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**Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 0108**

Client **UL USA**

Certificate No: **D2450V2-706\_Apr21**

## CALIBRATION CERTIFICATE

Object **D2450V2 - SN:706**

Calibration procedure(s) **QA CAL-05.v11**  
**Calibration Procedure for SAR Validation Sources between 0.7-3 GHz**

Calibration date: **April 23, 2021**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards               | ID #               | Cal Date (Certificate No.)        | Scheduled Calibration  |
|---------------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP                 | SN: 104778         | 09-Apr-21 (No. 217-03291/03292)   | Apr-22                 |
| Power sensor NRP-Z91            | SN: 103244         | 09-Apr-21 (No. 217-03291)         | Apr-22                 |
| Power sensor NRP-Z91            | SN: 103245         | 09-Apr-21 (No. 217-03292)         | Apr-22                 |
| Reference 20 dB Attenuator      | SN: BH9394 (20k)   | 09-Apr-21 (No. 217-03343)         | Apr-22                 |
| Type-N mismatch combination     | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344)         | Apr-22                 |
| Reference Probe EX3DV4          | SN: 7349           | 28-Dec-20 (No. EX3-7349_Dec20)    | Dec-21                 |
| DAE4                            | SN: 601            | 02-Nov-20 (No. DAE4-601_Nov20)    | Nov-21                 |
| Secondary Standards             | ID #               | Check Date (in house)             | Scheduled Check        |
| Power meter E4419B              | SN: GB39512475     | 30-Oct-14 (in house check Oct-20) | In house check: Oct-22 |
| Power sensor HP 8481A           | SN: US37292783     | 07-Oct-15 (in house check Oct-20) | In house check: Oct-22 |
| Power sensor HP 8481A           | SN: MY41092317     | 07-Oct-15 (in house check Oct-20) | In house check: Oct-22 |
| RF generator R&S SMT-06         | SN: 100972         | 15-Jun-15 (in house check Oct-20) | In house check: Oct-22 |
| Network Analyzer Agilent E8358A | SN: US41080477     | 31-Mar-14 (in house check Oct-20) | In house check: Oct-21 |

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

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

Signature

Issued: April 23, 2021

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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.

|                                     |                        |             |
|-------------------------------------|------------------------|-------------|
| <b>DASY Version</b>                 | DASY5                  | V52.10.4    |
| <b>Extrapolation</b>                | Advanced Extrapolation |             |
| <b>Phantom</b>                      | Modular Flat Phantom   |             |
| <b>Distance Dipole Center - TSL</b> | 10 mm                  | with Spacer |
| <b>Zoom Scan Resolution</b>         | dx, dy, dz = 5 mm      |             |
| <b>Frequency</b>                    | 2450 MHz $\pm$ 1 MHz   |             |

## Head TSL parameters

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 39.2           | 1.80 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 38.0 $\pm$ 6 % | 1.87 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
| SAR measured                                                | 250 mW input power | 13.4 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>52.3 W/kg <math>\pm</math> 17.0 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
| SAR measured                                                  | 250 mW input power | 6.22 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>24.5 W/kg <math>\pm</math> 16.5 % (k=2)</b> |

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

### Antenna Parameters with Head TSL

|                                      |                             |
|--------------------------------------|-----------------------------|
| Impedance, transformed to feed point | $51.1 \Omega + 5.7 j\Omega$ |
| Return Loss                          | - 24.9 dB                   |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.144 ns |
|----------------------------------|----------|

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

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

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

### Additional EUT Data

|                 |       |
|-----------------|-------|
| Manufactured by | SPEAG |
|-----------------|-------|

Test Laboratory: SPEAG, Zurich, Switzerland

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

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

Medium parameters used:  $f = 2450$  MHz;  $\sigma = 1.87$  S/m;  $\epsilon_r = 38$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.96, 7.96, 7.96) @ 2450 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

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

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

Reference Value = 114.2 V/m; Power Drift = -0.07 dB

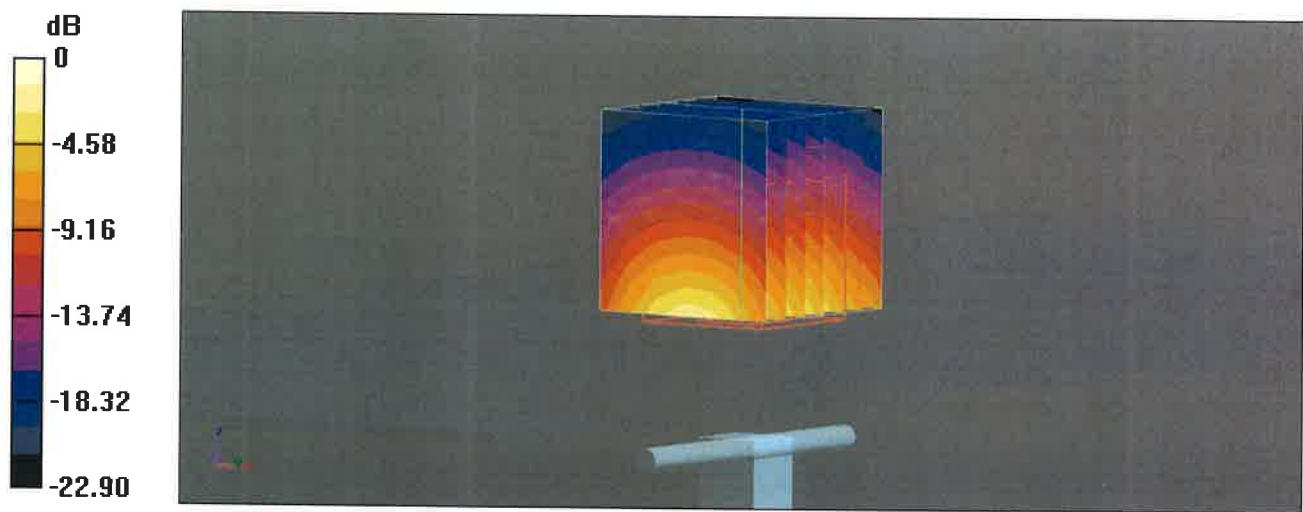
Peak SAR (extrapolated) = 26.7 W/kg

**SAR(1 g) = 13.4 W/kg; SAR(10 g) = 6.22 W/kg**

Smallest distance from peaks to all points 3 dB below = 9 mm

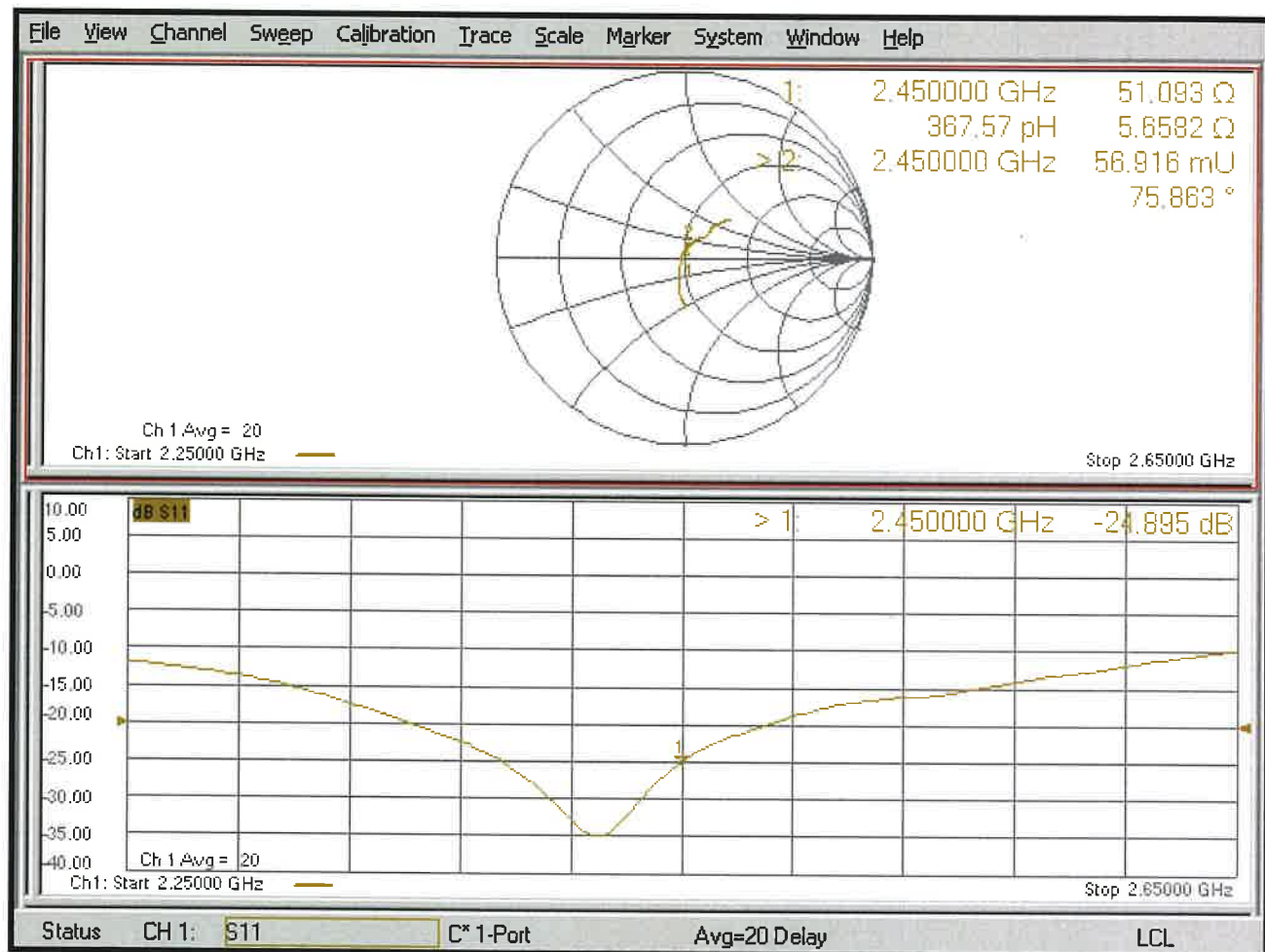
Ratio of SAR at M2 to SAR at M1 = 50.9%

Maximum value of SAR (measured) = 21.4 W/kg



0 dB = 21.4 W/kg = 13.30 dBW/kg

## Impedance Measurement Plot for Head TSL



## Appendix: Transfer Calibration at Four Validation Locations on SAM Head<sup>1</sup>

### Evaluation Condition

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

### SAR result with SAM Head (Top $\cong$ C0)

|                                                             |                  |                                                |
|-------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition        |                                                |
| SAR for nominal Head TSL parameters                         | normalized to 1W | <b>55.7 W/kg <math>\pm</math> 17.5 % (k=2)</b> |

|                                                               |                  |                                                |
|---------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition        |                                                |
| SAR for nominal Head TSL parameters                           | normalized to 1W | <b>26.0 W/kg <math>\pm</math> 16.9 % (k=2)</b> |

### SAR result with SAM Head (Mouth $\cong$ F90)

|                                                             |                  |                                                |
|-------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition        |                                                |
| SAR for nominal Head TSL parameters                         | normalized to 1W | <b>56.8 W/kg <math>\pm</math> 17.5 % (k=2)</b> |

|                                                               |                  |                                                |
|---------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition        |                                                |
| SAR for nominal Head TSL parameters                           | normalized to 1W | <b>27.3 W/kg <math>\pm</math> 16.9 % (k=2)</b> |

### SAR result with SAM Head (Neck $\cong$ H0)

|                                                             |                  |                                                |
|-------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition        |                                                |
| SAR for nominal Head TSL parameters                         | normalized to 1W | <b>53.5 W/kg <math>\pm</math> 17.5 % (k=2)</b> |

|                                                               |                  |                                                |
|---------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition        |                                                |
| SAR for nominal Head TSL parameters                           | normalized to 1W | <b>24.9 W/kg <math>\pm</math> 16.9 % (k=2)</b> |

### SAR result with SAM Head (Ear $\cong$ D90)

|                                                             |                  |                                                |
|-------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition        |                                                |
| SAR for nominal Head TSL parameters                         | normalized to 1W | <b>34.3 W/kg <math>\pm</math> 17.5 % (k=2)</b> |

|                                                               |                  |                                                |
|---------------------------------------------------------------|------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition        |                                                |
| SAR for nominal Head TSL parameters                           | normalized to 1W | <b>17.3 W/kg <math>\pm</math> 16.9 % (k=2)</b> |

<sup>1</sup> Additional assessments outside the current scope of SCS 0108



# CERTIFICATE OF CALIBRATION

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DATE OF ISSUE: 26/Feb/2021

CERTIFICATE NUMBER : 13685197JD01A



UL INTERNATIONAL (UK) LTD  
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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: | 15/Feb/2021 |
| Manufacturer:      | Speag                        |                  |             |
| Type/Model Number: | D2450V2                      |                  |             |
| Serial Number:     | 748                          |                  |             |
| Calibration Date:  | 19/Feb/2021                  |                  |             |
| Calibrated By:     | Masood Khan<br>Test Engineer |                  |             |
| Signature:         |                              |                  |             |

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

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The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2016:** 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. **DASY 6 System Handbook**
6. **Dipole Calibration Procedure V1.2:** Calibration performed as per internal procedure

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) |
|------------|------------------------------|-----------------|---------------|------------|-----------------------|------------------------|
| PRE0178317 | Data Acquisition Electronics | SPEAG           | DAE4          | 1542       | 17 Mar 2020           | 12                     |
| PRE0178313 | Probe                        | SPEAG           | EX3DV4        | 7497       | 24 Mar 2020           | 12                     |
| A1322      | Dipole                       | SPEAG           | D2450V2       | 725        | 08 Oct 2020           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi          | ART 100850-01 | 0001       | Cal as part of System | -                      |
| PRE0151441 | Power Sensor                 | Rhode & Schwarz | NRP8S         | 102481     | 27 Mar 2020           | 12                     |
| PRE0151154 | Vector Network Analyser      | Rhode & Schwarz | ZND           | 100151     | 15 Jun 2020           | 12                     |
| PRE0158684 | Calibration Kit              | Rhode & Schwarz | ZV-Z135       | 102144     | 27 May 2020           | 12                     |
| PRE0178154 | Signal Generator             | Rhode & Schwarz | SMB100A       | 175325     | 10 Jun 2020           | 12                     |

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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number:     | F13/5SC6F1/A/01                            |
| DASY Version:            | cDASY6.14.0.959                            |
| Phantom:                 | ELI Phantom                                |
| Distance Dipole Centre:  | 10mm (with spacer)                         |
| Frequency:               | 2450 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            | 2450            | 20.6 °C   | 20.4 °C | 20.6°C      | 20.6°C | $\epsilon_r$ | 39.2         | 39.60          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 1.80         | 1.80           | ± 5%            |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 200 mW input Power | Normalised to 1.00 W | Uncertainty (%)     |
|-----------------|-----------------------|--------------------|----------------------|---------------------|
| Head            | SAR averaged over 1g  | 13.10 W/Kg         | 52.15 W/Kg           | + 16.80% / - 16.43% |
|                 | SAR averaged over 10g | 6.15 W/Kg          | 24.48 W/Kg           | + 16.72% / - 16.42% |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Head            | Impedance   | 47.403 $\Omega$ +2.719 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 28.27                             | ± 2.03 dB                          |

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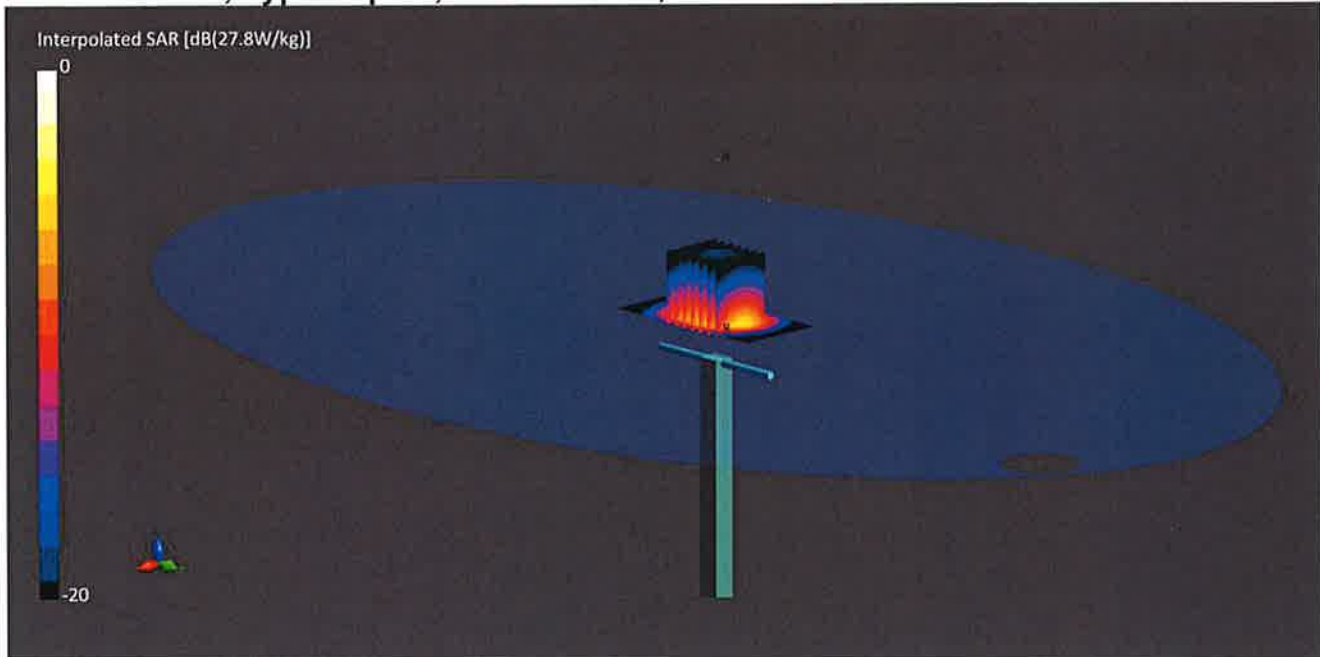
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D2450V2; Type: Dipole; Serial: SN748;



Communication System: CW UID: 0; Frequency: 2450.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site59\_19Feb2021\_104323\_Head - 2450 5%; Medium parameters used:  $f = 2450.0$  MHz;  $\sigma = 1.8$  S/m;  $\epsilon_r = 39.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = 0.92$  %;  $\Delta\sigma = 0.26$  %; No correction  
Phantom section: Flat;  
DASY 6 Configuration:

- Laboratory Name: Site59;
- Probe: EX3DV4 - SN7497; ConvF(7.62, 7.62, 7.62); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; All points
- Electronics: DAE4 - SN1542; Calibrated: 17 Mar 2020
- Phantom: ELI V8.0 (20deg probe tilt); Serial: 2100
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(30x30x30):** Measurement grid:  $dx=5$  mm,  $dy=5$  mm,  $dz=1.5$  mm; Grading Ratio: 1.5; Reference Value = 9.560 V/m; Power Drift = 0.00 dB

Minimum horizontal 3dB distance: 9.5 mm;

Vertical M2/M1 Ratio: 78.6 %;

**SAR(1 g) = 13.100 W/kg; SAR(10 g) = 6.150 W/kg**

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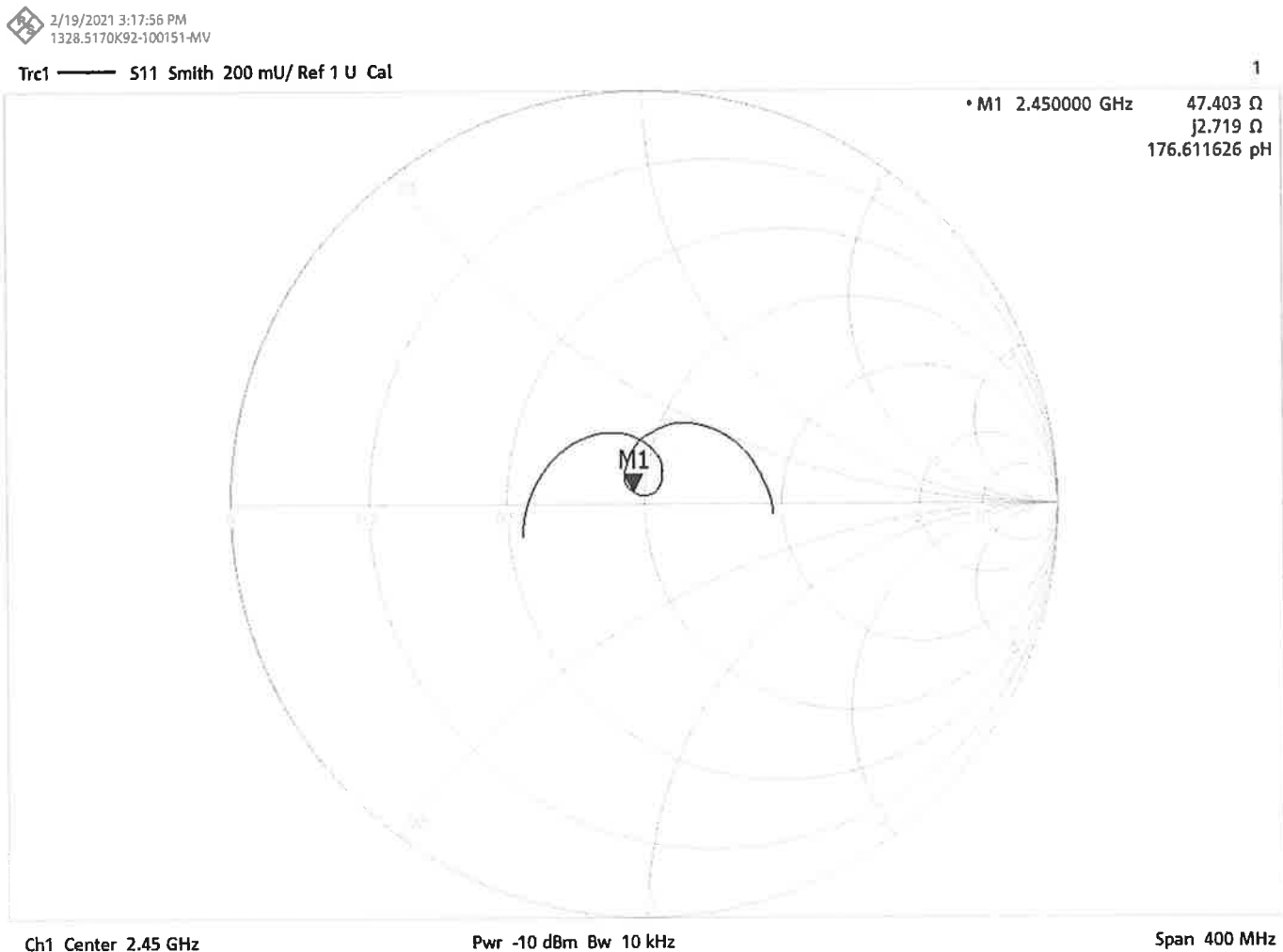
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### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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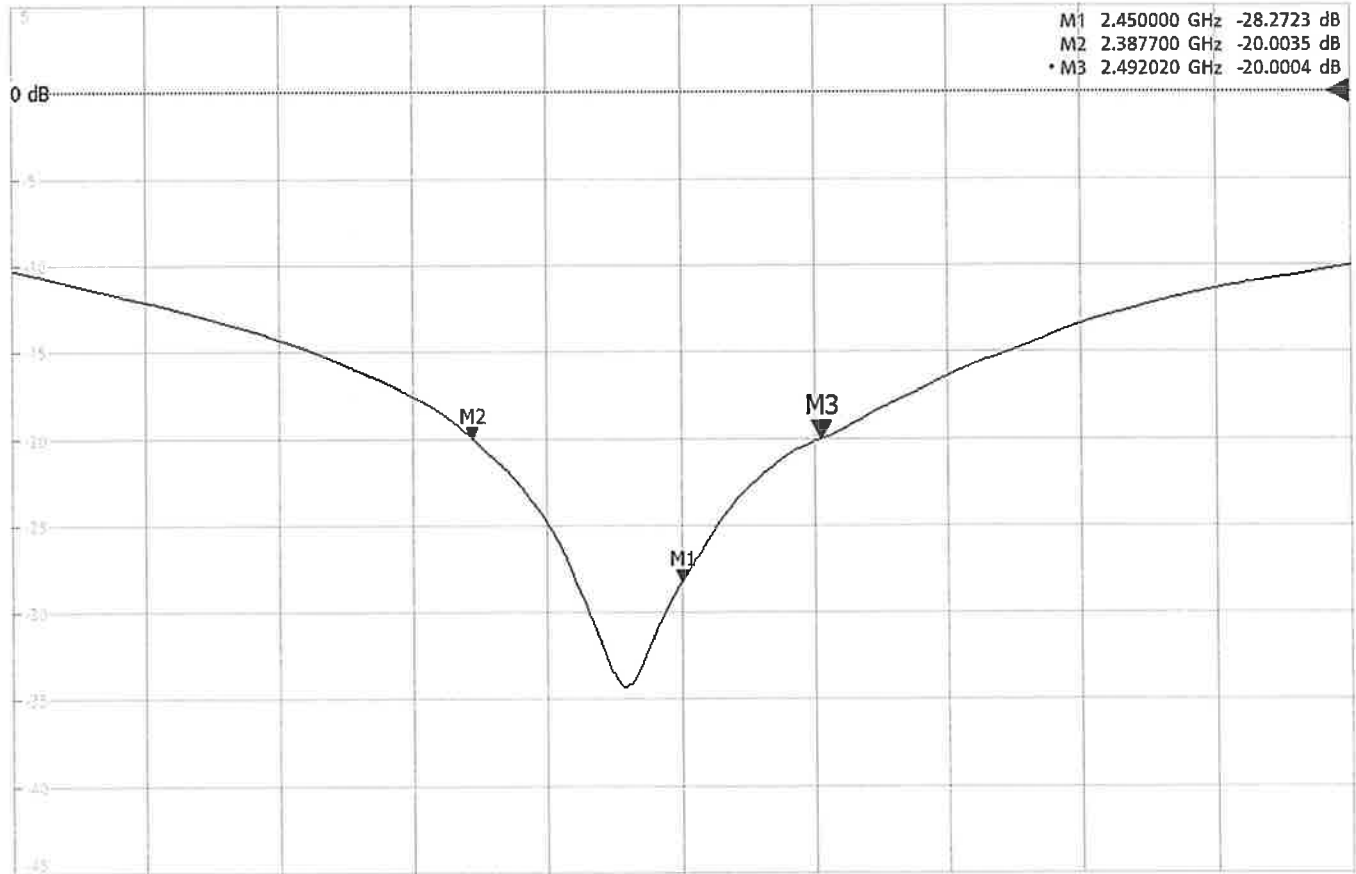
### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



2/19/2021 3:20:07 PM  
1328.5170K92-100151-MV

Trc1 — 511 dB Mag 5 dB/ Ref 0 dB Cal

1



Ch1 Center 2.45 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

**Calibration Certificate Label:**

|                                                                                                  |                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br><b>5772</b> | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13685197JD01A</p> <p>Instrument ID: 748</p> <p>Calibration Date: 19/Feb/2021</p> <p>Calibration Due Date:</p> |
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|                                                                                                  |                                                                                                                                                                                                                 |
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|                                                                                                    |                                                                                                                                                                                                                 |
|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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DATE OF ISSUE: 13/April/2021      CERTIFICATE NUMBER : 13697411JD01E



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Email: LST.UK.Calibration@ul.com



Page 1 of 6

**APPROVED SIGNATORY**

A handwritten signature in black ink, appearing to read 'Harmohan Sahota'.

