1750 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            | 1750            | 23.0 °C   | 23.0 °C | 20.0°C      | 20.0°C | $\epsilon_r$ | 40.10        | 40.38          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 1.37         | 1.39           | ± 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  | 9.11 W/Kg          | <b>36.26 W/Kg</b>    | ± 17.57%        |
|                 | SAR averaged over 10g | 4.86 W/Kg          | <b>19.34 W/Kg</b>    | ± 17.32%        |

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

| Simulant Liquid | Parameter   | Measured Level                  | Uncertainty (%)                    |
|-----------------|-------------|---------------------------------|------------------------------------|
| Head            | Impedance   | 49.21 $\Omega$ -0.63 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | -36.48                          | ± 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            | 1750            | 22.0 °C   | 22.0 °C | 22.0°C      | 22.0°C | $\epsilon_r$ | 53.40        | 52.41          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 1.49         | 1.47           | ± 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  | 9.38 W/Kg          | <b>37.34 W/Kg</b>    | ± 18.06%        |
|                 | SAR averaged over 10g | 5.02 W/Kg          | <b>19.98 W/Kg</b>    | ± 17.44%        |

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

| Simulant Liquid | Parameter   | Measured Level                 | Uncertainty (%)                    |
|-----------------|-------------|--------------------------------|------------------------------------|
| Body            | Impedance   | 49.29 $\Omega$ 3.26 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | -29.63                         | ± 2.03 dB                          |

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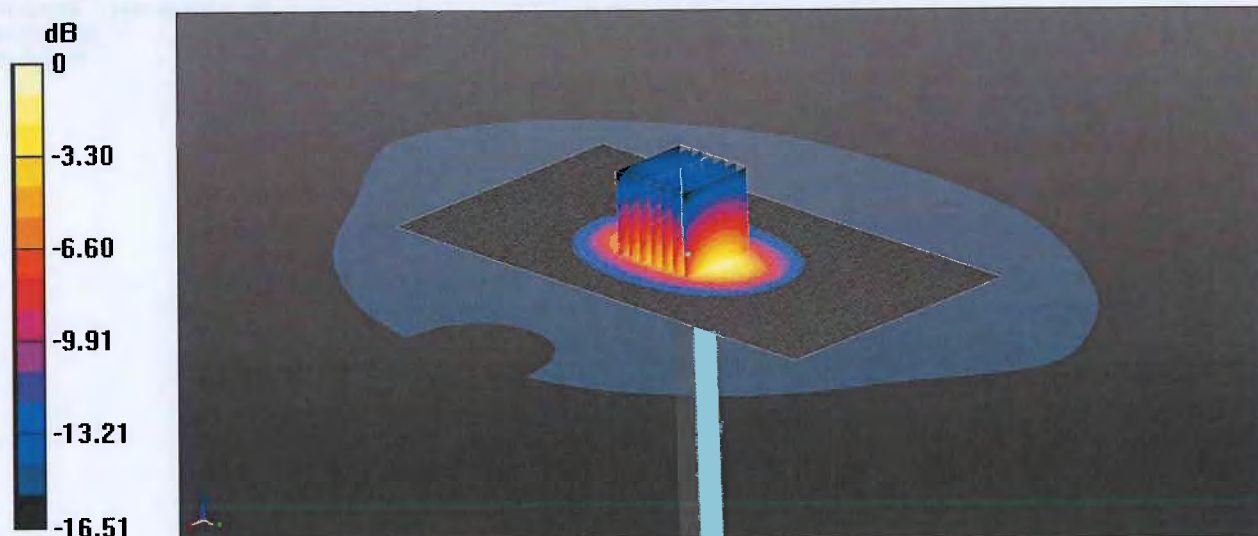
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1750V2 - SN1077; Type: D1750V2; Serial: SN1077



0 dB = 11.4 W/kg = 10.57 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1750 MHz; Duty Cycle: 1:1

Medium: 1750 1800 MHz HSL Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.393$  S/m;  $\epsilon_r = 40.378$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(5.47, 5.47, 5.47); Calibrated: 14/08/2017;
- Sensor-Surface: 3mm (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 (81x151x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