Harmohan Sahota

## Customer :

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

## Equipment Details:

|                    |                                                                             |                  |               |
|--------------------|-----------------------------------------------------------------------------|------------------|---------------|
| Description:       | Dipole Validation Kit                                                       | Date of Receipt: | 12/April/2021 |
| Manufacturer:      | Speag                                                                       |                  |               |
| Type/Model Number: | D2450V2                                                                     |                  |               |
| Serial Number:     | 899                                                                         |                  |               |
| Calibration Date:  | 13/April/2021                                                               |                  |               |
| Calibrated By:     | Ravish Foolchund<br>Laboratory Technician                                   |                  |               |
| Signature:         | A handwritten signature in black ink, appearing to read 'Ravish Foolchund'. |                  |               |

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

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The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2016:** 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. **DASY 6 System Handbook**
6. **Dipole Calibration Procedure V1.2:** Calibration performed as per internal procedure

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) |
|------------|------------------------------|-----------------|---------------|------------|-----------------------|------------------------|
| PRE0134060 | Data Acquisition Electronics | SPEAG           | DAE4          | 432        | 09 Oct 2020           | 12                     |
| PRE0134817 | Probe                        | SPEAG           | ES3DV3        | 3335       | 14 Jan 2021           | 12                     |
| PRE0131865 | Dipole Antenna               | SPEAG           | D2450V2       | 725        | 07 Oct 2020           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi          | ART 100850-01 | 0001       | Cal as part of System | -                      |
| PRE0151441 | Power Sensor                 | Rohde & Schwarz | NRP8S         | 102481     | 17 Apr 2020           | 12                     |
| PRE0151154 | Vector Network Analyser      | Rohde & Schwarz | ZND           | 100151     | 15 Jun 2020           | 12                     |
| PRE0158684 | Calibration Kit              | Rhode & Schwarz | ZV-Z135       | 102144     | 27 May 2020           | 12                     |
| PRE0178154 | Signal Generator             | Rohde & Schwarz | SMB 100A      | 175325     | 10 Jun 2020           | 12                     |

# CERTIFICATE OF CALIBRATION

## ISSUED BY UL INTERNATIONAL (UK) LTD

UKAS Accredited Calibration Laboratory No. 5772

CERTIFICATE  
NUMBER :  
13697411JD01E

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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number:     | F13/5SC6F1/A/01                            |
| DASY Version:            | cDASY6.14.0.959                            |
| Phantom:                 | Flat section of SAM Twin Phantom           |
| Distance Dipole Centre:  | 10mm (with spacer)                         |
| Frequency:               | 2450 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            | 2450            | 20.0 °C   | 19.8 °C | 19.8°C      | 19.8°C | $\epsilon_r$ | 39.20        | 38.75          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 1.80         | 1.83           | ± 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  | 12.80 W/Kg         | 50.96 W/Kg           | +16.80% / -16.43% |
|                 | SAR averaged over 10g | 6.00 W/Kg          | 23.89 W/Kg           | +16.72% / -16.42% |

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

| Simulant Liquid | Parameter   | Measured Level                   | Uncertainty (%)                    |
|-----------------|-------------|----------------------------------|------------------------------------|
| Head            | Impedance   | 44.55 $\Omega$ - 0.17 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | -24.78 dB                        | ± 2.93 dB                          |

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

DUT: D2450V2; Type: Dipole; Serial: SN899;



Communication System: CW UID: 0; Frequency: 2450.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_12Apr2021\_115940\_Head - 1750 1800 1900 2300 2450 2600 5%;  
Medium parameters used:  $f = 2450.0$  MHz;  $\sigma = 1.82$  S/m;  $\epsilon_r = 38.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -1.16$  %;  $\Delta\sigma = 1.39$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: ES3DV3 - SN3335; ConvF(4.64, 4.64, 4.64); Calibrated: 14 Jan 2021
- Sensor-Surface: 3 mm; VMS + 6p
- Electronics: DAE4 - SN432; Calibrated: 09 Oct 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(30x30x30):** Measurement grid:  $dx=5$  mm,  $dy=5$  mm,  $dz=1.5$  mm; Grading Ratio: 1.5; Reference Value = 17.230 V/m; Power Drift = -0.01 dB

Minimum horizontal 3dB distance: 9.0 mm;

Vertical M2/M1 Ratio: 82.1 %;

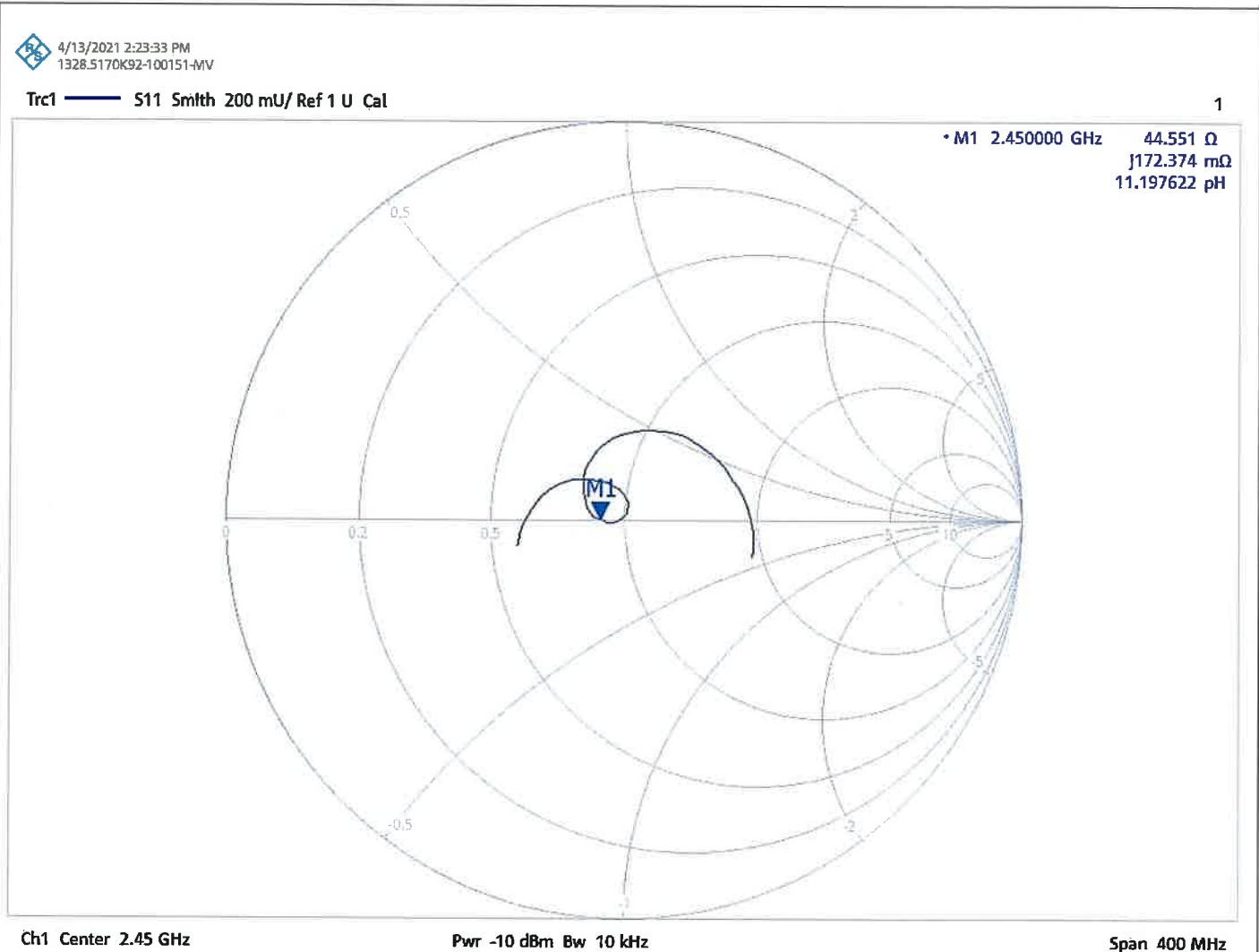
**SAR(1 g) = 12.800 W/kg; SAR(10 g) = 6.000 W/kg**

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



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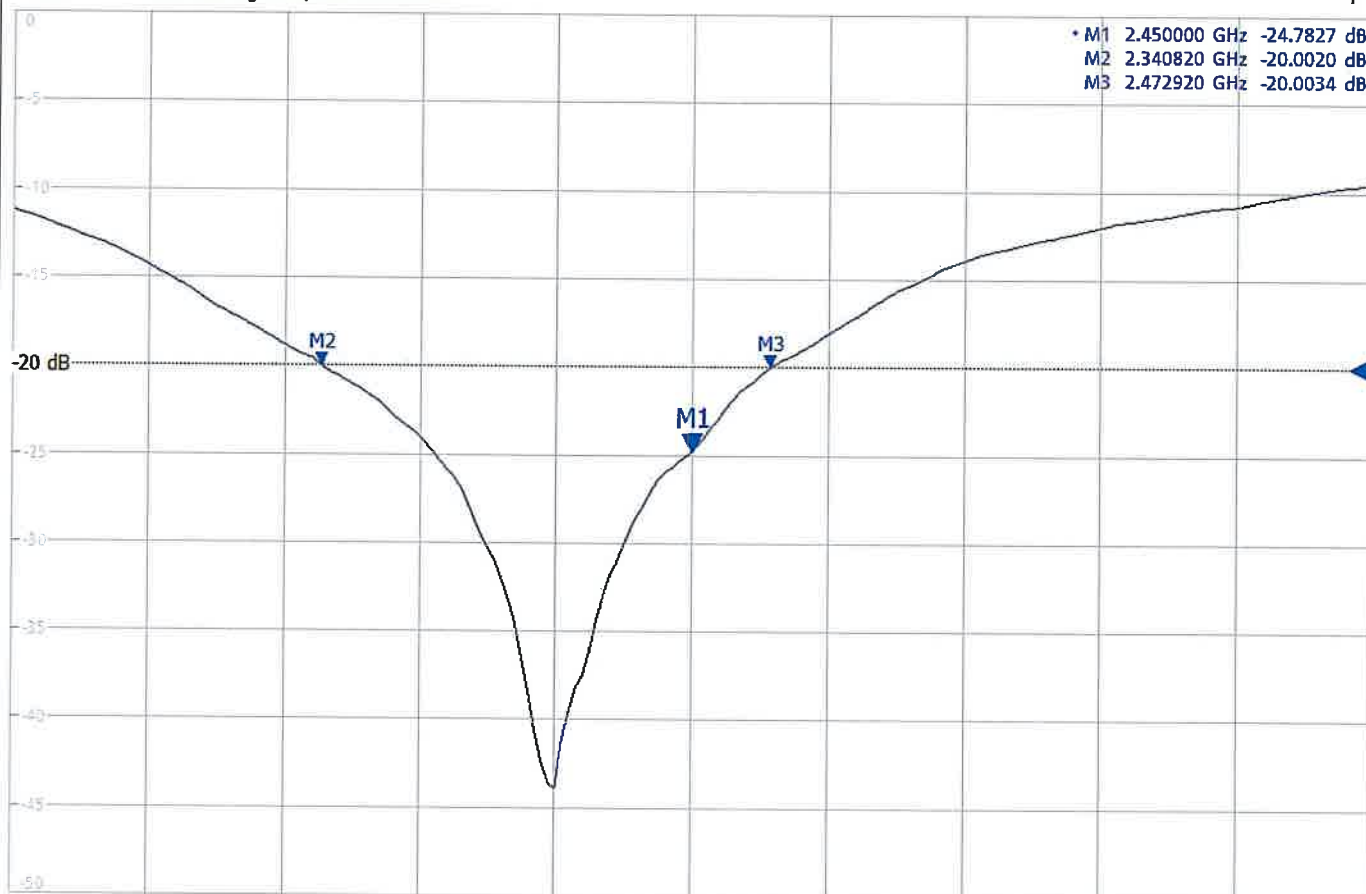
### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



4/13/2021 2:22:47 PM  
1328.5170K92-100151-MV

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

1



Ch1 Center 2.45 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

**Calibration Certificate Label:**

|                                                                                                  |                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br><b>5772</b> | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13697411JD01E</p> <p>Instrument ID: 899</p> <p>Calibration Date: 13/April/2021</p> <p>Calibration Due Date:</p> |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                  |                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br><b>5772</b> | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13697411JD01E</p> <p>Instrument ID: 899</p> <p>Calibration Date: 13/April/2021</p> <p>Calibration Due Date:</p> |
|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                                    |                                                                                                                                                                                                                   |
|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br><b>5772</b> | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13697411JD01E</p> <p>Instrument ID: 899</p> <p>Calibration Date: 13/April/2021</p> <p>Calibration Due Date:</p> |
|----------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

# CERTIFICATE OF CALIBRATION

ISSUED BY **UL INTERNATIONAL (UK) LTD**

DATE OF ISSUE: 29/Oct/2020

CERTIFICATE NUMBER : 13252590JD01E



UL INTERNATIONAL (UK) LTD  
UNIT 1-3 HORIZON  
KINGSLAND PARK, WADE ROAD  
BASINGSTOKE, HAMPSHIRE  
RG24 8AH, 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 'Harmohan Sahota', written over a horizontal line.

Harmohan Sahota

## Customer :

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

## Equipment Details:

|                    |                                           |                  |             |
|--------------------|-------------------------------------------|------------------|-------------|
| Description:       | Dipole Validation Kit                     | Date of Receipt: | 15/Oct/2020 |
| Manufacturer:      | Speag                                     |                  |             |
| Type/Model Number: | D2600V2                                   |                  |             |
| Serial Number:     | 1006                                      |                  |             |
| Calibration Date:  | 20/Oct/2020                               |                  |             |
| Calibrated By:     | Kaan Corbacioglu<br>Laboratory Technician |                  |             |

Signature:

A handwritten signature in black ink, appearing to read 'Kaan Corbacioglu', written over a horizontal line.

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 17025:2017 has been independently assessed.

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The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2016:** 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. **DASY5/6 System Handbook**
6. **Dipole Calibration Procedure V1.2:** Calibration performed as per internal procedure

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) |
|------------|------------------------------|-----------------|---------------|------------|-----------------------|------------------------|
| PRE0135115 | Data Acquisition Electronics | SPEAG           | DAE4          | 1438       | 14 Apr 2020           | 12                     |
| PRE0178314 | Probe                        | SPEAG           | EX3DV4        | 7496       | 24 Mar 2020           | 12                     |
| PRE0135603 | Dipole                       | SPEAG           | D2600V2       | 1109       | 14 Feb 2020           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi          | ART 100850-01 | 0001       | Cal as part of System | -                      |
| PRE0151441 | Power Sensor                 | Rhode & Schwarz | NRP8S         | 102481     | 27 Mar 2020           | 12                     |
| PRE0151154 | Vector Network Analyser      | Rhode & Schwarz | ZNB 8         | 100151     | 15 Jun 2020           | 12                     |
| PRE0158684 | Calibration Kit              | Rhode & Schwarz | ZV-Z135       | 102144     | 27 May 2020           | 12                     |
| PRE0178154 | Signal Generator             | Rhode & Schwarz | SMB100A       | 175325     | 10 Jun 2020           | 12                     |



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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number:     | F17/5ENYG1/A/01                            |
| DASY Version:            | cDASY6.14.0.959                            |
| Phantom:                 | Flat section of SAM Twin Phantom           |
| Distance Dipole Centre:  | 10 mm (with spacer)                        |
| Frequency:               | 2600 MHz                                   |

### Dielectric Property Measurements – Head Simulating Liquid (HSL)

| Simulant Liquid | Frequency (MHz) | Room Temp |        | Liquid Temp |        | Parameters   | Target Value | Measured Value | Uncertainty (%) |
|-----------------|-----------------|-----------|--------|-------------|--------|--------------|--------------|----------------|-----------------|
|                 |                 | Start     | End    | Start       | End    |              |              |                |                 |
| Head            | 2600            | 19.3°C    | 19.5°C | 19.8°C      | 20.0°C | $\epsilon_r$ | 39.01        | 38.12          | ± 5%            |
|                 |                 |           |        |             |        | $\sigma$     | 1.96         | 1.93           | ± 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  | 12.90 W/Kg         | <b>51.36 W/Kg</b>    | ± 17.57%        |
|                 | SAR averaged over 10g | 5.88 W/Kg          | <b>23.41 W/Kg</b>    | ± 17.32%        |

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

| Simulant Liquid | Parameter   | Measured Level                  | Uncertainty (%)                    |
|-----------------|-------------|---------------------------------|------------------------------------|
| Head            | Impedance   | 50.32 $\Omega$ - 7.35j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 22.72                           | ± 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            | 2600            | 19.4°C    | 19.4°C | 19.9°C      | 20.1°C | $\epsilon_r$ | 52.51        | 52.41          | ± 5%            |
|                 |                 |           |        |             |        | $\sigma$     | 2.17         | 2.22           | ± 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  | 13.30 W/Kg         | <b>52.95 W/Kg</b>    | ± 18.06%        |
|                 | SAR averaged over 10g | 5.92 W/Kg          | <b>23.57 W/Kg</b>    | ± 17.44%        |

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

| Simulant Liquid | Parameter   | Measured Level                  | Uncertainty (%)                    |
|-----------------|-------------|---------------------------------|------------------------------------|
| Body            | Impedance   | 46.68 $\Omega$ - 5.11j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 24.16                           | ± 2.03 dB                          |

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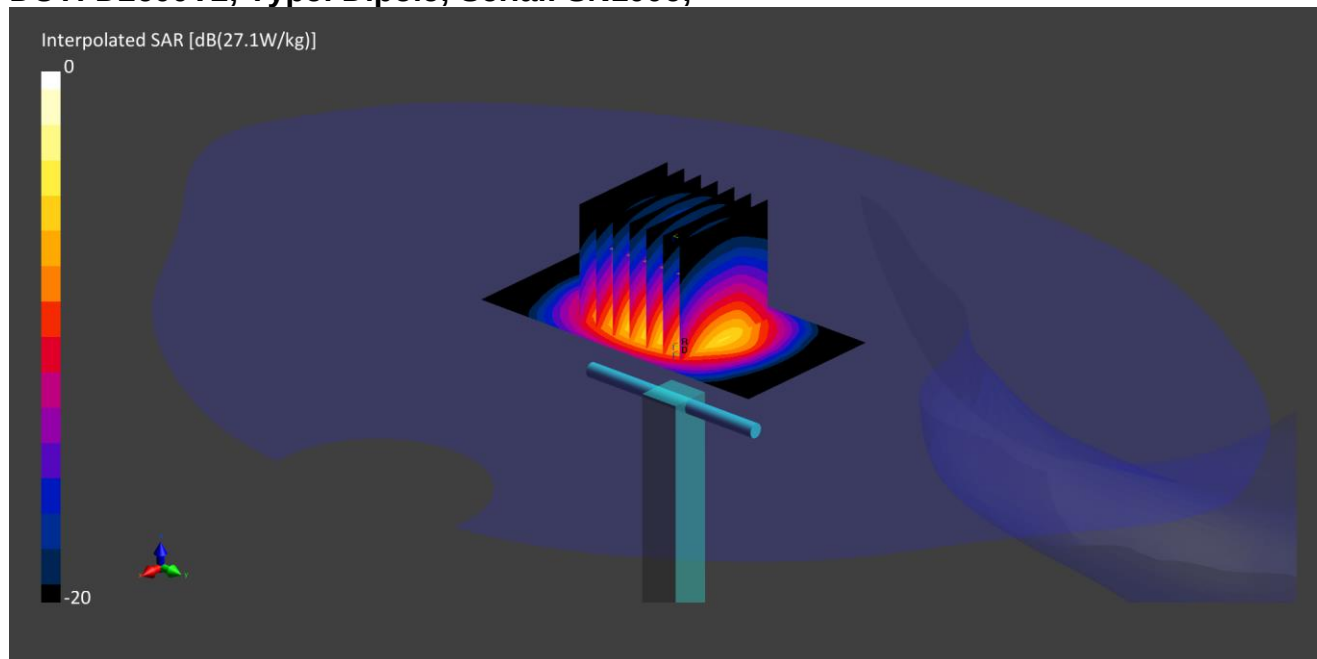
UKAS Accredited Calibration Laboratory No. 5772

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NUMBER :  
13252590JD01E

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

**DUT: D2600V2; Type: Dipole; Serial: SN1006;**



Communication System: CW UID: 0; Frequency: 2600.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_19Oct2020\_134430\_Head - 2300 2600 5%; Medium parameters used:  $f = 2600.0$  MHz;  $\sigma = 1.93$  S/m;  $\epsilon_r = 38.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -2.27$  %;  $\Delta\sigma = -1.97$  %; No correction  
Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(7.6, 7.6, 7.6); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(30x30x30):** Measurement grid:  $dx=5$  mm,  $dy=5$  mm,  $dz=1.5$  mm; Grading Ratio: 1.5; Reference Value = 17.480 V/m; Power Drift = -0.01 dB

Minimum horizontal 3dB distance: 9.0 mm;

Vertical M2/M1 Ratio: 79.8 %;