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

**Configuration/d=10mm, Pin=250mW 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 93.81 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 16.3 W/kg

**SAR(1 g) = 9.11 W/kg; SAR(10 g) = 4.86 W/kg**

Maximum value of SAR (measured) = 11.4 W/kg

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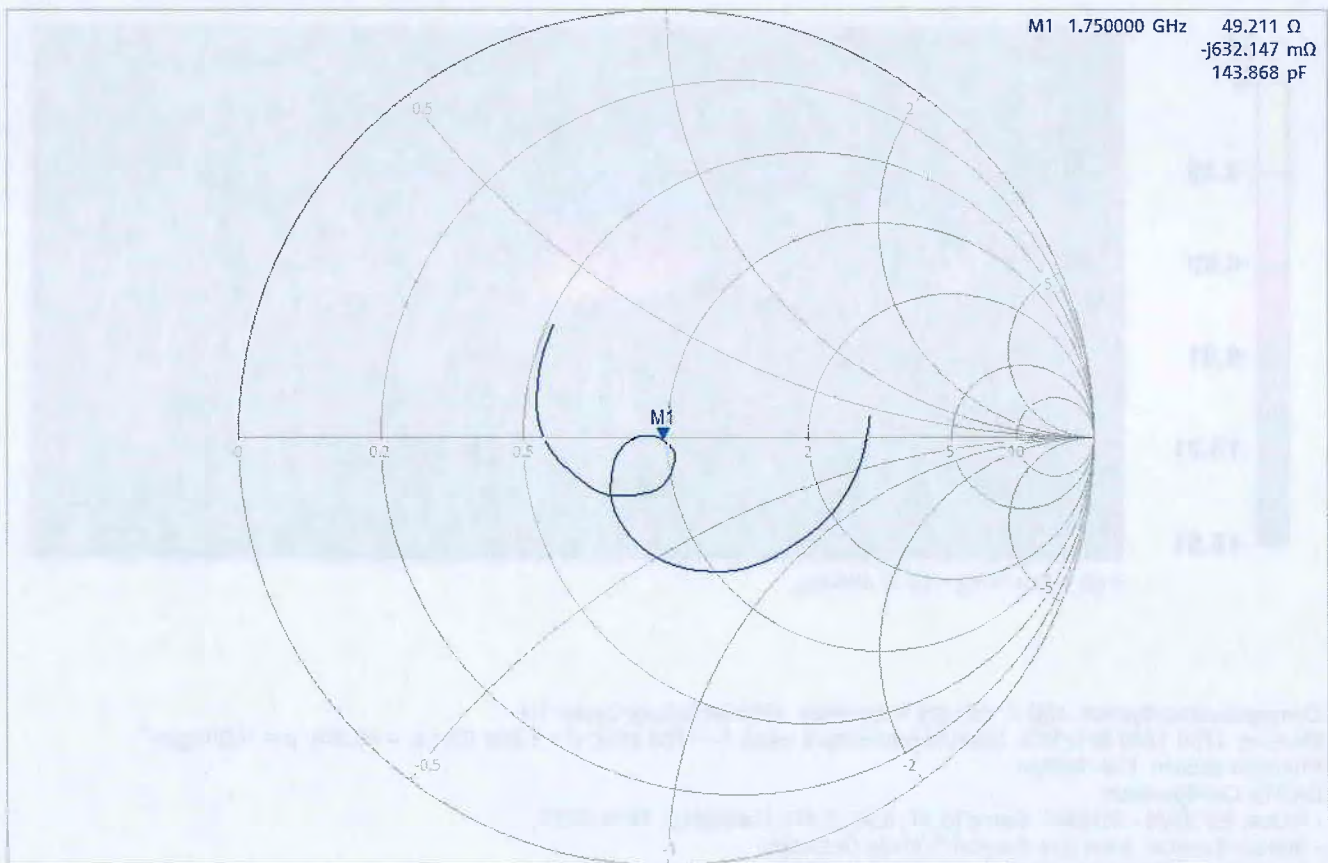
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### Impedance Measurement Plot for Head Stimulating Liquid (HSL)