**SAR(1 g) = 12.900 W/kg; SAR(10 g) = 5.880 W/kg**

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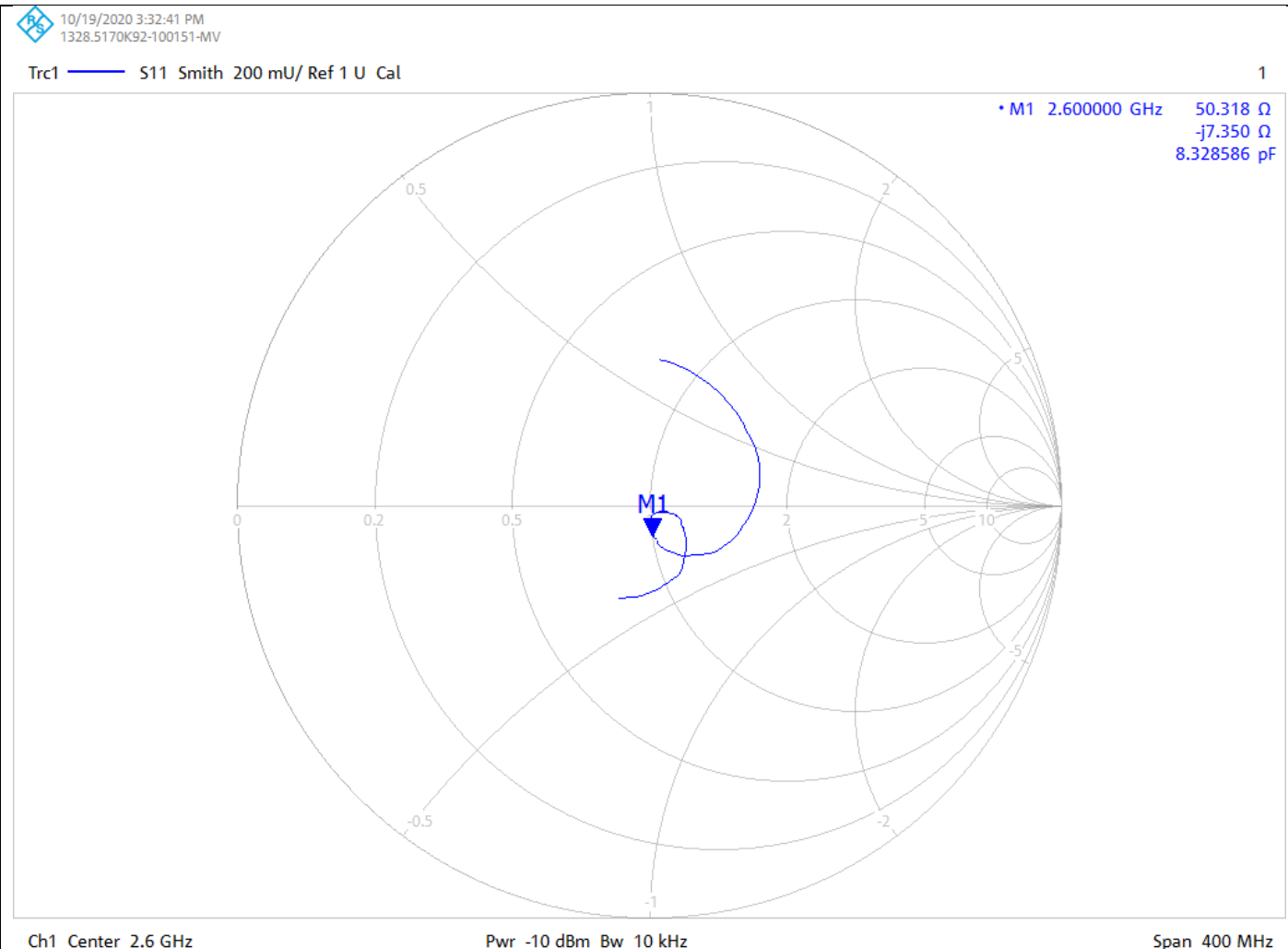
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### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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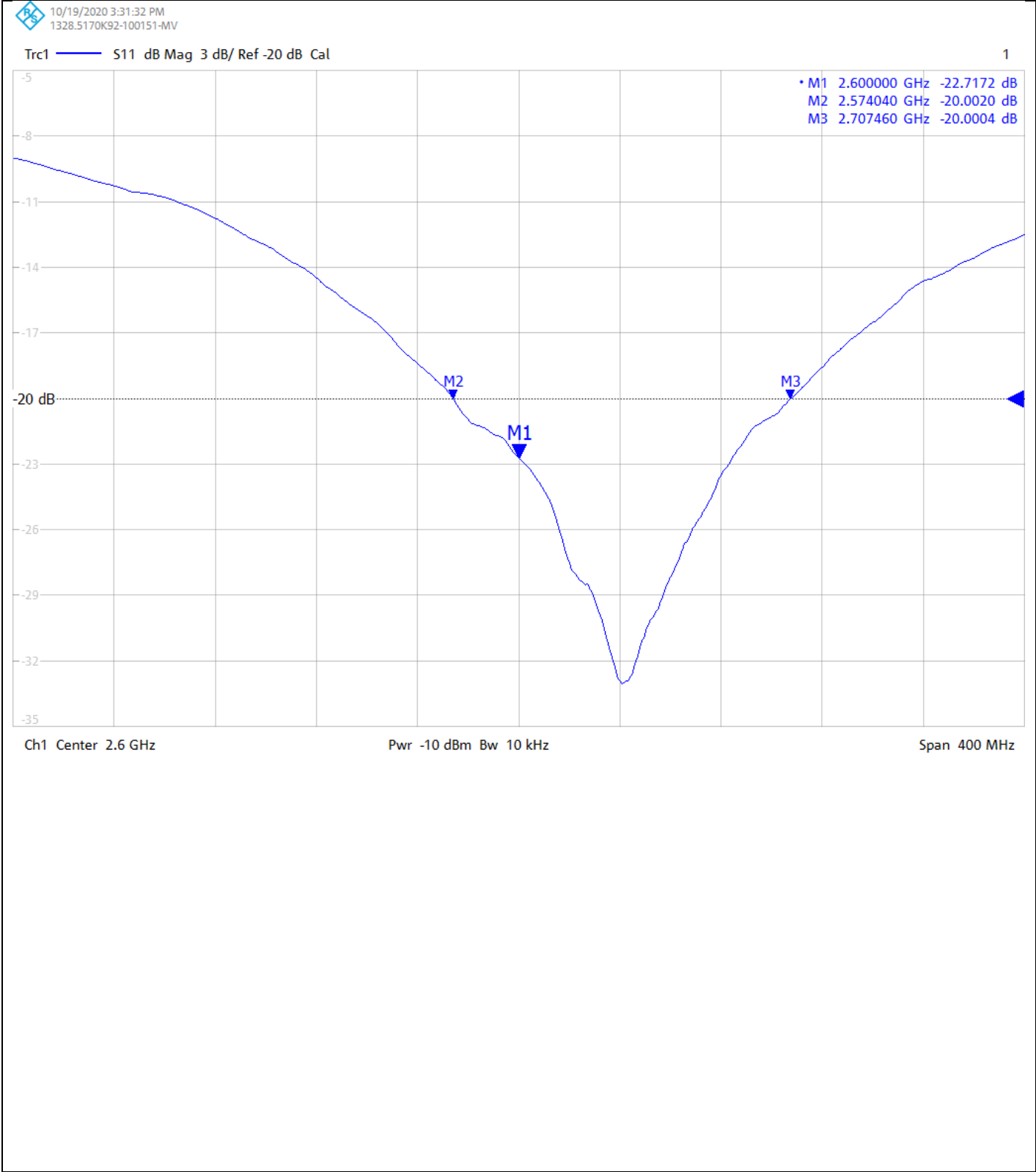
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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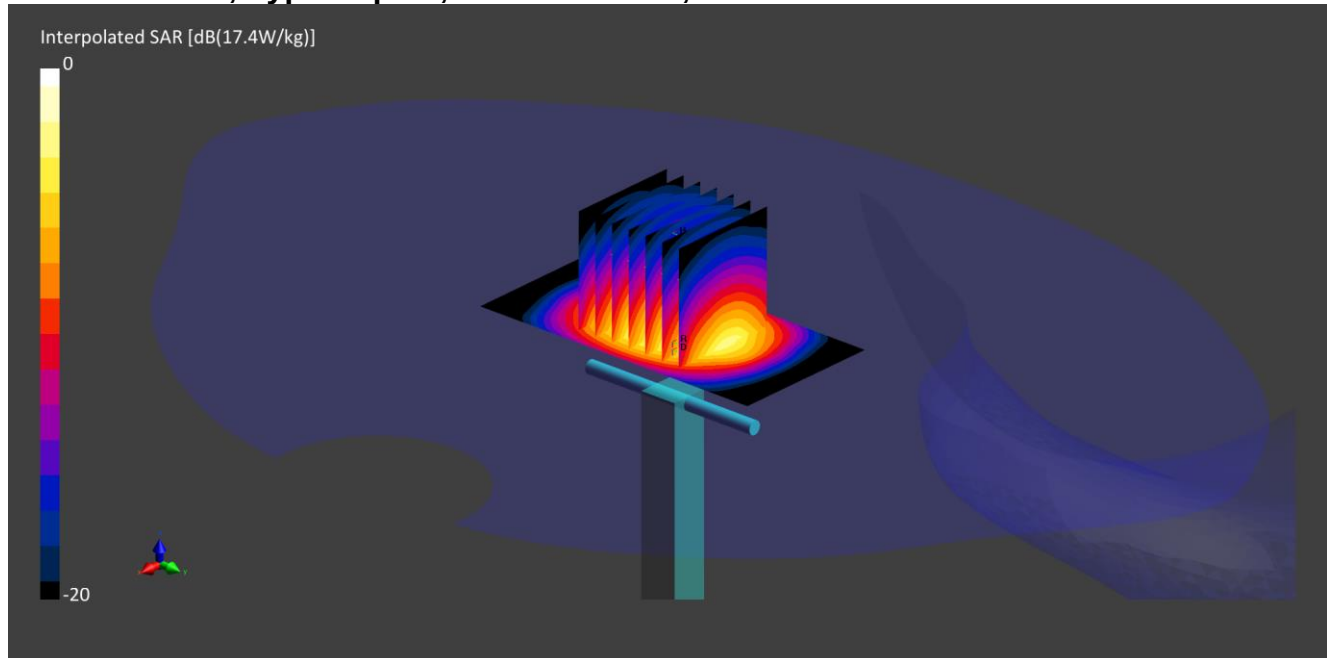
UKAS Accredited Calibration Laboratory No. 5772

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NUMBER :  
13252590JD01E

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

**DUT: D2600V2; Type: Dipole; Serial: SN1006;**



Communication System: CW UID: 0; Frequency: 2600.0 MHz; Duty Cycle: 1;  
Medium: MSL; Site65\_19Oct2020\_142913\_Body - 2600 5%; Medium parameters used:  $f = 2600.0$  MHz;  $\sigma = 2.22$  S/m;  $\epsilon_r = 52.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -0.17$  %;  $\Delta\sigma = 2.76$  %; No correction  
Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(7.58, 7.58, 7.58); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V5.0 (30deg probe tilt); Serial: 1818
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(30x30x30):** Measurement grid:  $dx=5$  mm,  $dy=5$  mm,  $dz=1.5$  mm; Grading Ratio: 1.5; Reference Value = 17.710 V/m; Power Drift = 0.01 dB

Minimum horizontal 3dB distance: 8.5 mm;

Vertical M2/M1 Ratio: 77.9 %;

**SAR(1 g) = 13.300 W/kg; SAR(10 g) = 5.920 W/kg**

# CERTIFICATE OF CALIBRATION

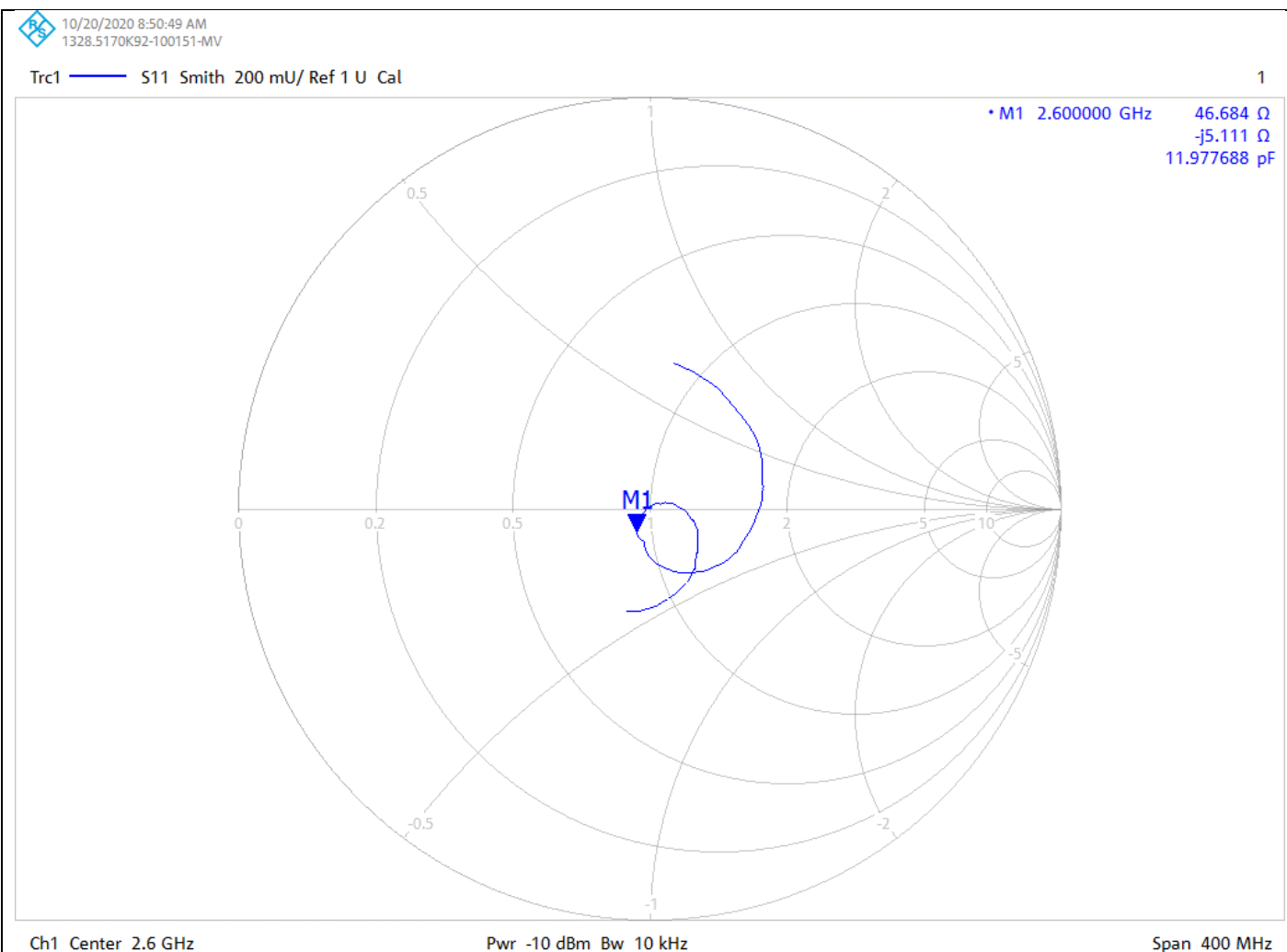
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### Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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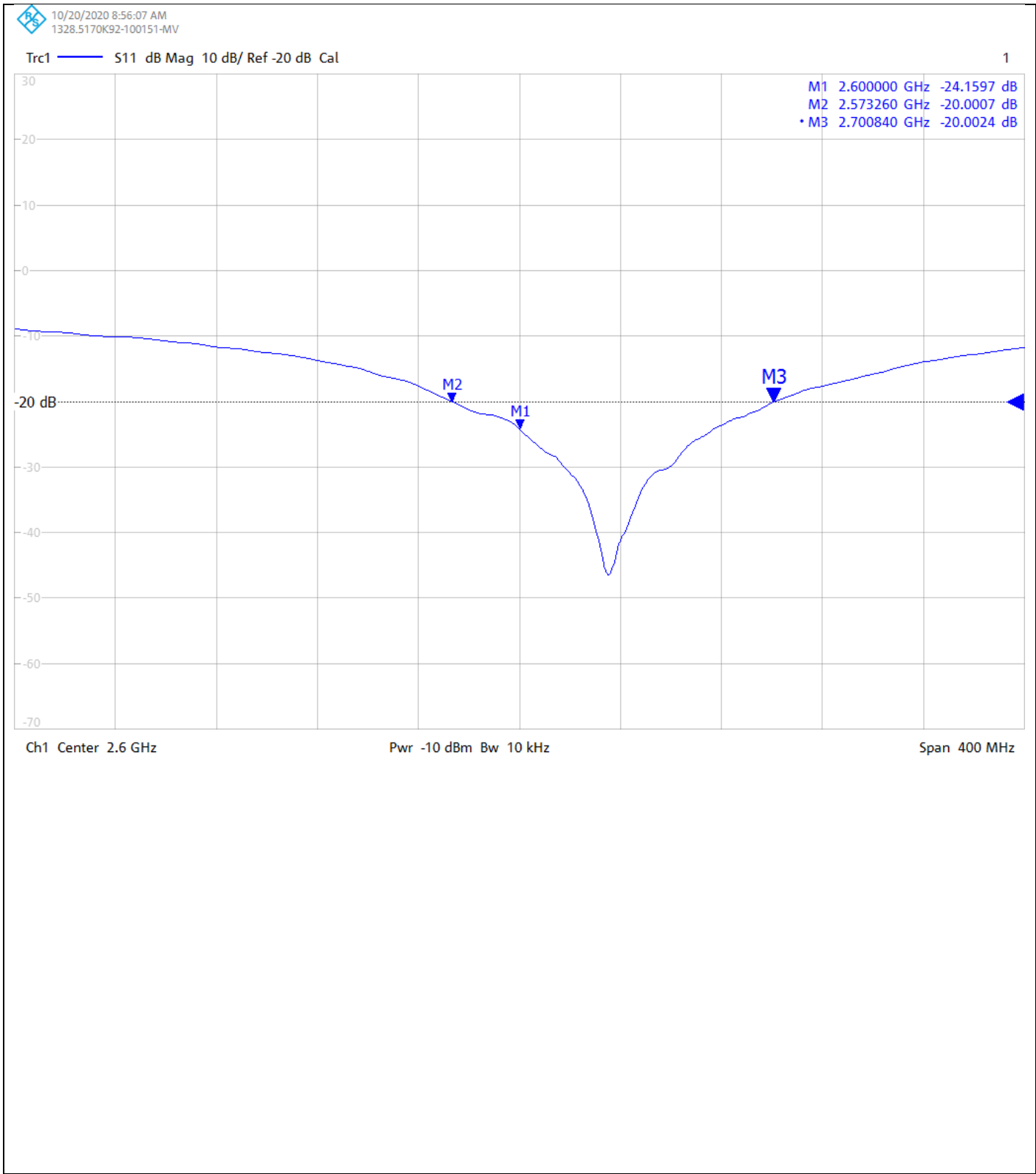
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### Return Loss Measurement Plot for Body Stimulating Liquid (MSL)





**Calibration Certificate Label:**

|                                                                                   |                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13252590JD01E</p> <p>Instrument ID: 1006</p> <p>Calibration Date: 20/Oct/2020</p> <p>Calibration Due Date:</p> |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                    |                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13252590JD01E</p> <p>Instrument ID: 1006</p> <p>Calibration Date: 20/Oct/2020</p> <p>Calibration Due Date:</p> |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                                                                     |                                                                                                                                                                                                                  |
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|  | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13252590JD01E</p> <p>Instrument ID: 1006</p> <p>Calibration Date: 20/Oct/2020</p> <p>Calibration Due Date:</p> |
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# CERTIFICATE OF CALIBRATION

ISSUED BY **UL INTERNATIONAL (UK) LTD**

DATE OF ISSUE: 15/April/2021      CERTIFICATE NUMBER : 13697411JD01G



UL INTERNATIONAL (UK) LTD  
UNIT 1-3 HORIZON  
KINGSLAND PARK, WADE ROAD  
BASINGSTOKE, HAMPSHIRE  
RG24 8AH, UK  
TEL: +44 (0) 1256 312100  
FAX: +44 (0) 1256 312001  
Email: LST.UK.Calibration@ul.com



Page 1 of 6

**APPROVED SIGNATORY**

Harmohan Sahota

## Customer :

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

## Equipment Details:

|                    |                                           |                  |               |
|--------------------|-------------------------------------------|------------------|---------------|
| Description:       | Dipole Validation Kit                     | Date of Receipt: | 12/April/2021 |
| Manufacturer:      | Speag                                     |                  |               |
| Type/Model Number: | D3500V2                                   |                  |               |
| Serial Number:     | 1011                                      |                  |               |
| Calibration Date:  | 15/April/2021                             |                  |               |
| Calibrated By:     | Ravish Foolchund<br>Laboratory Technician |                  |               |
| Signature:         |                                           |                  |               |

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

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UKAS Accredited Calibration Laboratory No. 5772

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13697411JD01G

Page 2 of 6

The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2016:** 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. **DASY 6 System Handbook**
6. **Dipole Calibration Procedure V1.2:** Calibration performed as per internal procedure

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) |
|------------|------------------------------|-----------------|---------------|------------|-----------------------|------------------------|
| PRE0134060 | Data Acquisition Electronics | SPEAG           | DAE4          | 432        | 09 Oct 2020           | 12                     |
| PRE0134817 | Probe                        | SPEAG           | ES3DV3        | 3335       | 14 Jan 2021           | 12                     |
| PRE0135600 | Dipole Antenna               | SPEAG           | D3500V2       | 1044       | 11 Feb 2021           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi          | ART 100850-01 | 0001       | Cal as part of System | -                      |
| PRE0151441 | Power Sensor                 | Rohde & Schwarz | NRP8S         | 102481     | 17 Apr 2020           | 12                     |
| PRE0151154 | Vector Network Analyser      | Rohde & Schwarz | ZND           | 100151     | 15 Jun 2020           | 12                     |
| PRE0158684 | Calibration Kit              | Rhode & Schwarz | ZV-Z135       | 102144     | 27 May 2020           | 12                     |
| PRE0178154 | Signal Generator             | Rohde & Schwarz | SMB 100A      | 175325     | 10 Jun 2020           | 12                     |

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CERTIFICATE  
NUMBER :  
13697411JD01G

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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number:     | F13/5SC6F1/A/01                            |
| DASY Version:            | cDASY6.14.0.959                            |
| Phantom:                 | Flat section of SAM Twin Phantom           |
| Distance Dipole Centre:  | 10mm (with spacer)                         |
| Frequency:               | 3500 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            | 3500            | 20.0 °C   | 20.2 °C | 22.0°C      | 22°C | $\epsilon_r$ | 37.93        | 37.27          | ± 5%            |
|                 |                 |           |         |             |      | $\sigma$     | 2.91         | 2.97           | ± 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  | 15.80 W/Kg         | 62.90 W/Kg           | +16.77% / -16.70% |
|                 | SAR averaged over 10g | 5.88 W/Kg          | 23.41 W/Kg           | ±16.70%           |

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

| Simulant Liquid | Parameter   | Measured Level                   | Uncertainty (%)                    |
|-----------------|-------------|----------------------------------|------------------------------------|
| Head            | Impedance   | 55.51 $\Omega$ - 1.96 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | -25.12 dB                        | ± 2.97 dB                          |

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

DUT: D3500V2; Type: Dipole; Serial: SN1011;



Communication System: CW UID: 0; Frequency: 3500.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_14Apr2021\_183123\_Head - 3500 5%; Medium parameters used:  $f = 3500.0$  MHz;  $\sigma = 2.97$  S/m;  $\epsilon_r = 37.3$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -1.72$  %;  $\Delta\sigma = 2.03$  %; No correction  
Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: ES3DV3 - SN3335; ConvF(4.09, 4.09, 4.09); Calibrated: 14 Jan 2021
- Sensor-Surface: 3 mm; VMS + 6p
- Electronics: DAE4 - SN432; Calibrated: 09 Oct 2020
- Phantom: Twin-SAM V5.0 (30deg probe tilt); Serial: 1818
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(28x28x28):** Measurement grid:  $dx=5$  mm,  $dy=5$  mm,  $dz=1.4$  mm; Grading Ratio: 1.5; Reference Value = 23.010 V/m; Power Drift = 0.01 dB

Minimum horizontal 3dB distance: 8.9 mm;

Vertical M2/M1 Ratio: 73.9 %;

**SAR(1 g) = 15.800 W/kg; SAR(10 g) = 5.880 W/kg**

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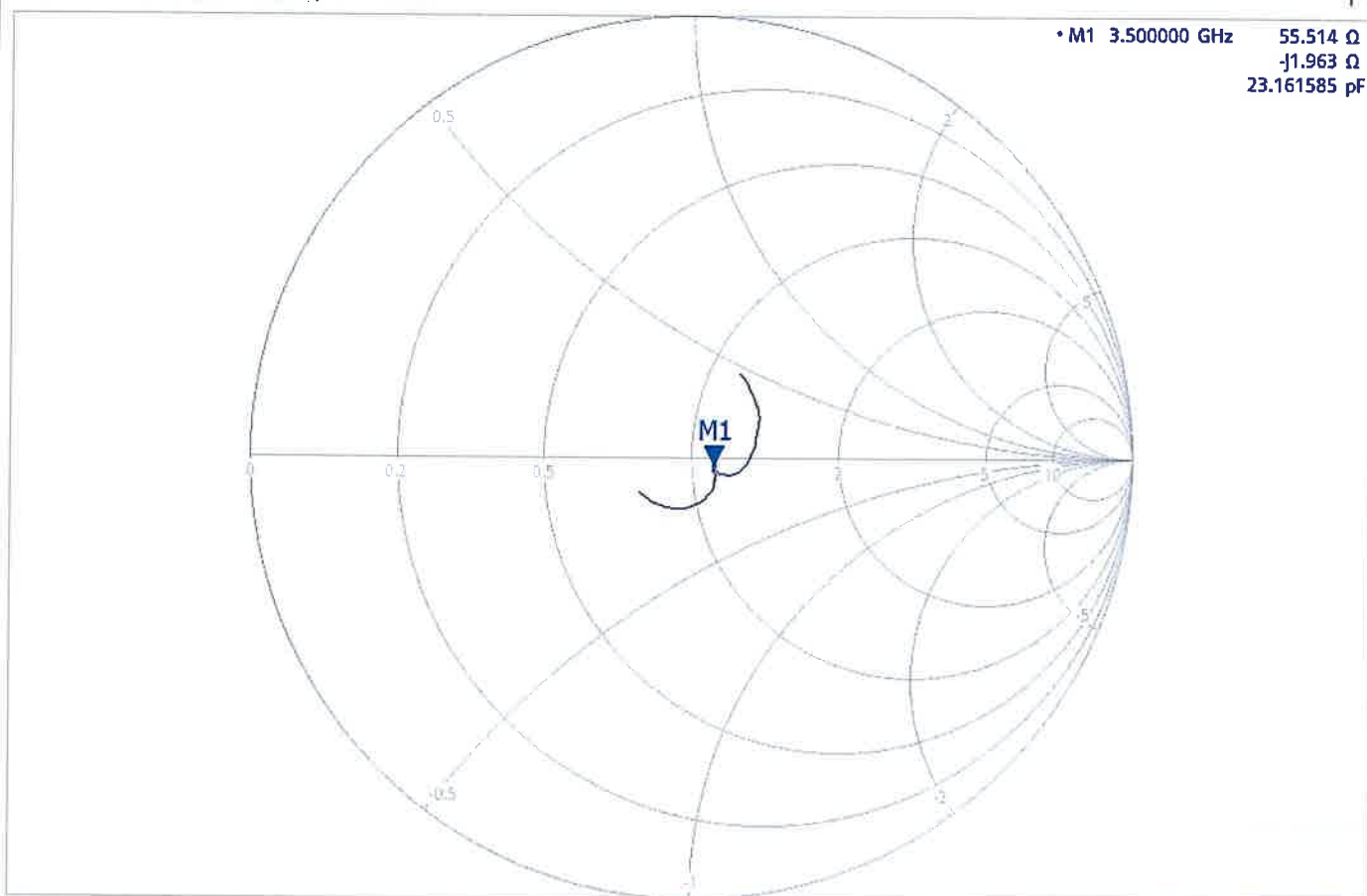
### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



4/15/2021 9:59:14 AM  
1328.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal

1



Ch1 Center 3.5 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

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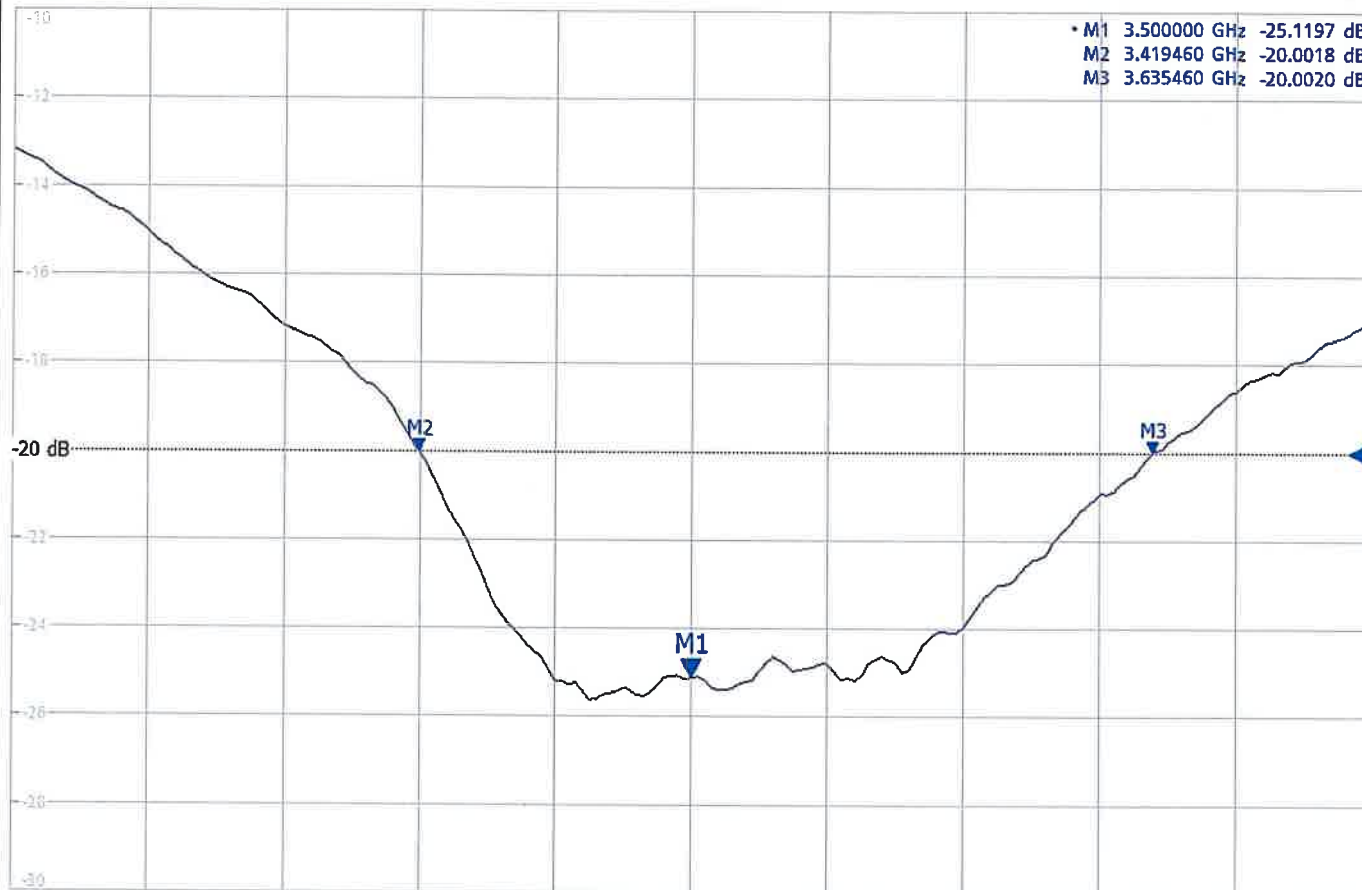
Page 6 of 6

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

4/15/2021 9:56:53 AM  
132B.5170K92-100151-MV

Trc1 — S11 dB Mag 2 dB/ Ref -20 dB Cal

1



Ch1 Center 3.5 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

**Calibration Certificate Label:**

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

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

|                                                                                                    |                                                                                                                                                                                                                    |
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# CERTIFICATE OF CALIBRATION

ISSUED BY UL INTERNATIONAL (UK) LTD

DATE OF ISSUE: 26/Feb/2021

CERTIFICATE NUMBER : 13685197JD01B



UL INTERNATIONAL (UK) LTD  
UNIT 1-3 HORIZON  
KINGSLAND PARK, WADE ROAD  
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RG24 8AH, UK  
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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: | 15/Feb/2021 |
| Manufacturer:      | Speag                        |                  |             |
| Type/Model Number: | D3500V2                      |                  |             |
| Serial Number:     | 1060                         |                  |             |
| Calibration Date:  | 25/Feb/2021                  |                  |             |
| Calibrated By:     | Masood Khan<br>Test 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 62209-1:2016**: 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. **DASY 6 System Handbook**
6. **Dipole Calibration Procedure V1.2**: Calibration performed as per internal procedure

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) |
|------------|------------------------------|-----------------|---------------|------------|-----------------------|------------------------|
| PRE0178317 | Data Acquisition Electronics | SPEAG           | DAE4          | 1542       | 17 Mar 2020           | 12                     |
| PRE0178313 | Probe                        | SPEAG           | EX3DV4        | 7497       | 24 Mar 2020           | 12                     |
| PRE0135600 | Dipole                       | SPEAG           | D3500V2       | 1044       | 11 Feb 2021           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi          | ART 100850-01 | 0001       | Cal as part of System | -                      |
| PRE0151441 | Power Sensor                 | Rhode & Schwarz | NRP8S         | 102481     | 27 Mar 2020           | 12                     |
| PRE0151154 | Vector Network Analyser      | Rhode & Schwarz | ZND           | 100151     | 15 Jun 2020           | 12                     |
| PRE0158684 | Calibration Kit              | Rhode & Schwarz | ZV-Z135       | 102144     | 27 May 2020           | 12                     |
| PRE0178154 | Signal Generator             | Rhode & Schwarz | SMB100A       | 175325     | 10 Jun 2020           | 12                     |

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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number:     | F13/5SC6F1/A/01                            |
| DASY Version:            | cDASY6.14.0.959                            |
| Phantom:                 | Flat section of SAM Twin Phantom           |
| Distance Dipole Centre:  | 10mm (with spacer)                         |
| Frequency:               | 3500 MHz                                   |

### Dielectric Property Measurements – Head Simulating Liquid (HSL)

| Simulant Liquid | Frequency<br>(MHz) | Room Temp |         | Liquid Temp |         | Parameters   | Target<br>Value | Measured<br>Value | Uncertainty<br>(%) |
|-----------------|--------------------|-----------|---------|-------------|---------|--------------|-----------------|-------------------|--------------------|
|                 |                    | Start     | End     | Start       | End     |              |                 |                   |                    |
| Head            | 3500               | 20.0 °C   | 19.8 °C | 20.4 °C     | 20.2 °C | $\epsilon_r$ | 37.93           | 39.38             | ± 10%              |
|                 |                    |           |         |             |         | $\sigma$     | 2.91            | 2.79              | ± 10%              |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 200 mW input Power | Normalised to 1.00 W | Uncertainty<br>(%) |
|-----------------|-----------------------|--------------------|----------------------|--------------------|
| Head            | SAR averaged over 1g  | 15.60 W/Kg         | <b>62.10W/Kg</b>     | +16.77% / -16.70%  |
|                 | SAR averaged over 10g | 5.91 W/Kg          | <b>23.53 W/Kg</b>    | ± 16.70%           |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty<br>(%)                 |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Head            | Impedance   | 53.917 $\Omega$ -4.632 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 24.68                             | ± 2.03 dB                          |

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

DUT: D3500V2; Type: Dipole; Serial: SN1060;



Communication System: CW UID: 0; Frequency: 3500.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site59\_25Feb2021\_111544\_Head - 3500 5%; Medium parameters used:  $f = 3500.0$  MHz;  $\sigma = 2.79$  S/m;  $\epsilon_r = 39.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = 3.82$  %;  $\Delta\sigma = -4.19$  %; No correction  
Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site59;
- Probe: EX3DV4 - SN7497; ConvF(7.17, 7.17, 7.17); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1542; Calibrated: 17 Mar 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1927
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(28x28x28):** Measurement grid:  $dx=5$  mm,  $dy=5$  mm,  $dz=1.4$  mm; Grading Ratio: 1.5; Reference Value = 21.350 V/m; Power Drift = -0.01 dB

Minimum horizontal 3dB distance: 8.0 mm;

Vertical M2/M1 Ratio: 74.4 %;

**SAR(1 g) = 15.600 W/kg; SAR(10 g) = 5.910 W/kg**

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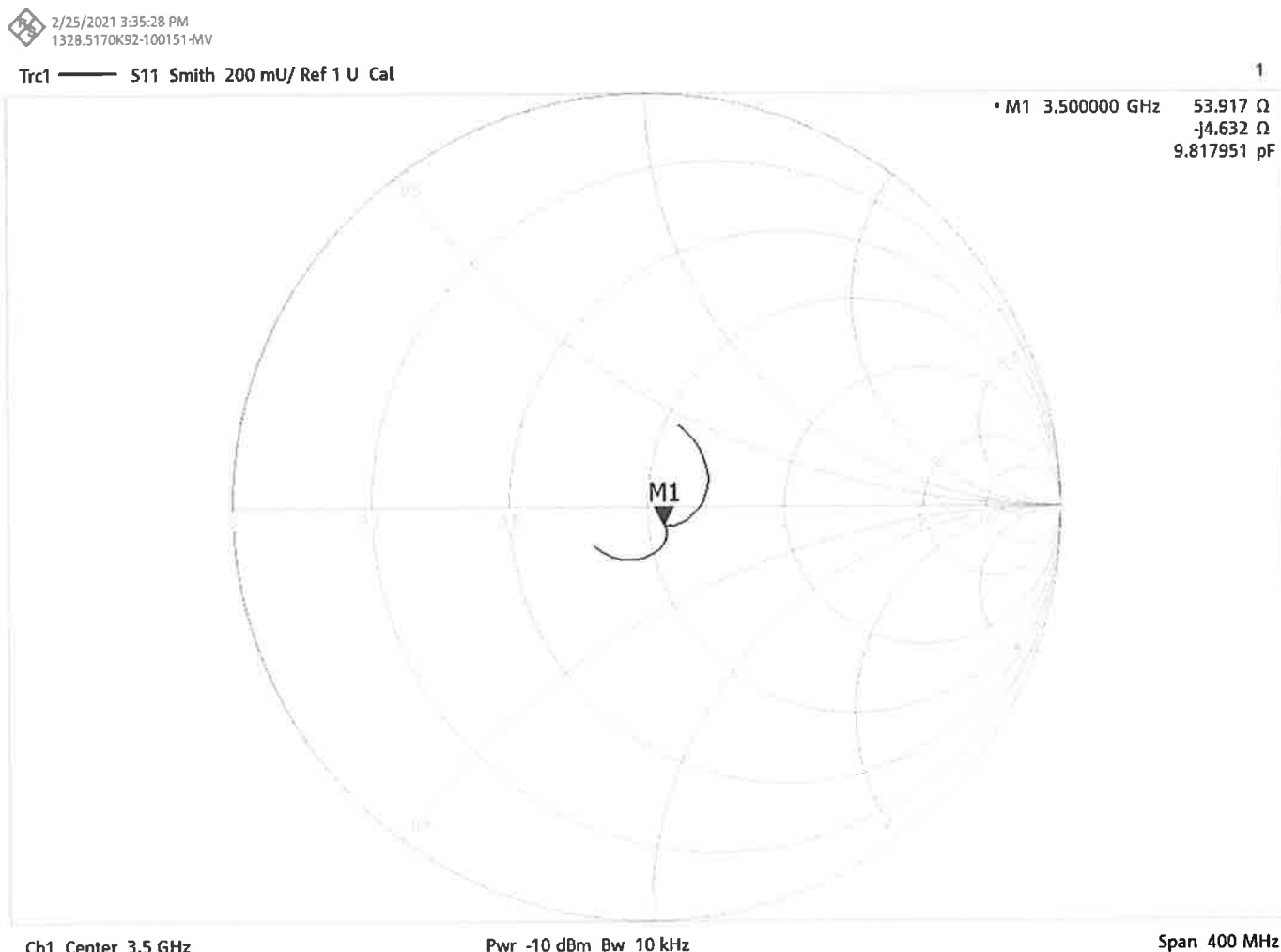
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### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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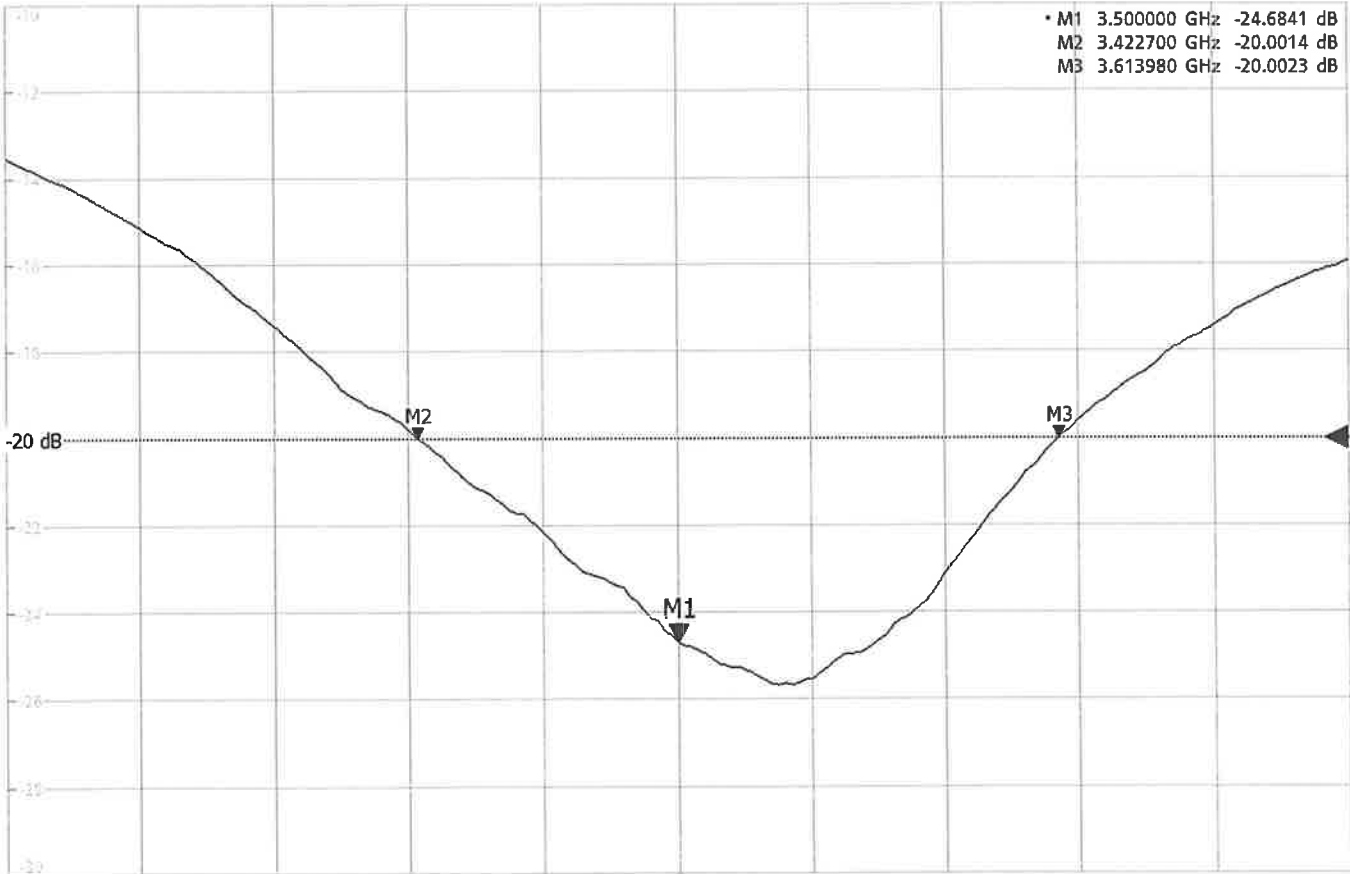
### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



2/25/2021 3:34:02 PM  
1328.5170K92-100151-MV

Trc1 — S11 dB Mag 2 dB/ Ref -20 dB Cal

1



Ch1 Center 3.5 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

**Calibration Certificate Label:**

|                                                                                                  |                                                                                                                                                                                                                  |
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| <br><b>5772</b> | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13685197JD01B</p> <p>Instrument ID: 1060</p> <p>Calibration Date: 25/Feb/2021</p> <p>Calibration Due Date:</p> |
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|                                                                                                  |                                                                                                                                                                                                                  |
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|                                                                                                    |                                                                                                                                                                                                                  |
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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

Client **UL USA**

Certificate No: **D3700V2-1039\_Apr21**

## CALIBRATION CERTIFICATE

Object **D3700V2 - SN:1039**

Calibration procedure(s) **QA CAL-22.v6  
Calibration Procedure for SAR Validation Sources between 3-10 GHz**

Calibration date: **April 16, 2021**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards               | ID #               | Cal Date (Certificate No.)        | Scheduled Calibration  |
|---------------------------------|--------------------|-----------------------------------|------------------------|
| Power meter NRP                 | SN: 104778         | 09-Apr-21 (No. 217-03291/03292)   | Apr-22                 |
| Power sensor NRP-Z91            | SN: 103244         | 09-Apr-21 (No. 217-03291)         | Apr-22                 |
| Power sensor NRP-Z91            | SN: 103245         | 09-Apr-21 (No. 217-03292)         | Apr-22                 |
| Reference 20 dB Attenuator      | SN: BH9394 (20k)   | 09-Apr-21 (No. 217-03343)         | Apr-22                 |
| Type-N mismatch combination     | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344)         | Apr-22                 |
| Reference Probe EX3DV4          | SN: 3503           | 30-Dec-20 (No. EX3-3503_Dec20)    | Dec-21                 |
| DAE4                            | SN: 601            | 02-Nov-20 (No. DAE4-601_Nov20)    | Nov-21                 |
| Secondary Standards             | ID #               | Check Date (in house)             | Scheduled Check        |
| Power meter E4419B              | SN: GB39512475     | 30-Oct-14 (in house check Oct-20) | In house check: Oct-22 |
| Power sensor HP 8481A           | SN: US37292783     | 07-Oct-15 (in house check Oct-20) | In house check: Oct-22 |
| Power sensor HP 8481A           | SN: MY41092317     | 07-Oct-15 (in house check Oct-20) | In house check: Oct-22 |
| RF generator R&S SMT-06         | SN: 100972         | 15-Jun-15 (in house check Oct-20) | In house check: Oct-22 |
| Network Analyzer Agilent E8358A | SN: US41080477     | 31-Mar-14 (in house check Oct-20) | In house check: Oct-21 |

Calibrated by: **Jeffrey Katzman** Laboratory Technician

Signature

Approved by: **Katja Pokovic** Technical Manager

Issued: April 16, 2021

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





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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

### Glossary:

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

### Calibration is Performed According to the Following Standards:

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

|                                     |                            |                                  |
|-------------------------------------|----------------------------|----------------------------------|
| <b>DASY Version</b>                 | DASY5                      | V52.10.4                         |
| <b>Extrapolation</b>                | Advanced Extrapolation     |                                  |
| <b>Phantom</b>                      | Modular Flat Phantom       |                                  |
| <b>Distance Dipole Center - TSL</b> | 10 mm                      | with Spacer                      |
| <b>Zoom Scan Resolution</b>         | dx, dy = 4 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| <b>Frequency</b>                    | 3700 MHz $\pm$ 1 MHz       |                                  |

## Head TSL parameters

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 37.7           | 3.12 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 37.0 $\pm$ 6 % | 3.09 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL

|                                                             |                    |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
| SAR measured                                                | 100 mW input power | 6.65 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>66.4 W/kg <math>\pm</math> 19.9 % (k=2)</b> |

|                                                               |                    |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
| SAR measured                                                  | 100 mW input power | 2.41 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>24.0 W/kg <math>\pm</math> 19.5 % (k=2)</b> |

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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 45.9 $\Omega$ - 1.6 j $\Omega$ |
| Return Loss                          | - 26.7 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.134 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 |
|-----------------|-------|

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 3700 MHz; Type: D3700V2; Serial: D3700V2 - SN:1039**