10/10/2017 9:09:15 AM  
1326.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal Smo

1



Ch1 Start 1.55 GHz

Pwr -10 dBm Bw 10 kHz

Stop 1.95 GHz

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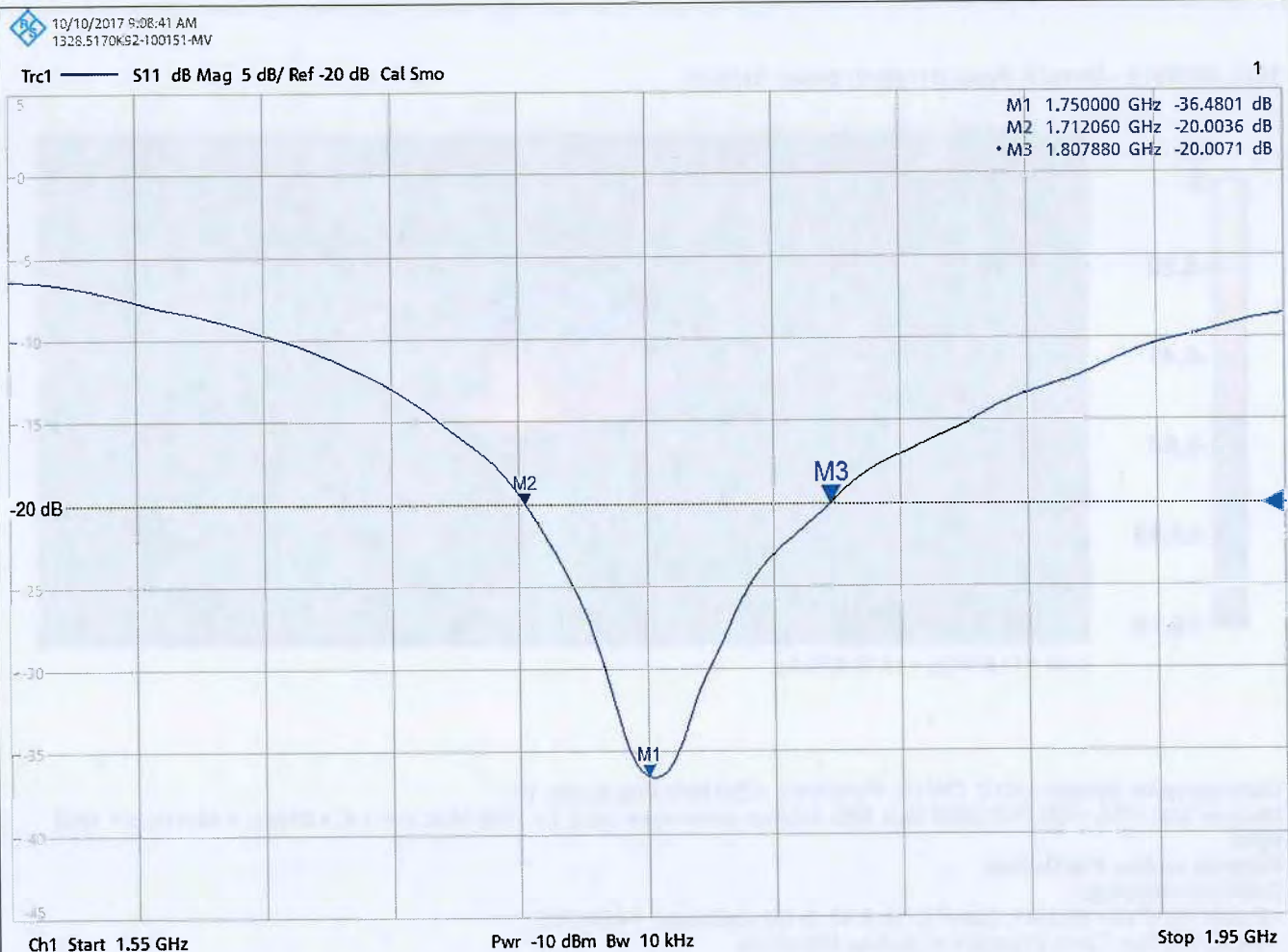