Communication System: UID 0 - CW; Frequency: 3700 MHz

Medium parameters used:  $f = 3700$  MHz;  $\sigma = 3.09$  S/m;  $\epsilon_r = 37.0$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.73, 7.73, 7.73) @ 3700 MHz; Calibrated: 30.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3700MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 71.87 V/m; Power Drift = -0.04 dB

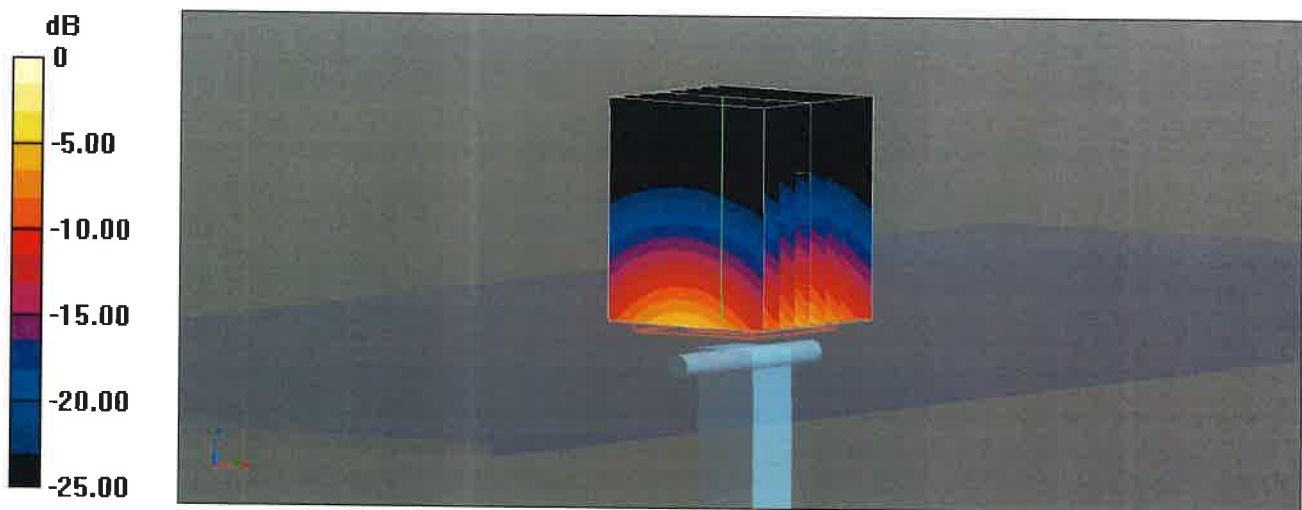
Peak SAR (extrapolated) = 18.9 W/kg

**SAR(1 g) = 6.65 W/kg; SAR(10 g) = 2.41 W/kg**

Smallest distance from peaks to all points 3 dB below = 8.4 mm

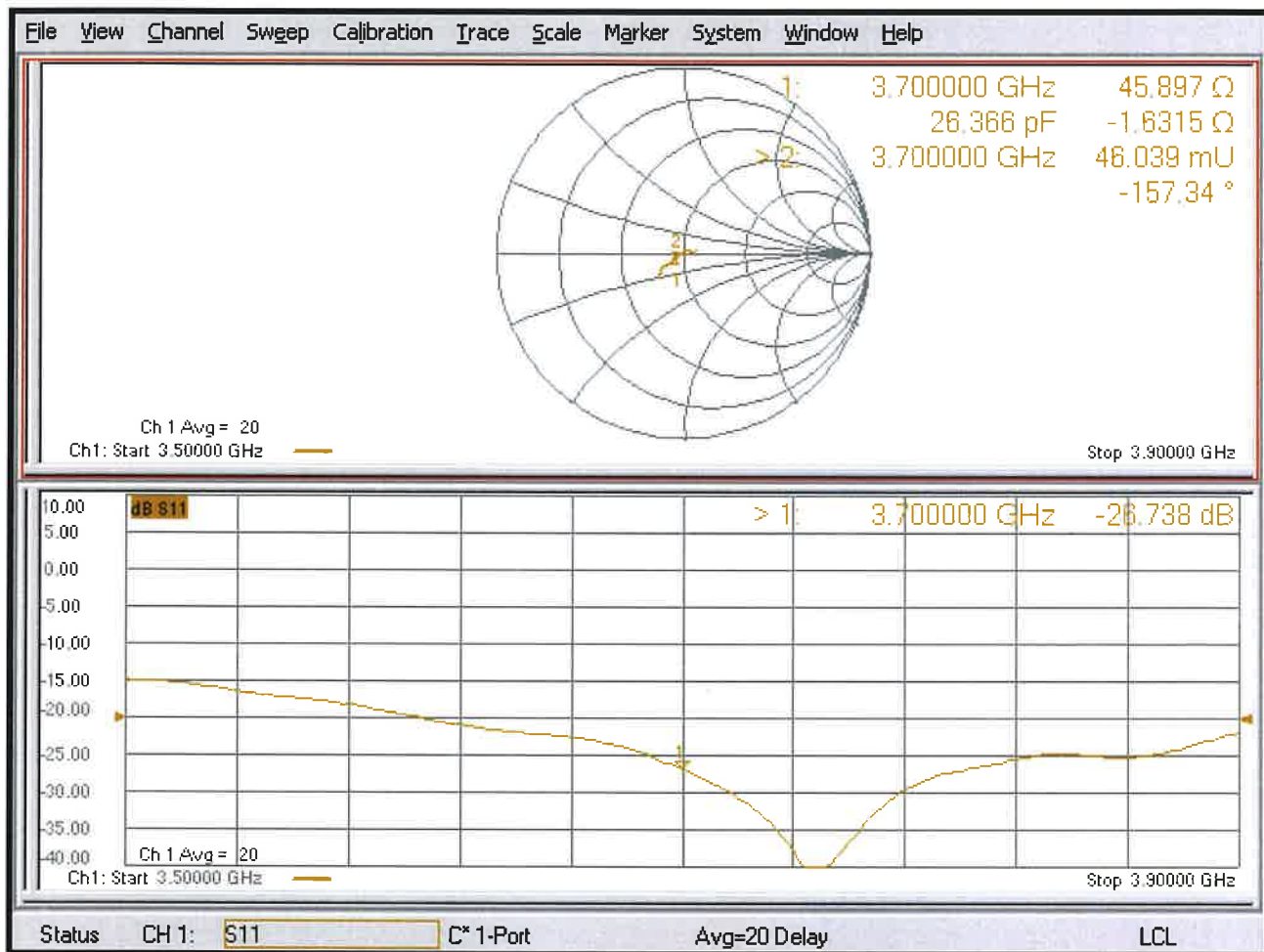
Ratio of SAR at M2 to SAR at M1 = 73.5%

Maximum value of SAR (measured) = 13.2 W/kg



0 dB = 13.2 W/kg = 11.19 dBW/kg

## Impedance Measurement Plot for Head TSL





Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 0108**

Client **UL USA**

Certificate No: **D3900V2-1052\_Aug20**

## CALIBRATION CERTIFICATE

Object **D3900V2 - SN:1052**

Calibration procedure(s) **QA CAL-22.v5  
Calibration Procedure for SAR Validation Sources between 3-10 GHz**

Calibration date: **August 03, 2020**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards           | ID #               | Cal Date (Certificate No.)      | Scheduled Calibration |
|-----------------------------|--------------------|---------------------------------|-----------------------|
| Power meter NRP             | SN: 104778         | 01-Apr-20 (No. 217-03100/03101) | Apr-21                |
| Power sensor NRP-Z91        | SN: 103244         | 01-Apr-20 (No. 217-03100)       | Apr-21                |
| Power sensor NRP-Z91        | SN: 103245         | 01-Apr-20 (No. 217-03101)       | Apr-21                |
| Reference 20 dB Attenuator  | SN: BH9394 (20k)   | 31-Mar-20 (No. 217-03106)       | Apr-21                |
| Type-N mismatch combination | SN: 310982 / 06327 | 31-Mar-20 (No. 217-03104)       | Apr-21                |
| Reference Probe EX3DV4      | SN: 3503           | 31-Dec-19 (No. EX3-3503_Dec19)  | Dec-20                |
| DAE4                        | SN: 601            | 27-Dec-19 (No. DAE4-601_Dec19)  | Dec-20                |

| Secondary Standards             | ID #           | Check Date (in house)             | Scheduled Check        |
|---------------------------------|----------------|-----------------------------------|------------------------|
| Power meter E4419B              | SN: GB39512475 | 30-Oct-14 (in house check Feb-19) | In house check: Oct-20 |
| Power sensor HP 8481A           | SN: US37292783 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| Power sensor HP 8481A           | SN: MY41092317 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| RF generator R&S SMT-06         | SN: 100972     | 15-Jun-15 (in house check Oct-18) | In house check: Oct-20 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-19) | In house check: Oct-20 |

Calibrated by: **Jeffrey Katzman**      **Jeffrey Katzman**      **Laboratory Technician**

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

Issued: August 3, 2020

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





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Accreditation No.: **SCS 0108**

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Multilateral Agreement for the recognition of calibration certificates

### Glossary:

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

### Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "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                      | V52.10.4                         |
| Extrapolation                | Advanced Extrapolation     |                                  |
| Phantom                      | Modular Flat Phantom       |                                  |
| Distance Dipole Center - TSL | 10 mm                      | with Spacer                      |
| Zoom Scan Resolution         | dx, dy = 4 mm, dz = 1.4 mm | Graded Ratio = 1.4 (Z direction) |
| Frequency                    | 3900 MHz $\pm$ 1 MHz       |                                  |

## Head TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Head TSL parameters             | 22.0 °C             | 37.5           | 3.32 mho/m           |
| Measured Head TSL parameters            | (22.0 $\pm$ 0.2) °C | 37.1 $\pm$ 6 % | 3.21 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                                          | 100 mW input power | 6.99 W/kg                                      |
| SAR for nominal Head TSL parameters                   | normalized to 1W   | <b>70.1 W/kg <math>\pm</math> 19.9 % (k=2)</b> |

|                                                         |                    |                                                |
|---------------------------------------------------------|--------------------|------------------------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Head TSL | condition          |                                                |
| SAR measured                                            | 100 mW input power | 2.43 W/kg                                      |
| SAR for nominal Head TSL parameters                     | normalized to 1W   | <b>24.3 W/kg <math>\pm</math> 19.5 % (k=2)</b> |

## Body TSL parameters

The following parameters and calculations were applied.

|                                         | Temperature         | Permittivity   | Conductivity         |
|-----------------------------------------|---------------------|----------------|----------------------|
| Nominal Body TSL parameters             | 22.0 °C             | 50.8           | 3.78 mho/m           |
| Measured Body TSL parameters            | (22.0 $\pm$ 0.2) °C | 50.0 $\pm$ 6 % | 3.77 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                                          | 100 mW input power | 6.51 W/kg                                      |
| SAR for nominal Body TSL parameters                   | normalized to 1W   | <b>64.9 W/kg <math>\pm</math> 19.9 % (k=2)</b> |

|                                                         |                    |                                                |
|---------------------------------------------------------|--------------------|------------------------------------------------|
| SAR averaged over 10 cm <sup>3</sup> (10 g) of Body TSL | condition          |                                                |
| SAR measured                                            | 100 mW input power | 2.24 W/kg                                      |
| SAR for nominal Body TSL parameters                     | normalized to 1W   | <b>22.3 W/kg <math>\pm</math> 19.5 % (k=2)</b> |



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

### Antenna Parameters with Head TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 48.5 $\Omega$ - 5.9 j $\Omega$ |
| Return Loss                          | - 24.2 dB                      |

### Antenna Parameters with Body TSL

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 48.3 $\Omega$ - 2.7 j $\Omega$ |
| Return Loss                          | - 29.7 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.106 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 |
|-----------------|-------|

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 3900 MHz; Type: D3900V2; Serial: D3900V2 - SN:1052**

Communication System: UID 0 - CW; Frequency: 3900 MHz

Medium parameters used:  $f = 3900$  MHz;  $\sigma = 3.21$  S/m;  $\epsilon_r = 37.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.39, 7.39, 7.39) @ 3900 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Head Tissue/Pin=100 mW, d=10mm, f=3900MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 72.87 V/m; Power Drift = -0.04 dB

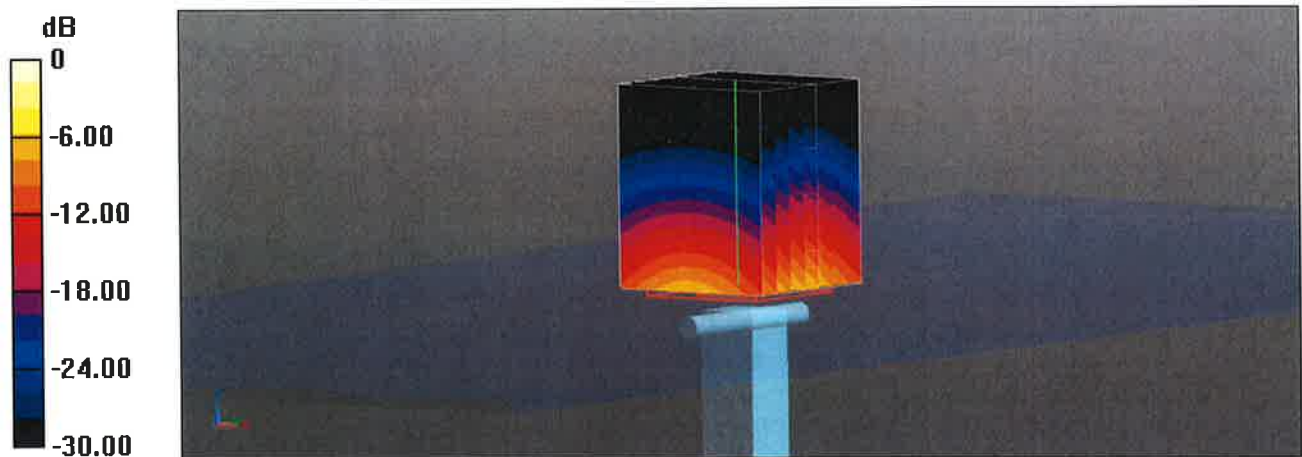
Peak SAR (extrapolated) = 20.2 W/kg

**SAR(1 g) = 6.99 W/kg; SAR(10 g) = 2.43 W/kg**

Smallest distance from peaks to all points 3 dB below = 8 mm

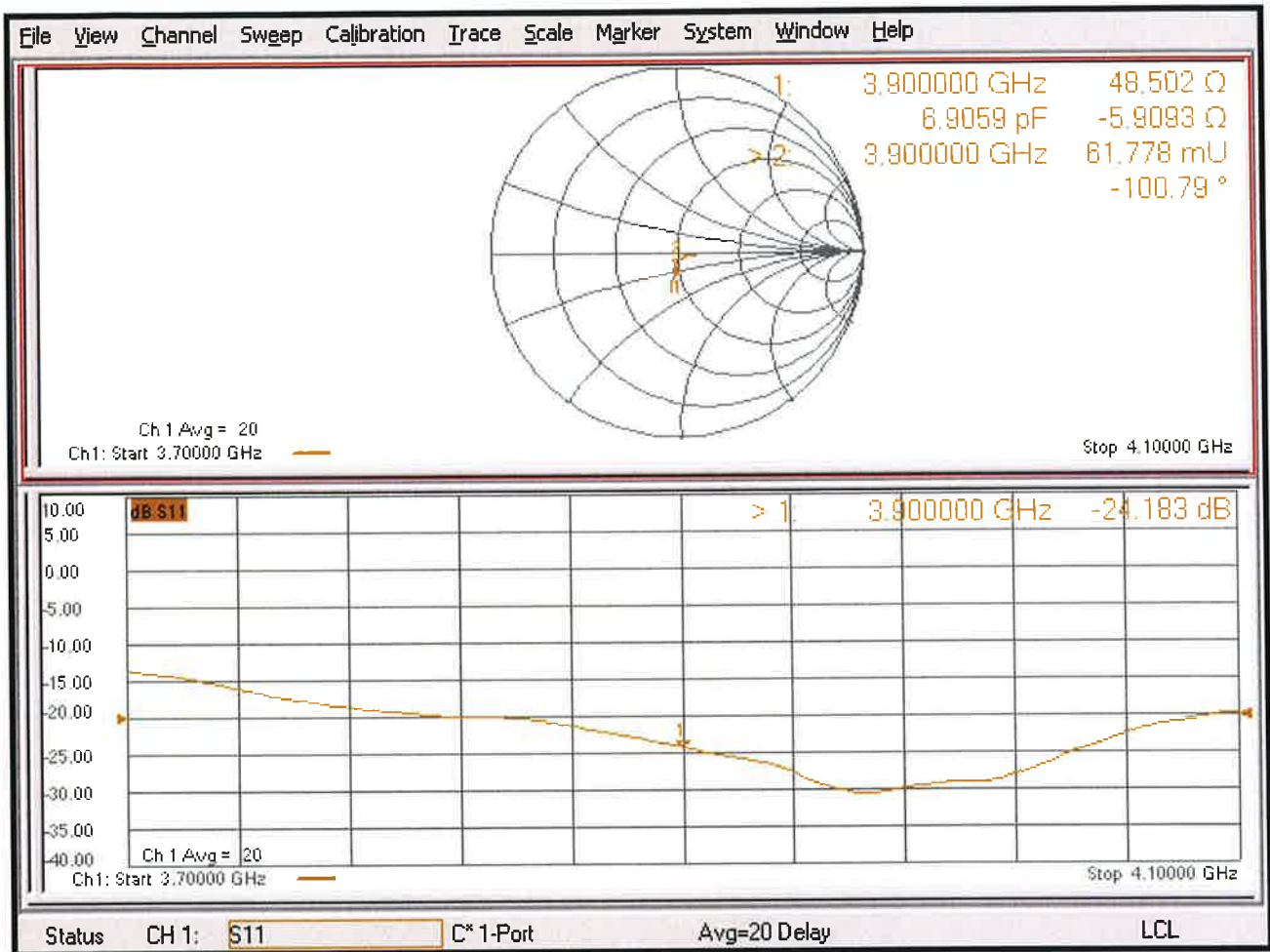
Ratio of SAR at M2 to SAR at M1 = 73.5%

Maximum value of SAR (measured) = 14.0 W/kg



0 dB = 14.0 W/kg = 11.46 dBW/kg

Impedance Measurement Plot for Head TSL



Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: Dipole 3900 MHz; Type: D3900V2; Serial: D3900V2 - SN:1052**

Communication System: UID 0 - CW; Frequency: 3900 MHz

Medium parameters used:  $f = 3900$  MHz;  $\sigma = 3.77$  S/m;  $\epsilon_r = 50.0$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(7.18, 7.18, 7.18) @ 3900 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Body Tissue/Pin=100 mW, d=10mm, f=3900MHz/Zoom Scan, dist=1.4mm (8x8x8)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 64.81 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 19.5 W/kg

**SAR(1 g) = 6.51 W/kg; SAR(10 g) = 2.24 W/kg**

Smallest distance from peaks to all points 3 dB below = 8 mm

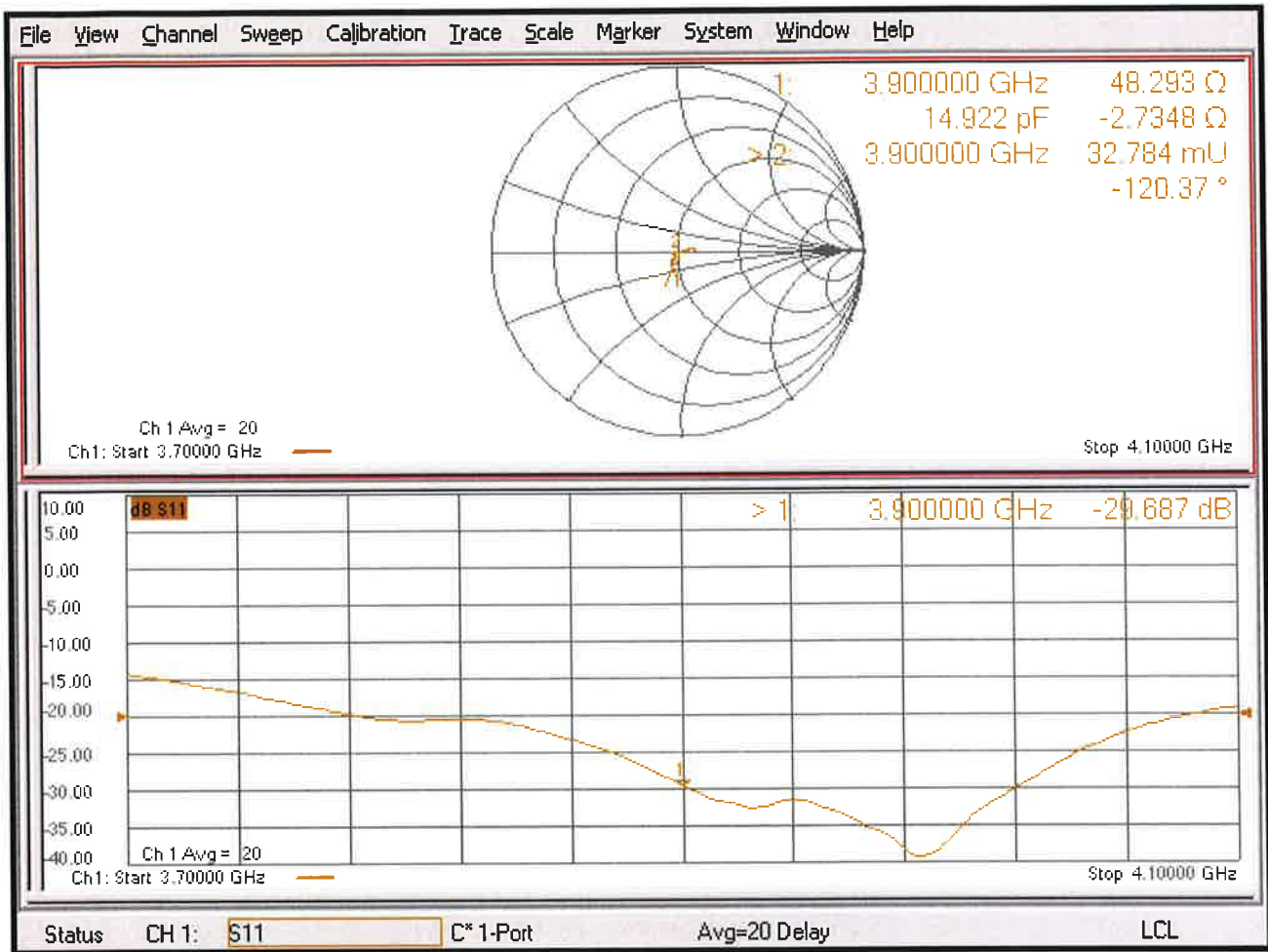
Ratio of SAR at M2 to SAR at M1 = 72.4%

Maximum value of SAR (measured) = 13.1 W/kg



0 dB = 13.1 W/kg = 11.17 dBW/kg

Impedance Measurement Plot for Body TSL



# CERTIFICATE OF CALIBRATION

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DATE OF ISSUE: 04/May/2021      CERTIFICATE NUMBER : 13685197JD01C



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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: | 15/Feb/2021 |
| Manufacturer:      | Speag                        |                  |             |
| Type/Model Number: | D5GHzV2                      |                  |             |
| Serial Number:     | 1003                         |                  |             |
| Calibration Date:  | 17/Feb/2021                  |                  |             |
| Calibrated By:     | Masood Khan<br>Test Engineer |                  |             |
| Signature:         |                              |                  |             |

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

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

Use of the UKAS mark demonstrates that compliance with the requirements of BS/EN/ISO/IEC 17025:2017 has been independently assessed.

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The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2016:** 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. **DASY 6 System Handbook**
6. **Dipole Calibration Procedure V1.2:** Calibration performed as per internal procedure

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) |
|------------|------------------------------|-----------------|---------------|------------|-----------------------|------------------------|
| PRE0178316 | Data Acquisition Electronics | SPEAG           | DAE4          | 1541       | 17 Mar 2020           | 12                     |
| PRE0178266 | Probe                        | SPEAG           | EX3DV4        | 7495       | 24 Mar 2020           | 12                     |
| PRE0178323 | Dipole                       | SPEAG           | D5GHzV2       | 1274       | 13 Mar 2020           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi          | ART 100850-01 | 0001       | Cal as part of System | -                      |
| PRE0151441 | Power Sensor                 | Rhode & Schwarz | NRP8S         | 102481     | 27 Mar 2020           | 12                     |
| PRE0151154 | Vector Network Analyser      | Rhode & Schwarz | ZND           | 100151     | 15 Jun 2020           | 12                     |
| PRE0158684 | Calibration Kit              | Rhode & Schwarz | ZV-Z135       | 102144     | 27 May 2020           | 12                     |
| PRE0178154 | Signal Generator             | Rhode & Schwarz | SMB100A       | 175325     | 10 Jun 2020           | 12                     |

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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number:     | F17/5ENYG1/A/01                            |
| DASY Version:            | cDASY6.14.0.959                            |
| Phantom:                 | Flat section of SAM Twin Phantom           |
| Distance Dipole Centre:  | 10mm (with spacer)                         |
| Frequency:               | 5GHz                                       |

Frequency :5250 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            | 5250            | 20.0 °C   | 19.8 °C | 20.4°C      | 20.4°C | $\epsilon_r$ | 35.93        | 36.39          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 4.71         | 4.78           | ± 5%            |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%)   |
|-----------------|-----------------------|--------------------|----------------------|-------------------|
| Head            | SAR averaged over 1g  | 7.71 W/Kg          | <b>77.1 W/Kg</b>     | +16.77% / -16.70% |
|                 | SAR averaged over 10g | 2.22 W/Kg          | <b>22.2 W/Kg</b>     | ± 16.70%          |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Head            | Impedance   | 58.749 $\Omega$ +3.909 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 21.10                             | ± 2.03 dB                          |

Frequency :5600 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            | 5600            | 20.0 °C   | 19.8 °C | 20.4°C      | 20.4°C | $\epsilon_r$ | 35.53        | 35.71          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 5.10         | 5.20           | ± 5%            |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%)   |
|-----------------|-----------------------|--------------------|----------------------|-------------------|
| Head            | SAR averaged over 1g  | 8.47 W/Kg          | <b>84.7 W/Kg</b>     | +16.77% / -16.70% |
|                 | SAR averaged over 10g | 2.42 W/Kg          | <b>24.2 W/Kg</b>     | ± 16.70%          |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Head            | Impedance   | 46.857 $\Omega$ +1.626 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 28.75                             | ± 2.03 dB                          |



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**Frequency :5750 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            | 5750            | 20.0 °C   | 19.8 °C | 20.4°C      | 20.4°C | $\epsilon_r$ | 35.36        | 35.42          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 5.22         | 5.38           | ± 5%            |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%)   |
|-----------------|-----------------------|--------------------|----------------------|-------------------|
| Head            | SAR averaged over 1g  | 7.57 W/Kg          | <b>75.7 W/Kg</b>     | +16.77% / -16.70% |
|                 | SAR averaged over 10g | 2.18 W/Kg          | <b>21.8 W/Kg</b>     | ± 16.70%          |

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

| Simulant Liquid | Parameter   | Measured Level                     | Uncertainty (%)                    |
|-----------------|-------------|------------------------------------|------------------------------------|
| Head            | Impedance   | 59.697 $\Omega$ + 0.126 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 21.07                              | ± 2.03 dB                          |

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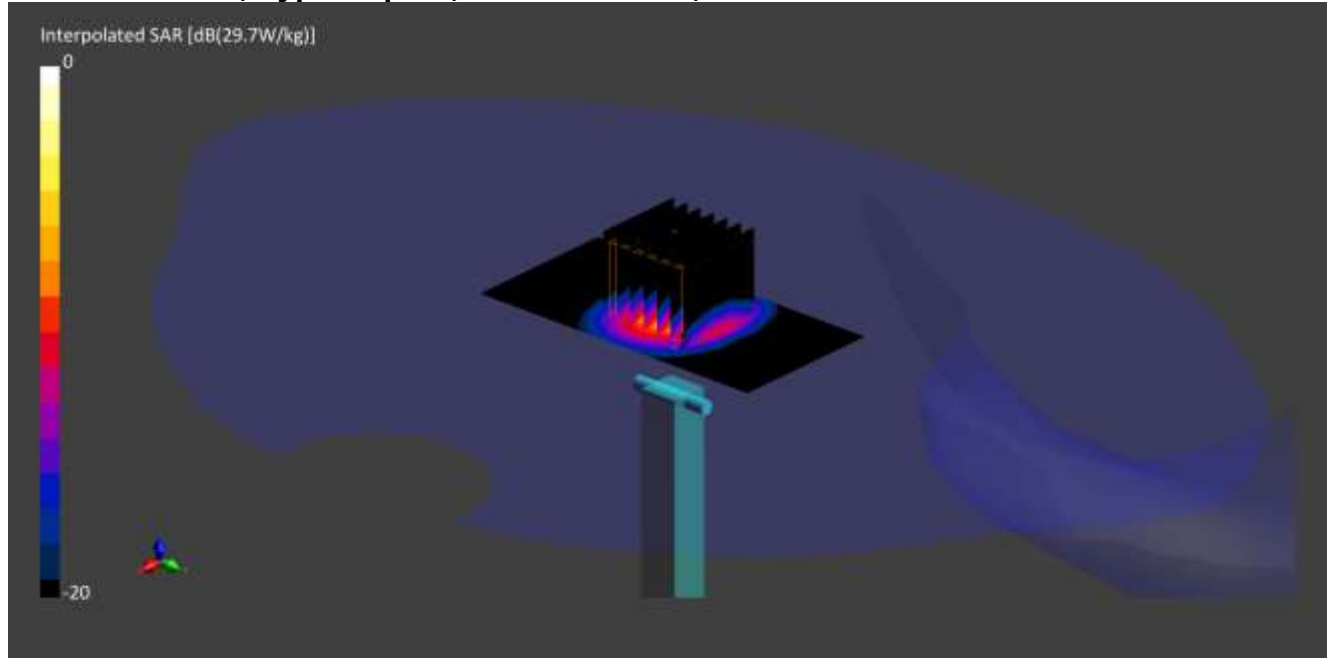
UKAS Accredited Calibration Laboratory No. 5772

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

**DUT: D5GHzV2; Type: Dipole; Serial: SN1003;**



Communication System: CW UID: 0; Frequency: 5250.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_17Feb2021\_110903\_Head - 3500 5250 5600 5750 5%; Medium  
parameters used:  $f = 5250.0$  MHz;  $\sigma = 4.78$  S/m;  $\epsilon_r = 36.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = 1.27$  %;  $\Delta\sigma = 1.65$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7495; ConvF(5.17, 5.17, 5.17); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1541; Calibrated: 17 Mar 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 10.780 V/m; Power Drift = 0.00 dB

Minimum horizontal 3dB distance: 7.2 mm;

Vertical M2/M1 Ratio: 64.8 %;

**SAR(1 g) = 7.710 W/kg; SAR(10 g) = 2.220 W/kg**

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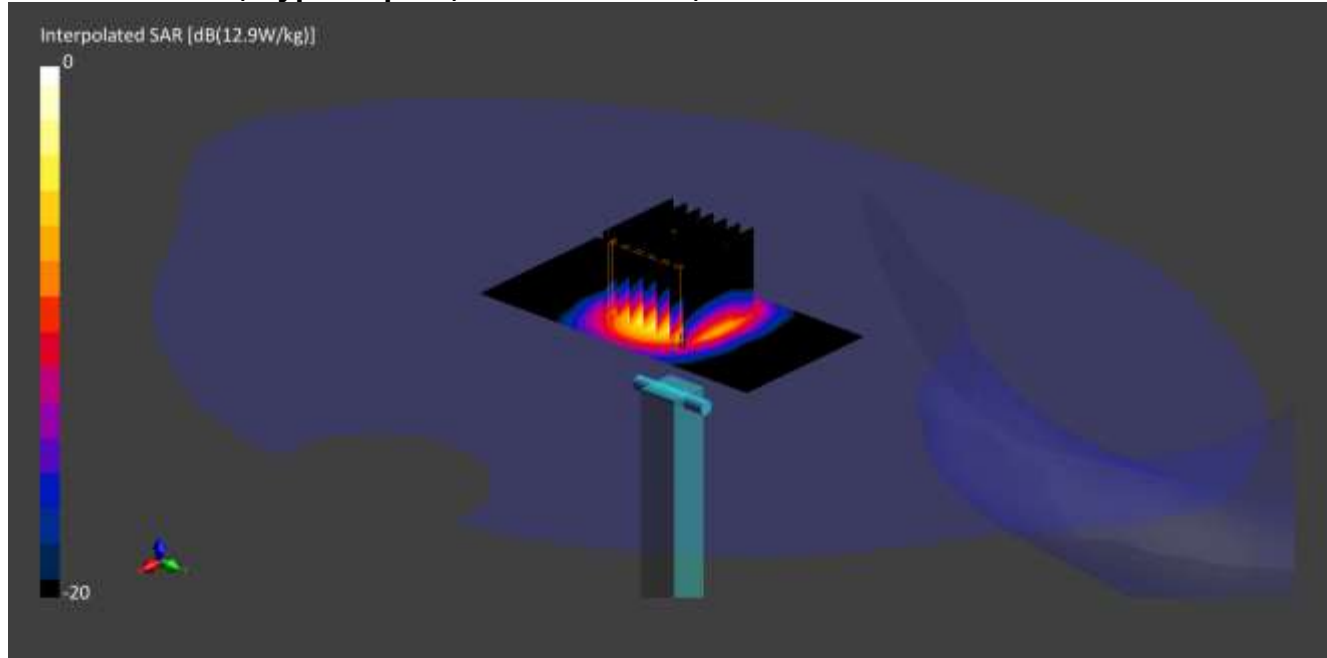
UKAS Accredited Calibration Laboratory No. 5772

CERTIFICATE  
NUMBER :  
13685197JD01C

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

**DUT: D5GHzV2; Type: Dipole; Serial: SN1003;**



Communication System: CW UID: 0; Frequency: 5600.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_17Feb2021\_110903\_Head - 3500 5250 5600 5750 5%; Medium  
parameters used:  $f = 5600.0$  MHz;  $\sigma = 5.2$  S/m;  $\epsilon_r = 35.7$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = 0.50$  %;  $\Delta\sigma = 2.66$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7495; ConvF(4.66, 4.66, 4.66); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1541; Calibrated: 17 Mar 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 12.690 V/m; Power Drift = 0.00 dB

Minimum horizontal 3dB distance: 7.2 mm;

Vertical M2/M1 Ratio: 61.8 %;

**SAR(1 g) = 8.470 W/kg; SAR(10 g) = 2.420 W/kg**

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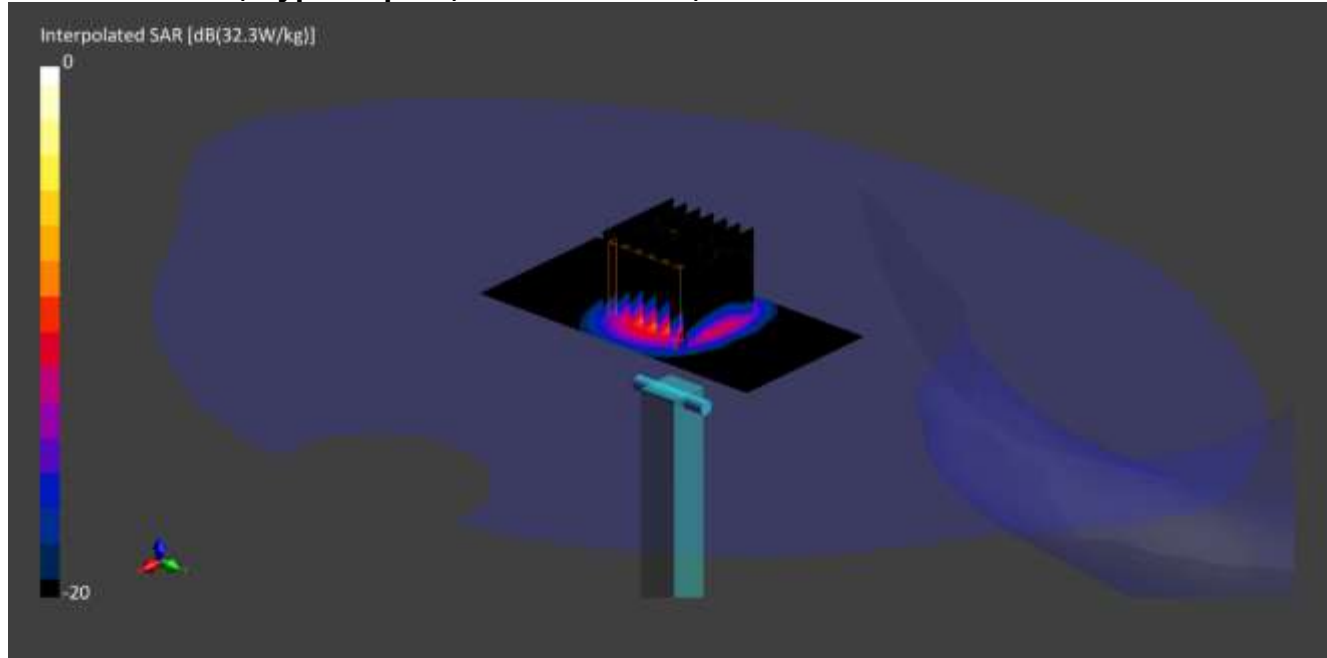
UKAS Accredited Calibration Laboratory No. 5772

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NUMBER :  
13685197JD01C

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

**DUT: D5GHzV2; Type: Dipole; Serial: SN1003;**



Communication System: CW UID: 0; Frequency: 5750.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_17Feb2021\_110903\_Head - 3500 5250 5600 5750 5%; Medium  
parameters used:  $f = 5750.0$  MHz;  $\sigma = 5.38$  S/m;  $\epsilon_r = 35.4$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = 0.17$  %;  $\Delta\sigma = 3.17$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7495; ConvF(4.89, 4.89, 4.89); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1541; Calibrated: 17 Mar 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 11.320 V/m; Power Drift = 0.00 dB

Minimum horizontal 3dB distance: 7.5 mm;

Vertical M2/M1 Ratio: 60.3 %;

**SAR(1 g) = 7.570 W/kg; SAR(10 g) = 2.180 W/kg**

# CERTIFICATE OF CALIBRATION

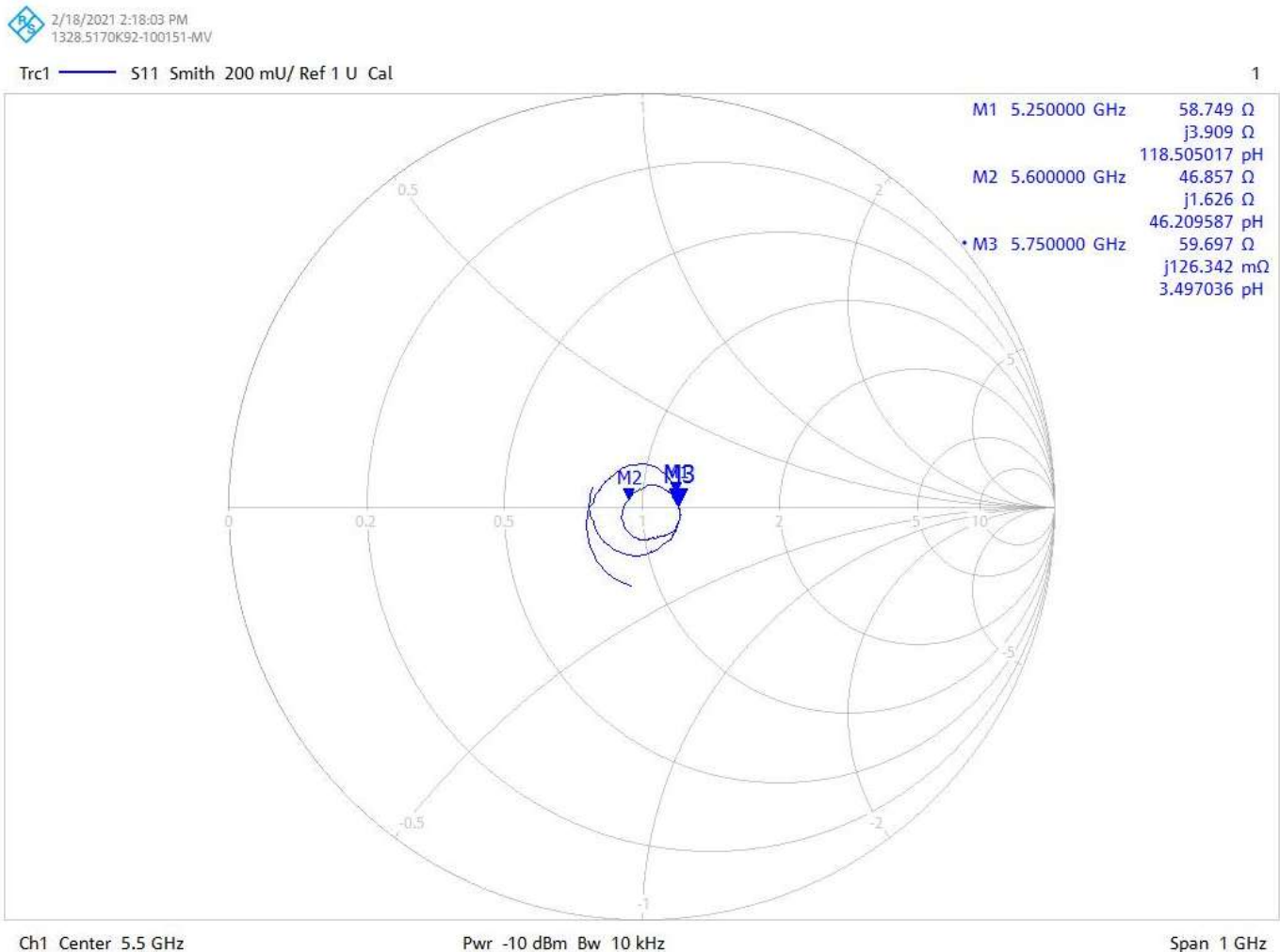
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### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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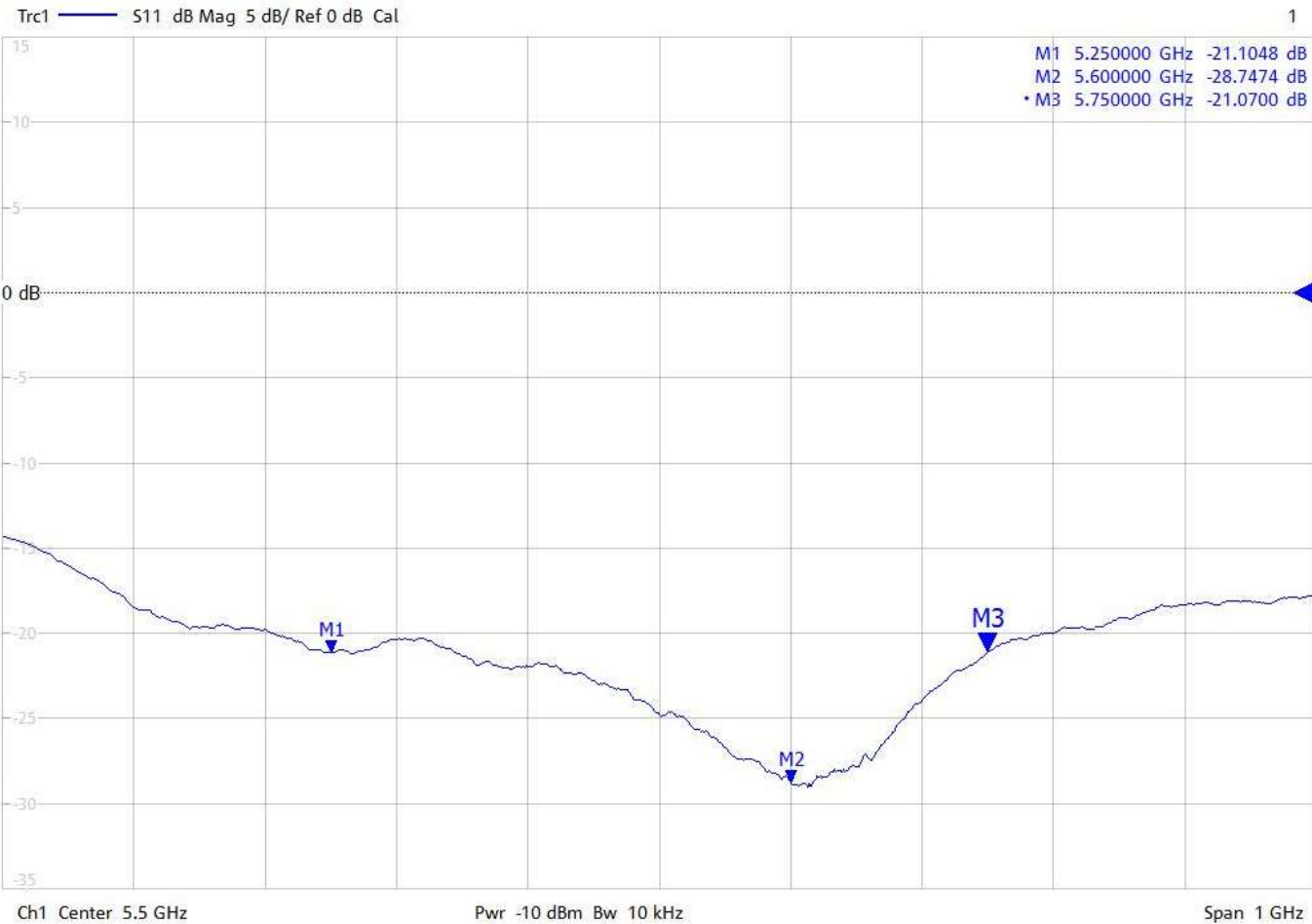
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### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)

2/18/2021 2:25:45 PM  
1328.5170K92-100151-MV



**Calibration Certificate Label:**

|                                                                                                 |                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  <p>5772</p>   | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13685197JD01C</p> <p>Instrument ID: 1003</p> <p>Calibration Date: 17/Feb/2021</p> <p>Calibration Due Date:</p> |
|  <p>5772</p>   | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13685197JD01C</p> <p>Instrument ID: 1003</p> <p>Calibration Date: 17/Feb/2021</p> <p>Calibration Due Date:</p> |
|  <p>5772</p> | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13685197JD01C</p> <p>Instrument ID: 1003</p> <p>Calibration Date: 17/Feb/2021</p> <p>Calibration Due Date:</p> |



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

Accreditation No.: **SCS 0108**

Client **UL USA**

Certificate No: **D5GHzV2-1138\_Aug20**

## CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1138**

Calibration procedure(s) **QA CAL-22.v5  
 Calibration Procedure for SAR Validation Sources between 3-10 GHz**

Calibration date: **August 17, 2020**

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

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

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards           | ID #               | Cal Date (Certificate No.)      | Scheduled Calibration |
|-----------------------------|--------------------|---------------------------------|-----------------------|
| Power meter NRP             | SN: 104778         | 01-Apr-20 (No. 217-03100/03101) | Apr-21                |
| Power sensor NRP-Z91        | SN: 103244         | 01-Apr-20 (No. 217-03100)       | Apr-21                |
| Power sensor NRP-Z91        | SN: 103245         | 01-Apr-20 (No. 217-03101)       | Apr-21                |
| Reference 20 dB Attenuator  | SN: BH9394 (20k)   | 31-Mar-20 (No. 217-03106)       | Apr-21                |
| Type-N mismatch combination | SN: 310982 / 06327 | 31-Mar-20 (No. 217-03104)       | Apr-21                |
| Reference Probe EX3DV4      | SN: 3503           | 31-Dec-19 (No. EX3-3503_Dec19)  | Dec-20                |
| DAE4                        | SN: 601            | 27-Dec-19 (No. DAE4-601_Dec19)  | Dec-20                |

| Secondary Standards             | ID #           | Check Date (in house)             | Scheduled Check        |
|---------------------------------|----------------|-----------------------------------|------------------------|
| Power meter E4419B              | SN: GB39512475 | 30-Oct-14 (in house check Feb-19) | In house check: Oct-20 |
| Power sensor HP 8481A           | SN: US37292783 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| Power sensor HP 8481A           | SN: MY41092317 | 07-Oct-15 (in house check Oct-18) | In house check: Oct-20 |
| RF generator R&S SMT-06         | SN: 100972     | 15-Jun-15 (in house check Oct-18) | In house check: Oct-20 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-19) | In house check: Oct-20 |

|                |                 |                       |           |
|----------------|-----------------|-----------------------|-----------|
|                | Name            | Function              | Signature |
| Calibrated by: | Jeffrey Katzman | Laboratory Technician |           |
| Approved by:   | Katja Pokovic   | Technical Manager     |           |

Issued: August 17, 2020

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





Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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Multilateral Agreement for the recognition of calibration certificates