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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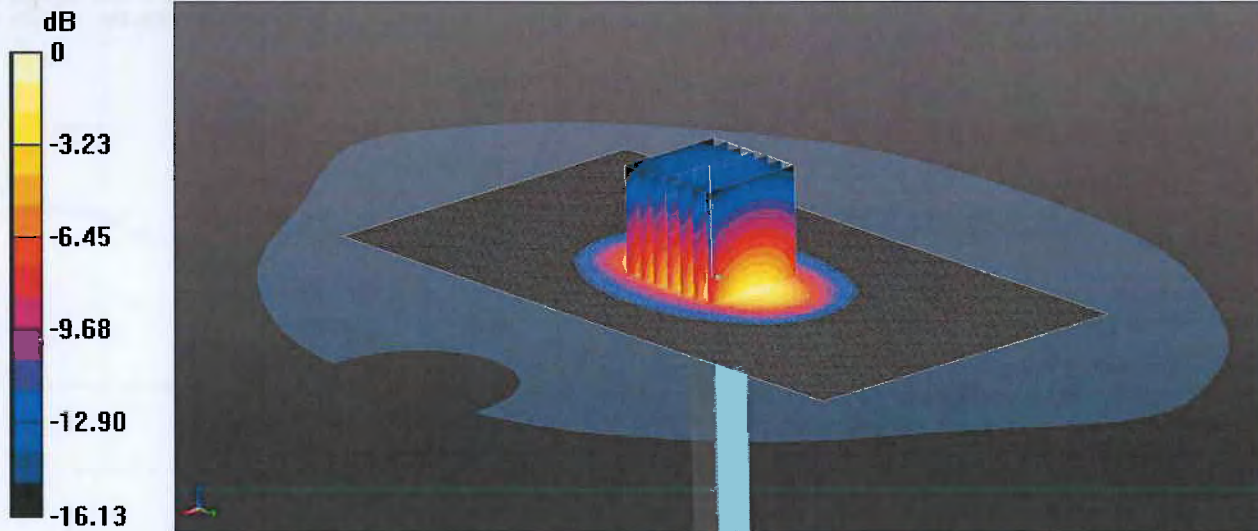
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D1750V2 - SN1077; Type: D1750V2; Serial: SN1077



0 dB = 11.8 W/kg = 10.72 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1750 MHz; Duty Cycle: 1:1

Medium: 900, 1750, 1800, 1900, 2600 MHz MSL Medium parameters used:  $f = 1750$  MHz;  $\sigma = 1.474$  S/m;  $\epsilon_r = 52.411$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(5.12, 5.12, 5.12); Calibrated: 14/08/2017;
- Sensor-Surface: 3mm (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 2 2/Area Scan (81x151x1):** Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 12.1 W/kg

**Configuration/d=10mm, Pin=250mW 2 2 2 2/Zoom Scan (5x5x7) (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 92.81 V/m; Power Drift = 0.01 dB

Peak SAR (extrapolated) = 16.5 W/kg

**SAR(1 g) = 9.38 W/kg; SAR(10 g) = 5.02 W/kg**

Maximum value of SAR (measured) = 11.8 W/kg

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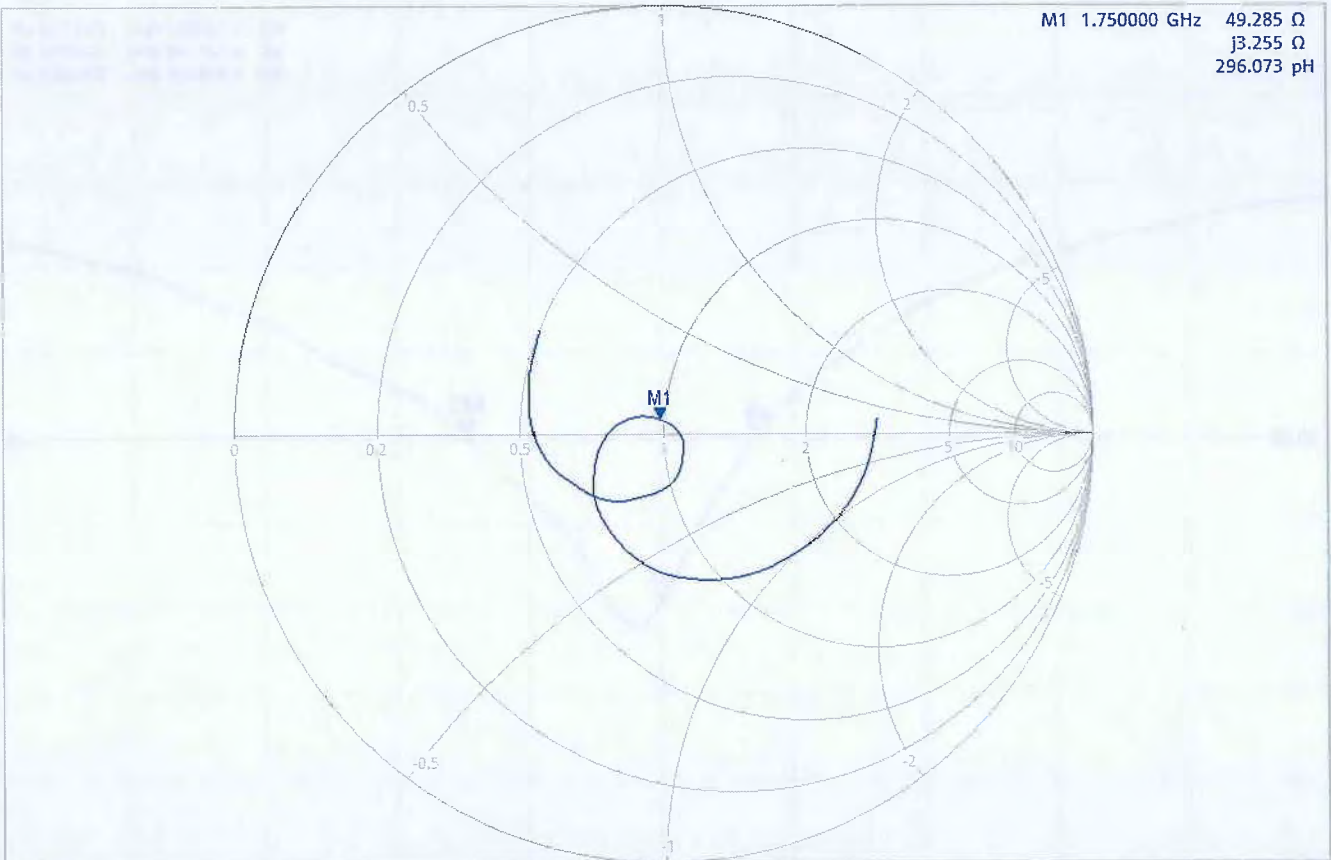
### Impedance Measurement Plot for Body Stimulating Liquid (MSL)

10/9/2017 2:16:47 PM  
1328.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal Smo