### Glossary:

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

### Calibration is Performed According to the Following Standards:

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

|                                     |                                                                      |                                  |
|-------------------------------------|----------------------------------------------------------------------|----------------------------------|
| <b>DASY Version</b>                 | DASY5                                                                | V52.10.4                         |
| <b>Extrapolation</b>                | Advanced Extrapolation                                               |                                  |
| <b>Phantom</b>                      | Modular Flat Phantom V5.0                                            |                                  |
| <b>Distance Dipole Center - TSL</b> | 10 mm                                                                | with Spacer                      |
| <b>Zoom Scan Resolution</b>         | dx, dy = 10.0 mm, dz = 10.0 mm                                       | Graded Ratio = 1.4 (Z direction) |
| <b>Frequency</b>                    | 5250 MHz $\pm$ 1 MHz<br>5600 MHz $\pm$ 1 MHz<br>5800 MHz $\pm$ 1 MHz |                                  |

## Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 35.9           | 4.71 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 34.6 $\pm$ 6 % | 4.48 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL at 5250 MHz

| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                | 100 mW input power | 8.07 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>80.0 W/kg <math>\pm</math> 19.9 % (k=2)</b> |

| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                  | 100 mW input power | 2.31 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>22.8 W/kg <math>\pm</math> 19.5 % (k=2)</b> |

## Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

|                                                | Temperature         | Permittivity   | Conductivity         |
|------------------------------------------------|---------------------|----------------|----------------------|
| <b>Nominal Head TSL parameters</b>             | 22.0 °C             | 35.5           | 5.07 mho/m           |
| <b>Measured Head TSL parameters</b>            | (22.0 $\pm$ 0.2) °C | 34.2 $\pm$ 6 % | 4.83 mho/m $\pm$ 6 % |
| <b>Head TSL temperature change during test</b> | < 0.5 °C            | ----           | ----                 |

## SAR result with Head TSL at 5600 MHz

| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                                |
|-------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                | 100 mW input power | 8.36 W/kg                                      |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>82.8 W/kg <math>\pm</math> 19.9 % (k=2)</b> |

| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                                |
|---------------------------------------------------------------|--------------------|------------------------------------------------|
| SAR measured                                                  | 100 mW input power | 2.38 W/kg                                      |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>23.5 W/kg <math>\pm</math> 19.5 % (k=2)</b> |

## Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

|                                         | Temperature     | Permittivity | Conductivity     |
|-----------------------------------------|-----------------|--------------|------------------|
| Nominal Head TSL parameters             | 22.0 °C         | 35.3         | 5.27 mho/m       |
| Measured Head TSL parameters            | (22.0 ± 0.2) °C | 33.9 ± 6 %   | 5.03 mho/m ± 6 % |
| Head TSL temperature change during test | < 0.5 °C        | ----         | ----             |

## SAR result with Head TSL at 5800 MHz

|                                                             |                    |                                 |
|-------------------------------------------------------------|--------------------|---------------------------------|
| <b>SAR averaged over 1 cm<sup>3</sup> (1 g) of Head TSL</b> | Condition          |                                 |
| SAR measured                                                | 100 mW input power | 8.09 W/kg                       |
| SAR for nominal Head TSL parameters                         | normalized to 1W   | <b>80.1 W/kg ± 19.9 % (k=2)</b> |

|                                                               |                    |                                 |
|---------------------------------------------------------------|--------------------|---------------------------------|
| <b>SAR averaged over 10 cm<sup>3</sup> (10 g) of Head TSL</b> | condition          |                                 |
| SAR measured                                                  | 100 mW input power | 2.30 W/kg                       |
| SAR for nominal Head TSL parameters                           | normalized to 1W   | <b>22.7 W/kg ± 19.5 % (k=2)</b> |

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

### Antenna Parameters with Head TSL at 5250 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 50.0 $\Omega$ - 6.1 j $\Omega$ |
| Return Loss                          | - 24.3 dB                      |

### Antenna Parameters with Head TSL at 5600 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 56.9 $\Omega$ - 2.4 j $\Omega$ |
| Return Loss                          | - 23.3 dB                      |

### Antenna Parameters with Head TSL at 5800 MHz

|                                      |                                |
|--------------------------------------|--------------------------------|
| Impedance, transformed to feed point | 54.9 $\Omega$ - 1.9 j $\Omega$ |
| Return Loss                          | - 26.1 dB                      |

### General Antenna Parameters and Design

|                                  |          |
|----------------------------------|----------|
| Electrical Delay (one direction) | 1.201 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 |
|-----------------|-------|

Test Laboratory: SPEAG, Zurich, Switzerland

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

Communication System: UID 0 - CW; Frequency: 5250 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz  
Medium parameters used:  $f = 5250$  MHz;  $\sigma = 4.48$  S/m;  $\epsilon_r = 34.6$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5600$  MHz;  $\sigma = 4.83$  S/m;  $\epsilon_r = 34.2$ ;  $\rho = 1000$  kg/m<sup>3</sup>,  
Medium parameters used:  $f = 5800$  MHz;  $\sigma = 5.03$  S/m;  $\epsilon_r = 33.9$ ;  $\rho = 1000$  kg/m<sup>3</sup>  
Phantom section: Flat Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.5, 5.5, 5.5) @ 5250 MHz, ConvF(5.1, 5.1, 5.1) @ 5600 MHz, ConvF(5.01, 5.01, 5.01) @ 5800 MHz; Calibrated: 31.12.2019
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 27.12.2019
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 76.68 V/m; Power Drift = -0.08 dB

Peak SAR (extrapolated) = 28.4 W/kg

**SAR(1 g) = 8.07 W/kg; SAR(10 g) = 2.31 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.4 mm

Ratio of SAR at M2 to SAR at M1 = 69.9%

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

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

Reference Value = 77.08 V/m; Power Drift = -0.07 dB

Peak SAR (extrapolated) = 31.5 W/kg

**SAR(1 g) = 8.36 W/kg; SAR(10 g) = 2.38 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.4 mm

Ratio of SAR at M2 to SAR at M1 = 67.6%

Maximum value of SAR (measured) = 19.9 W/kg

**Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan,**

**dist=1.4mm (8x8x7)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=1.4mm

Reference Value = 73.94 V/m; Power Drift = -0.07 dB

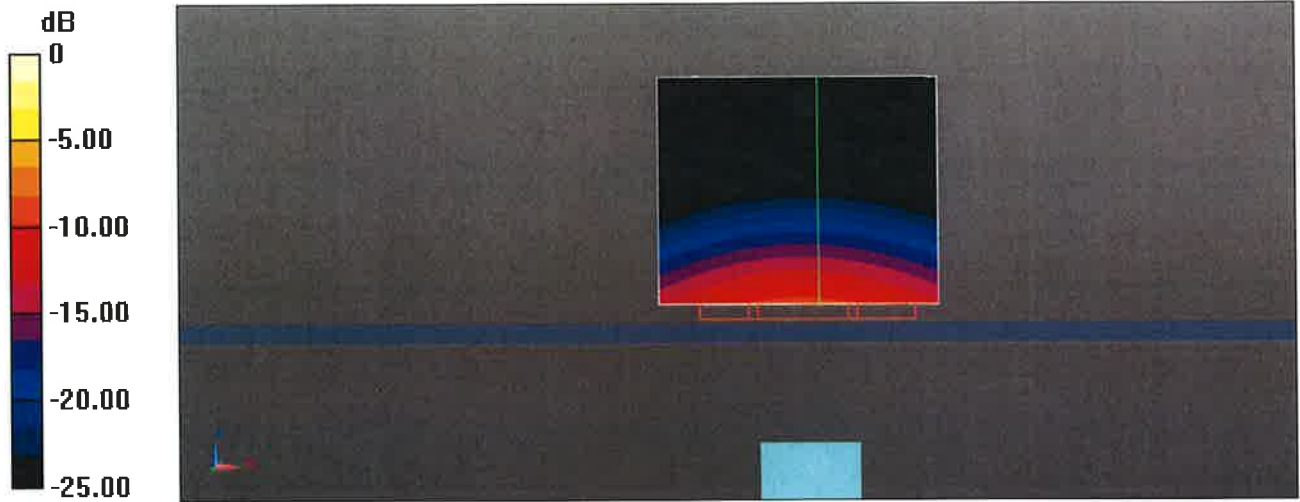
Peak SAR (extrapolated) = 32.7 W/kg

**SAR(1 g) = 8.09 W/kg; SAR(10 g) = 2.30 W/kg**

Smallest distance from peaks to all points 3 dB below = 7.4 mm

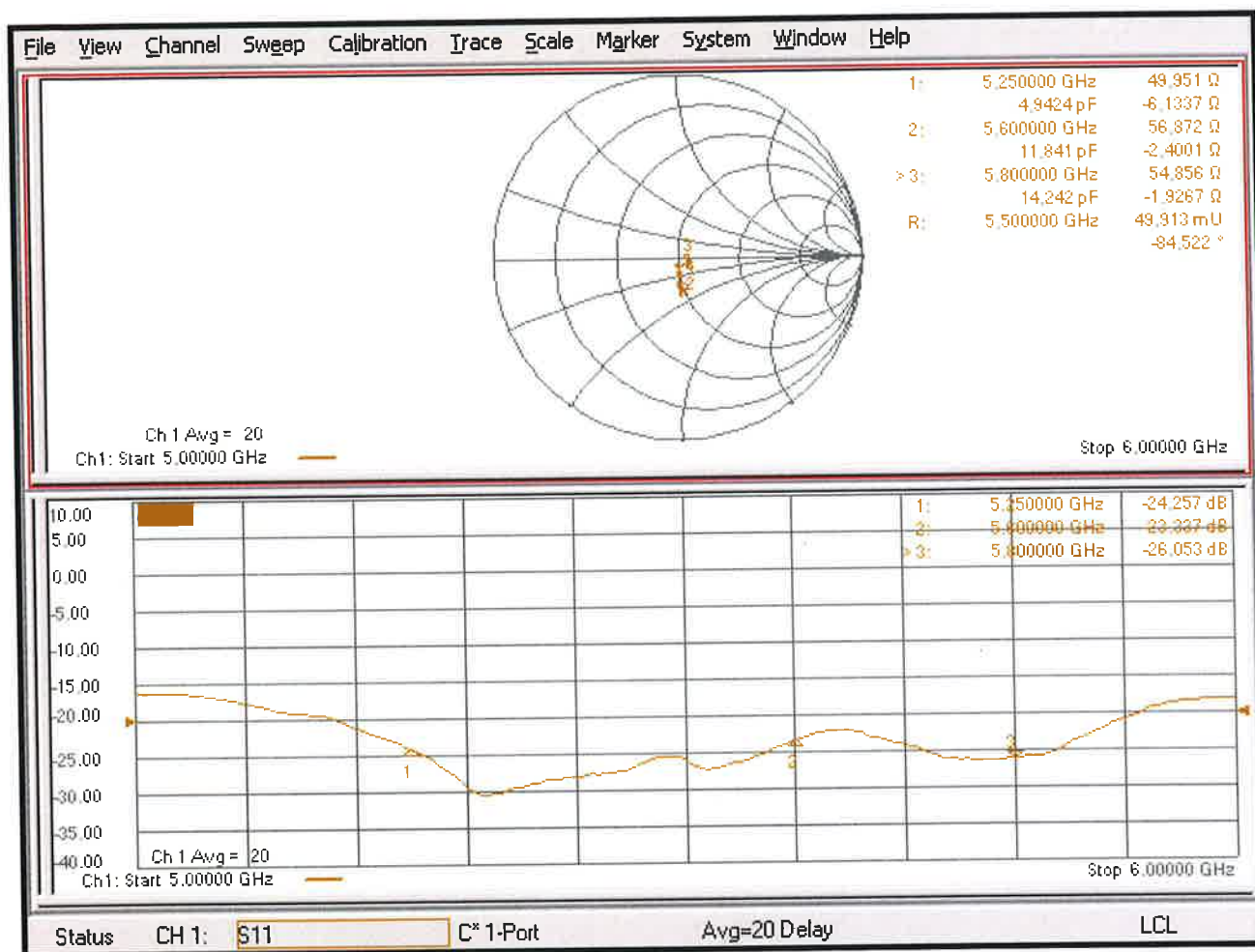
Ratio of SAR at M2 to SAR at M1 = 65.1%

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



0 dB = 19.9 W/kg = 12.99 dBW/kg

# Impedance Measurement Plot for Head TSL



# CERTIFICATE OF CALIBRATION

ISSUED BY UL INTERNATIONAL (UK) LTD

DATE OF ISSUE: 27/Nov/2020

CERTIFICATE NUMBER : 13252589JD01F



5772

UL INTERNATIONAL (UK) LTD  
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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: | 26/Nov/2020 |
| Manufacturer:      | SPEAG                        |                  |             |
| Type/Model Number: | D5GHzV2                      |                  |             |
| Serial Number:     | 1168                         |                  |             |
| Calibration Date:  | 27/Nov/2020                  |                  |             |
| Calibrated By:     | Masood Khan<br>Test Engineer |                  |             |

Signature:

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

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

Use of the UKAS mark demonstrates that compliance with the requirements of BS/EN/ISO/IEC 17025:2017 has been independently assessed.



# CERTIFICATE OF CALIBRATION

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UKAS Accredited Calibration Laboratory No. 5772

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Page 2 of 16

The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2016**: 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. **DASY6 System Handbook**
6. **Dipole Calibration Procedure V1.2**: Calibration performed as per internal procedure

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) |
|------------|------------------------------|-----------------|---------------|------------|-----------------------|------------------------|
| PRE0135115 | Data Acquisition Electronics | SPEAG           | DAE4          | 1438       | 14 Apr 2020           | 12                     |
| PRE0178314 | Probe                        | SPEAG           | EX3DV4        | 7496       | 24 Mar 2020           | 12                     |
| PRE0132081 | Dipole                       | SPEAG           | D5GHzV2       | 1016       | 18 Feb 2020           | 12                     |
| PRE0151451 | Power Monitoring Kit         | Art-Fi          | ART 100850-01 | 0001       | Cal as part of System | -                      |
| PRE0151441 | Power Sensor                 | Rhode & Schwarz | NRP8S         | 102481     | 27 Mar 2020           | 12                     |
| PRE0151154 | Vector Network Analyser      | Rhode & Schwarz | ZNB 8         | 100151     | 15 Jun 2020           | 12                     |
| PRE0158684 | Calibration Kit              | Rhode & Schwarz | ZV-Z135       | 102144     | 27 May 2020           | 12                     |
| PRE0178154 | Signal Generator             | HP              | 8648C         | 3537A01598 | 22 Jan 2020           | 12                     |

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### SAR System Specification

|                          |                                            |
|--------------------------|--------------------------------------------|
| Robot System Positioner: | Stäubli Unimation Corp. Robot Model: TX60L |
| Robot Serial Number:     | F17/5ENYG1/A/01                            |
| DASY Version:            | cDASY6.14.0.959                            |
| Phantom:                 | Flat section of SAM Twin Phantom           |
| Distance Dipole Centre:  | 10 mm (with spacer)                        |

**Frequency: 5250 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            | 5250            | 20.3 °C   | 20.3 °C | 21.4 °C     | 21.4 °C | $\epsilon_r$ | 35.93        | 35.77          | ± 5%            |
|                 |                 |           |         |             |         | $\sigma$     | 4.71         | 4.69           | ± 5%            |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Head            | SAR averaged over 1g  | 8.08 W/Kg          | <b>80.8 W/Kg</b>     | ± 18.75%        |
|                 | SAR averaged over 10g | 2.33 W/Kg          | <b>23.3 W/Kg</b>     | ± 18.63%        |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Head            | Impedance   | 59.368 $\Omega$ +3.959 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 20.57                             | ± 2.23 dB                          |

**Frequency: 5600 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            | 5600            | 20.3 °C   | 20.3 °C | 21.4 °C     | 21.4 °C | $\epsilon_r$ | 35.53        | 35.10          | ± 5%            |
|                 |                 |           |         |             |         | $\sigma$     | 5.07         | 5.07           | ± 5%            |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Head            | SAR averaged over 1g  | 8.61 W/Kg          | <b>86.1 W/Kg</b>     | ± 18.75%        |
|                 | SAR averaged over 10g | 2.45 W/Kg          | <b>24.5 W/Kg</b>     | ± 18.63%        |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Head            | Impedance   | 46.438 $\Omega$ +5.066 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 23.78                             | ± 2.23 dB                          |

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**Frequency: 5750 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            | 5750            | 20.3 °C   | 20.3 °C | 21.4°C      | 21.4°C | $\epsilon_r$ | 35.36        | 34.81          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 5.22         | 5.24           | ± 5%            |

### SAR Results – Head Simulating Liquid (HSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Head            | SAR averaged over 1g  | 7.80 W/Kg          | <b>78.0 W/Kg</b>     | ± 18.75%        |
|                 | SAR averaged over 10g | 2.24 W/Kg          | <b>22.4 W/Kg</b>     | ± 18.63%        |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Head            | Impedance   | 58.790 $\Omega$ -2.037 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 21.77                             | ± 2.23 dB                          |

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**Frequency: 5250 MHz**

### 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            | 5250            | 20.9 °C   | 20.9 °C | 21.0°C      | 21.0°C | $\epsilon_r$ | 48.95        | 47.85          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 5.36         | 5.38           | ± 5%            |

### SAR Results – Body Simulating Liquid (MSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Body            | SAR averaged over 1g  | 7.26 W/Kg          | <b>72.6 W/Kg</b>     | ± 18.53%        |
|                 | SAR averaged over 10g | 2.04 W/Kg          | <b>20.4 W/Kg</b>     | ± 18.61%        |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Body            | Impedance   | 58.323 $\Omega$ +3.270 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 21.54                             | ± 2.23 dB                          |

**Frequency: 5600 MHz**

### 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            | 5600            | 20.3 °C   | 20.3 °C | 21.4°C      | 21.4°C | $\epsilon_r$ | 48.47        | 47.09          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 5.77         | 5.86           | ± 5%            |

### SAR Results – Body Simulating Liquid (MSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Body            | SAR averaged over 1g  | 7.76 W/Kg          | <b>77.6 W/Kg</b>     | ± 18.53%        |
|                 | SAR averaged over 10g | 2.17 W/Kg          | <b>21.7 W/Kg</b>     | ± 18.61%        |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Body            | Impedance   | 45.652 $\Omega$ +4.355 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 23.77                             | ± 2.23 dB                          |

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**Frequency: 5750 MHz**

### 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            | 5750            | 20.9 °C   | 20.9 °C | 21.0°C      | 21.0°C | $\epsilon_r$ | 48.3         | 46.78          | ± 5%            |
|                 |                 |           |         |             |        | $\sigma$     | 5.94         | 6.07           | ± 5%            |

### SAR Results – Body Simulating Liquid (MSL)

| Simulant Liquid | SAR Measured          | 100 mW input Power | Normalised to 1.00 W | Uncertainty (%) |
|-----------------|-----------------------|--------------------|----------------------|-----------------|
| Body            | SAR averaged over 1g  | 7.14 W/Kg          | 71.4 W/Kg            | ± 18.53%        |
|                 | SAR averaged over 10g | 2.01 W/Kg          | 20.1 W/Kg            | ± 18.61%        |

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

| Simulant Liquid | Parameter   | Measured Level                    | Uncertainty (%)                    |
|-----------------|-------------|-----------------------------------|------------------------------------|
| Body            | Impedance   | 59.598 $\Omega$ -1.316 j $\Omega$ | ± 0.28 $\Omega$ ± 0.044 j $\Omega$ |
|                 | Return Loss | 21.19                             | ± 2.23 dB                          |

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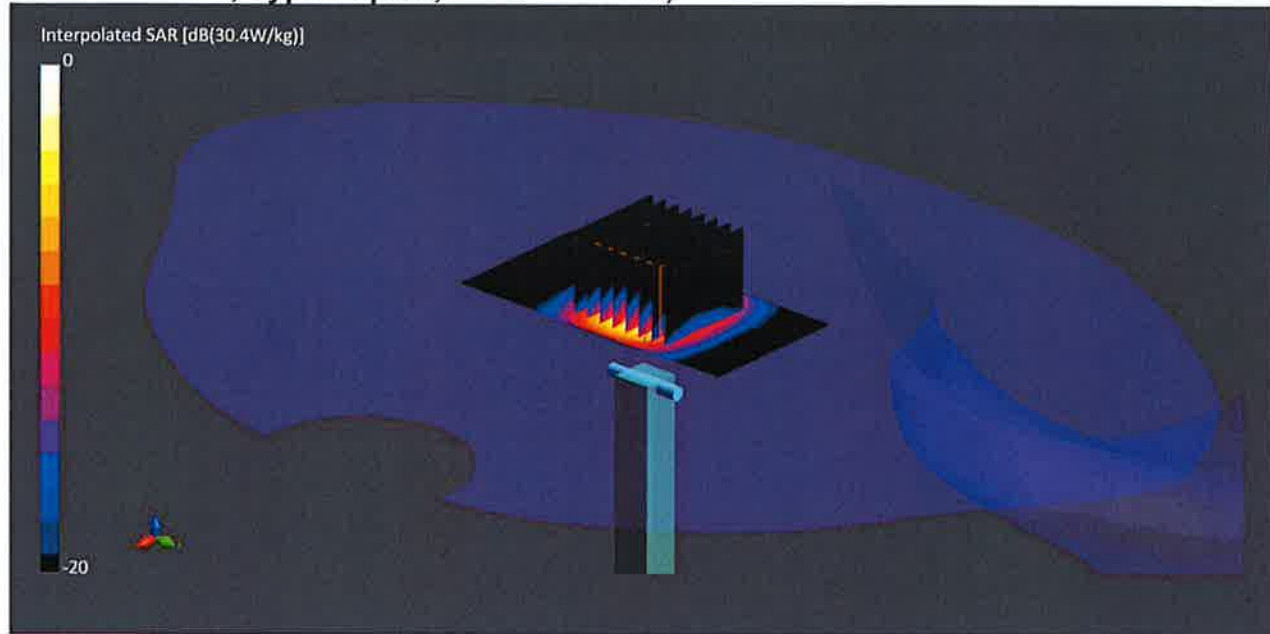
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2; Type: Dipole; Serial: SN1168;



Communication System: CW UID: 0; Frequency: 5250.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_26Nov2020\_102813\_Head - 5Ghz 5%; Medium parameters used:  $f = 5250.0$  MHz;  $\sigma = 4.69$  S/m;  $\epsilon_r = 35.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -0.44$  %;  $\Delta\sigma = -0.42$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(5.18, 5.18, 5.18); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 12.150 V/m; Power Drift = 0.01 dB

Minimum horizontal 3dB distance: 6.9 mm;

Vertical M2/M1 Ratio: 65.9 %;

**SAR(1 g) = 8.080 W/kg; SAR(10 g) = 2.330 W/kg**

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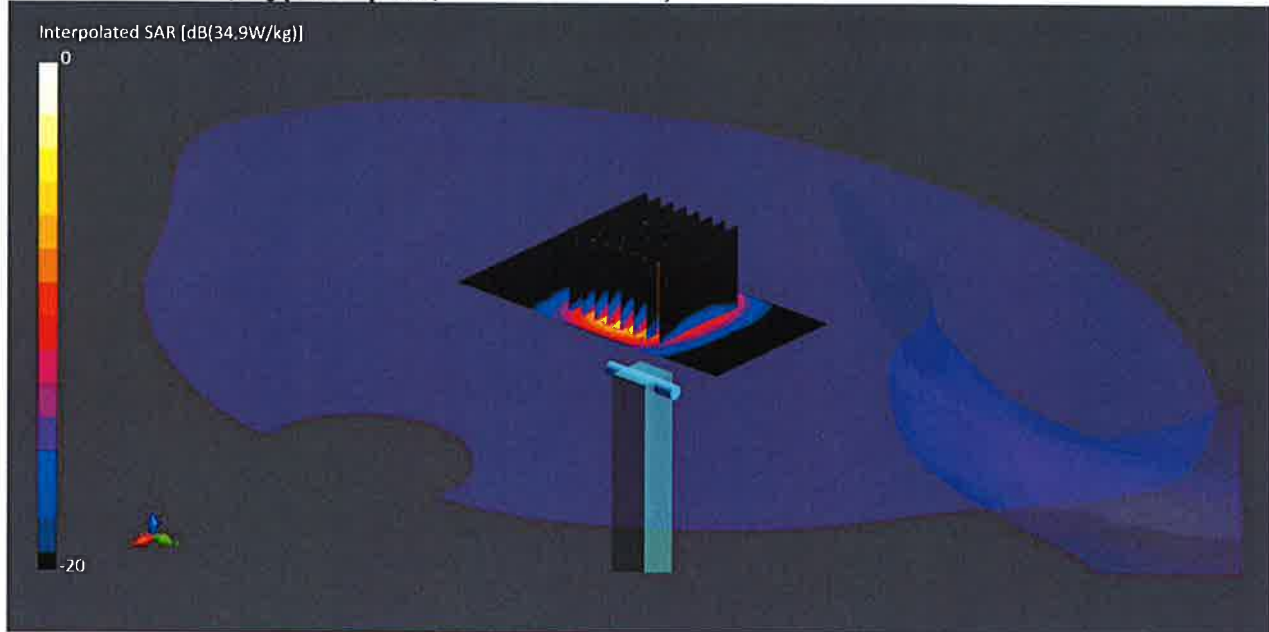
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2; Type: Dipole; Serial: SN1168;