1

M1 1.750000 GHz 49.285  $\Omega$   
j3.255  $\Omega$   
296.073 pF



Ch1 Start 1.55 GHz

Pwr -10 dBm Bw 10 kHz

Stop 1.95 GHz

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

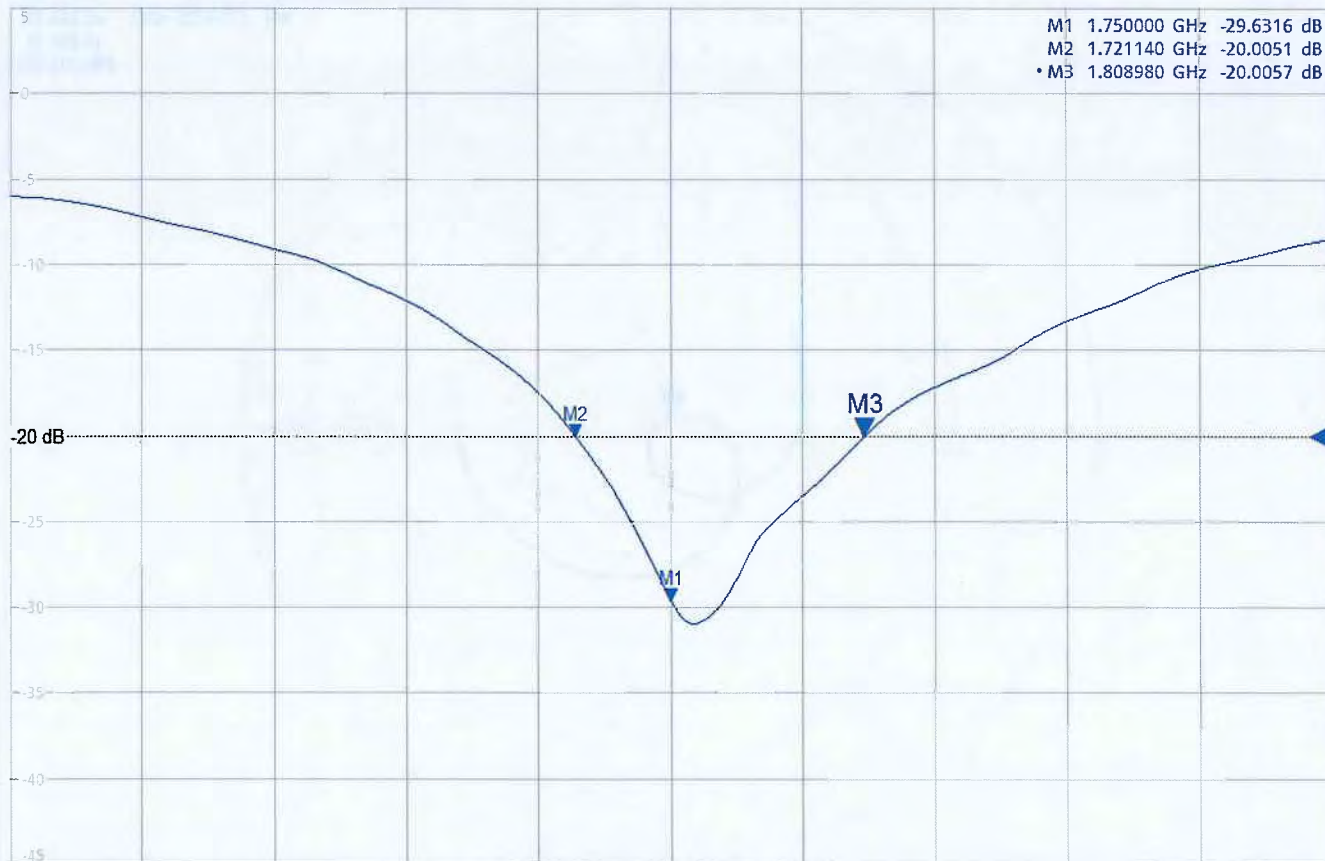


10/9/2017 2:15:13 PM  
1328.5170K92-100151-MV

Trc1 — S11 dB Mag 5 dB/Ref -20 dB Cal Smo

1

M1 1.750000 GHz -29.6316 dB  
M2 1.721140 GHz -20.0051 dB  
• M3 1.808980 GHz -20.0057 dB



Ch1 Start 1.55 GHz

Pwr -10 dBm Bw 10 kHz

Stop 1.95 GHz

**Calibration Certificate Label:**

|                                                                                   |                                                                                                                                                                                         |
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|  | <p><b>UL VS LTD - Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 11903941JD01B</p> <p>Instrument ID: 1077</p> <p>Calibration Date: 05/Oct/2017</p> <p>Calibration Due Date:</p> |
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