Communication System: CW UID: 0; Frequency: 5600.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_26Nov2020\_102813\_Head - 5Ghz 5%; Medium parameters used:  $f = 5600.0$  MHz;  $\sigma = 5.07$  S/m;  $\epsilon_r = 35.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -1.22$  %;  $\Delta\sigma = 0.14$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(4.65, 4.65, 4.65); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 13.300 V/m; Power Drift = 0.02 dB

Minimum horizontal 3dB distance: 7.4 mm;

Vertical M2/M1 Ratio: 63.3 %;

**SAR(1 g) = 8.610 W/kg; SAR(10 g) = 2.450 W/kg**

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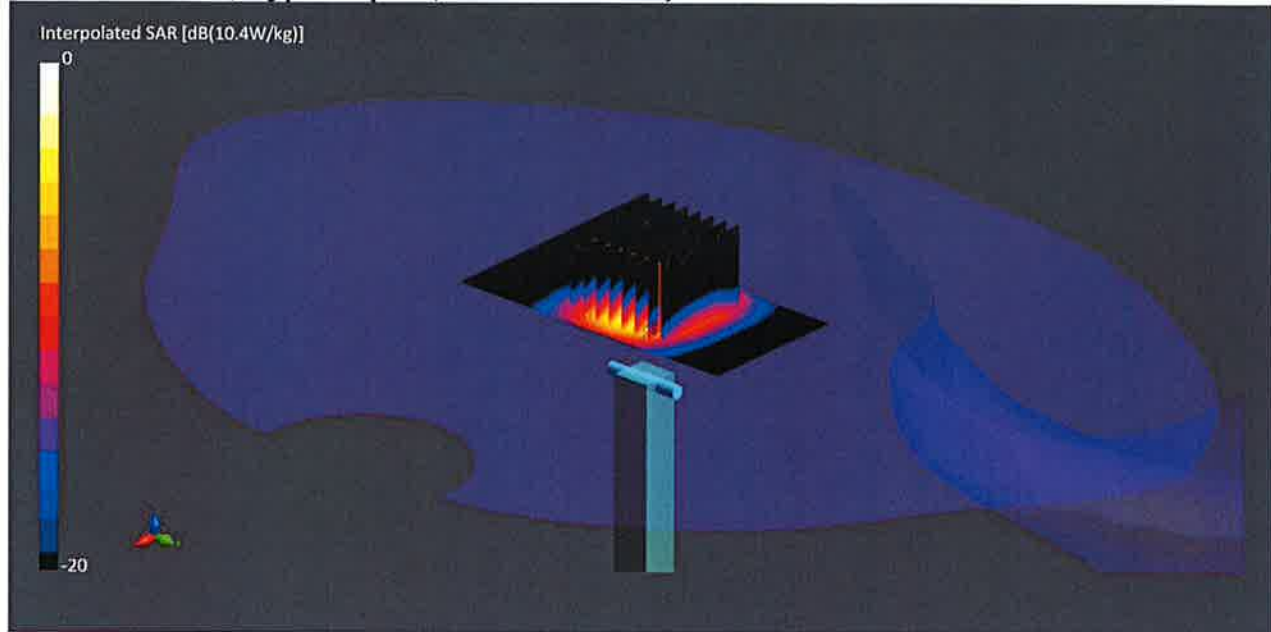
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### DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2; Type: Dipole; Serial: SN1168;



Communication System: CW UID: 0; Frequency: 5750.0 MHz; Duty Cycle: 1;  
Medium: HSL; Site65\_26Nov2020\_102813\_Head - 5Ghz 5%; Medium parameters used:  $f = 5750.0$  MHz;  $\sigma = 5.24$  S/m;  $\epsilon_r = 34.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -1.56$  %;  $\Delta\sigma = 0.45$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(4.8, 4.8, 4.8); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 11.300 V/m; Power Drift = 0.00 dB

Minimum horizontal 3dB distance: 7.5 mm;

Vertical M2/M1 Ratio: 62.1 %;

**SAR(1 g) = 7.800 W/kg; SAR(10 g) = 2.240 W/kg**



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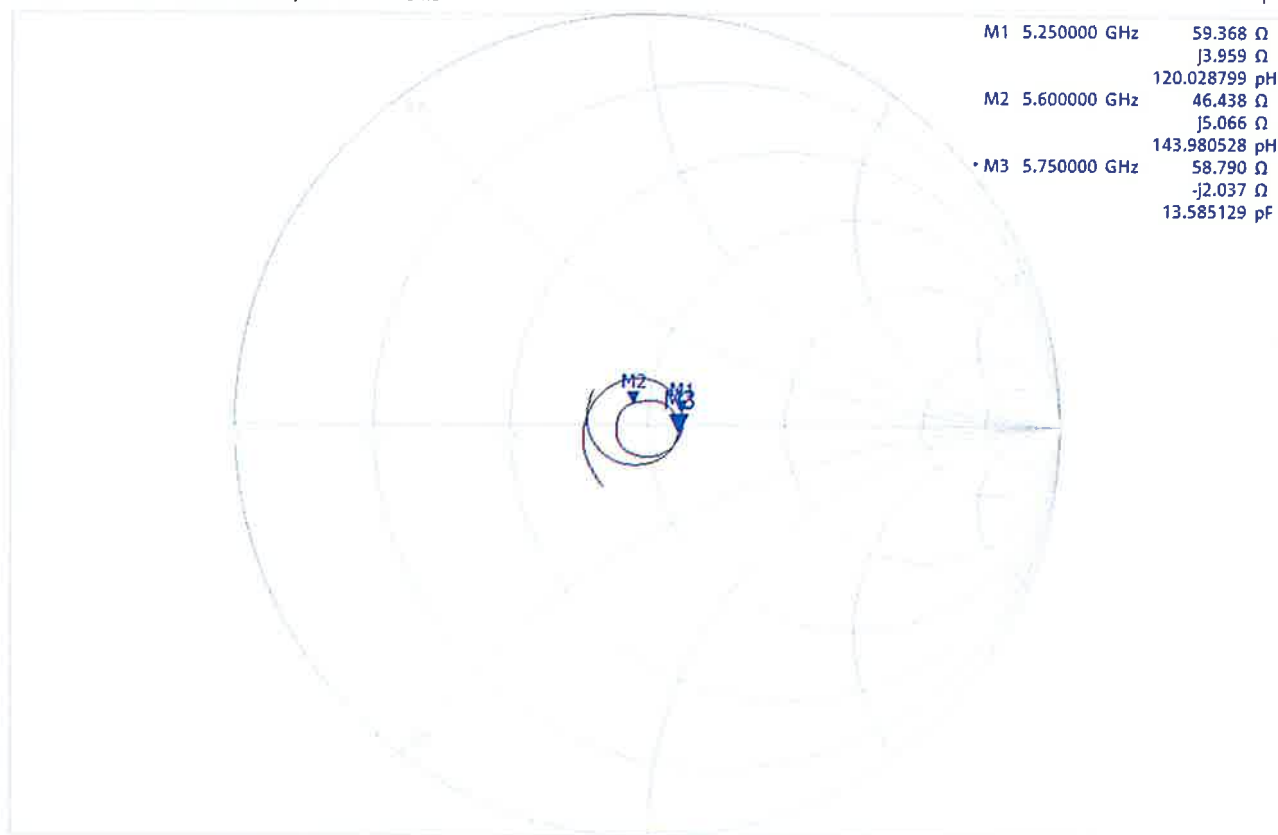
### Impedance Measurement Plot for Head Stimulating Liquid (HSL)



11/27/2020 10:51:38 AM  
1328.5170K92-100151-MV

Trc1 — S11 Sm1th 200 mU/ Ref 1 U Cal Smo

1



Ch1 Start 5 GHz

Pwr -10 dBm Bw 10 kHz

Stop 6 GHz

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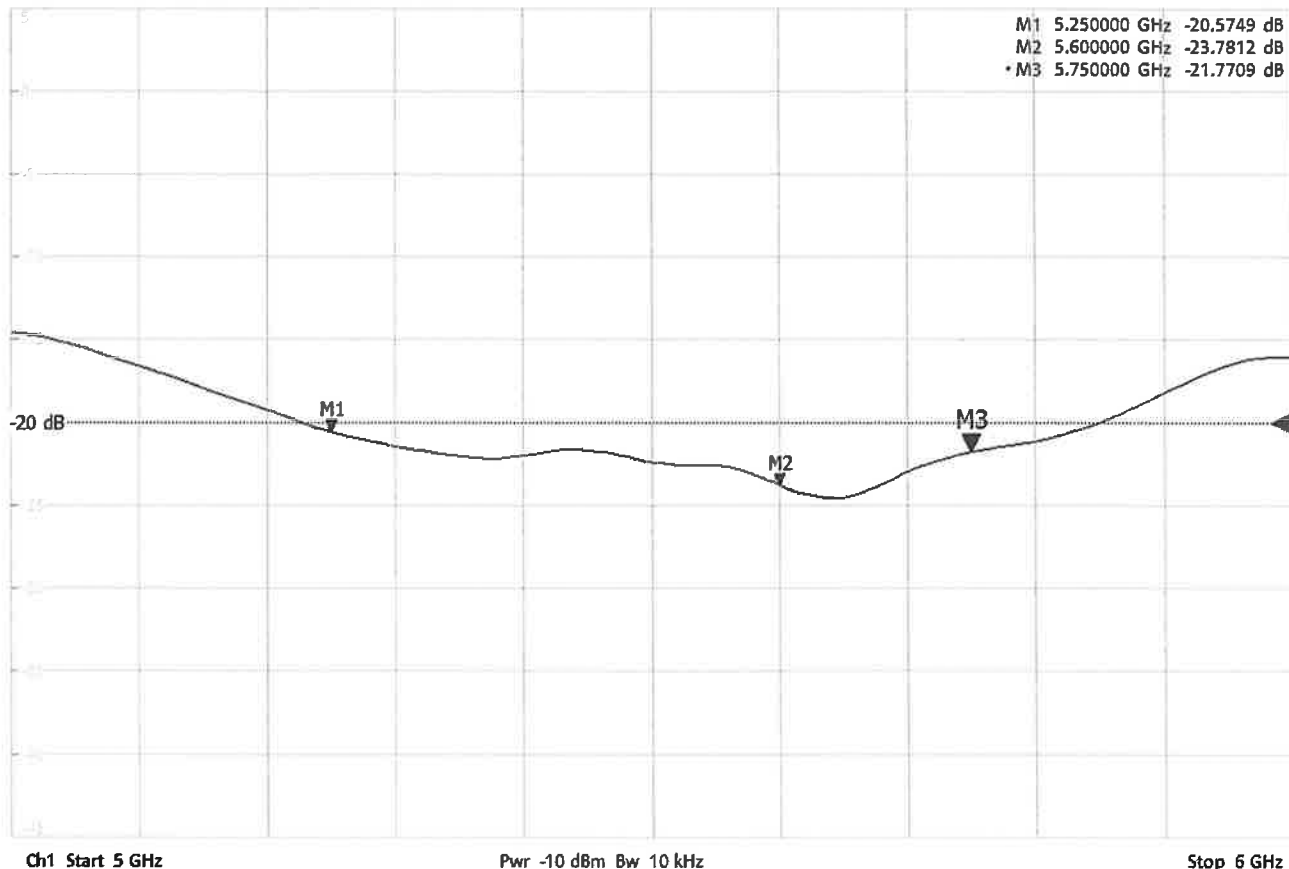
### Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



11/27/2020 10:50:58 AM  
1328.5170K92-100151-MV

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

1



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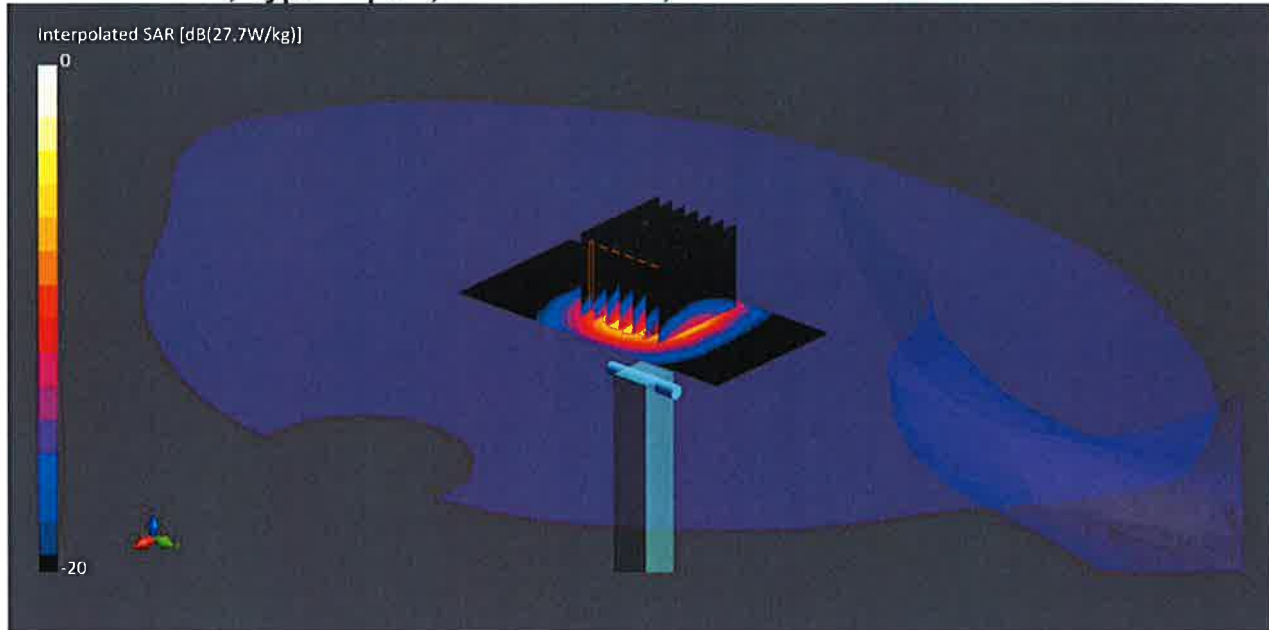
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D5GHzV2; Type: Dipole; Serial: SN1168;



Communication System: CW UID: 0; Frequency: 5250.0 MHz; Duty Cycle: 1;  
Medium: MSL; Site65\_27Nov2020\_101444\_Body - 5GHz 5%; Medium parameters used:  $f = 5250.0$  MHz;  $\sigma = 5.38$  S/m;  $\epsilon_r = 47.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -2.24$  %;  $\Delta\sigma = 0.51$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(4.75, 4.75, 4.75); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V5.0 (30deg probe tilt); Serial: 1818
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 11.310 V/m; Power Drift = 0.02 dB

Minimum horizontal 3dB distance: 7.2 mm;

Vertical M2/M1 Ratio: 65.2 %;

**SAR(1 g) = 7.260 W/kg; SAR(10 g) = 2.040 W/kg**

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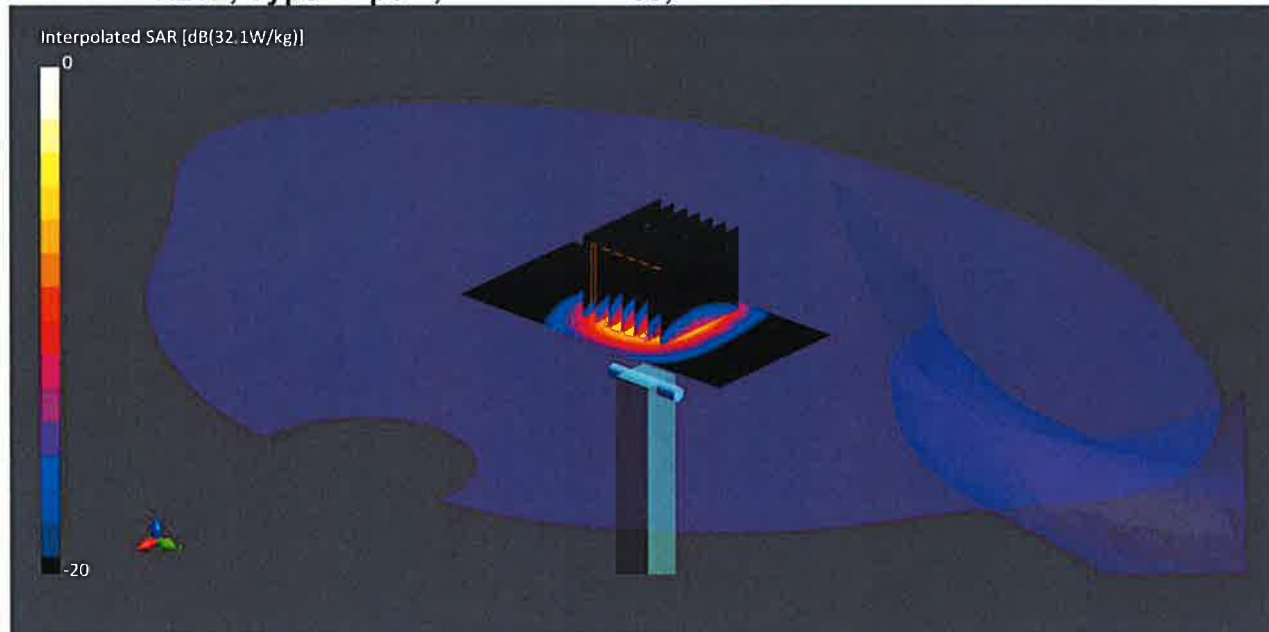
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D5GHzV2; Type: Dipole; Serial: SN1168;



Communication System: CW UID: 0; Frequency: 5600.0 MHz; Duty Cycle: 1;  
Medium: MSL; Site65\_27Nov2020\_101444\_Body - 5GHz 5%; Medium parameters used:  $f = 5600.0$  MHz;  $\sigma = 5.86$  S/m;  $\epsilon_r = 47.1$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -2.85$  %;  $\Delta\sigma = 1.67$  %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(4.18, 4.18, 4.18); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V5.0 (30deg probe tilt); Serial: 1818
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 11.940 V/m; Power Drift = -0.02 dB

Minimum horizontal 3dB distance: 7.2 mm;

Vertical M2/M1 Ratio: 62.3 %;

**SAR(1 g) = 7.760 W/kg; SAR(10 g) = 2.170 W/kg**

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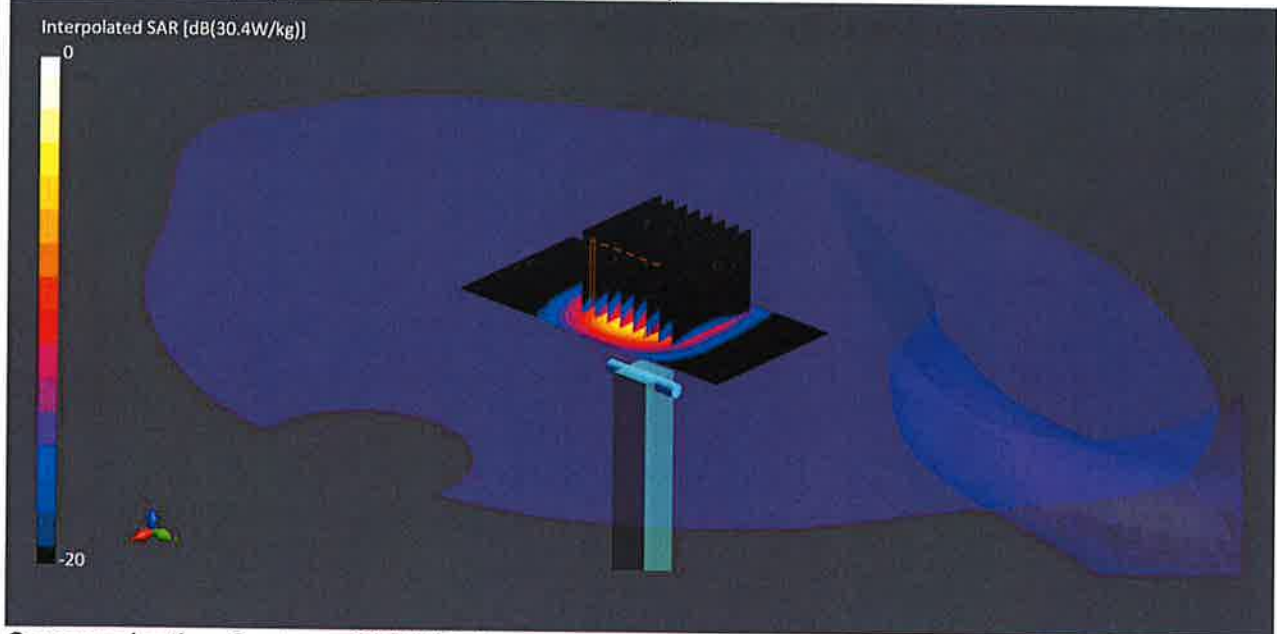
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### DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D5GHzV2; Type: Dipole; Serial: SN1168;



Communication System: CW UID: 0; Frequency: 5750.0 MHz; Duty Cycle: 1;  
Medium: MSL; Site65\_27Nov2020\_101444\_Body - 5GHz 5%; Medium parameters used:  $f = 5750.0$  MHz;  $\sigma = 6.07$  S/m;  $\epsilon_r = 46.8$ ;  $\rho = 1000$  kg/m<sup>3</sup>;  $\Delta\epsilon_r = -3.09$  %;  $\Delta\sigma = 2.12$  %; No correction  
Phantom section: Flat;

DASY 6 Configuration:

- Probe: EX3DV4 - SN7496; ConvF(4.21, 4.21, 4.21); Calibrated: 24 Mar 2020
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 14 Apr 2020
- Phantom: Twin-SAM V5.0 (30deg probe tilt); Serial: 1818
- Measurement SW: cDASY6.14.0.959

**Area Scan (40x80):** Interpolated grid:  $dx=10$  mm,  $dy=10$  mm

**Zoom Scan1(22x22x22):** Measurement grid:  $dx=4$  mm,  $dy=4$  mm,  $dz=1.4$  mm; Grading Ratio: 1.4; Reference Value = 10.460 V/m; Power Drift = -0.01 dB

Minimum horizontal 3dB distance: 7.4 mm;

Vertical M2/M1 Ratio: 60.9 %;

**SAR(1 g) = 7.140 W/kg; SAR(10 g) = 2.010 W/kg**

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



11/27/2020 10:53:38 AM  
1328,5170K92-100151-MV

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

1

|      |              |                  |
|------|--------------|------------------|
| M1   | 5.250000 GHz | 58.323 $\Omega$  |
|      |              | j3.270 $\Omega$  |
|      |              | 99.123370 pF     |
| M2   | 5.600000 GHz | 45.652 $\Omega$  |
|      |              | j4.355 $\Omega$  |
|      |              | 123.762870 pF    |
| • M3 | 5.750000 GHz | 59.598 $\Omega$  |
|      |              | -j1.316 $\Omega$ |
|      |              | 21.028883 pF     |

Ch1 Start 5 GHz

Pwr -10 dBm Bw 10 kHz

Stop 6 GHz

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

11/27/2020 10:54:19 AM  
1328.5170K92-100151-MV

Trc1 — 511 dB Mag 5 dB/ Ref -20 dB Cal Smo



Ch1 Start 5 GHz

Pwr -10 dBm Bw 10 kHz

Stop 6 GHz

**Calibration Certificate Label:**

|                                                                                                  |                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br><b>5772</b> | <p><b>UL INTERNATIONAL (UK) LTD</b><br/><b>Tel: +44 (0) 1256312000</b></p> <p>Certificate Number: 13252589JD01F</p> <p>Instrument ID: 1168</p> <p>Calibration Date: 27/Nov/2020</p> <p>Calibration Due Date:</p> |
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