

CERTIFICATE OF CALIBRATION

ISSUED BY UL INTERNATIONAL (UK) LTD

DATE OF ISSUE: 29/Nov/2021

CERTIFICATE NUMBER : 13685241JD01A



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:	19/Nov/2021
Manufacturer:	SPEAG		
Type/Model Number:	D750V3		
Serial Number:	1071		
Calibration Date:	24/Nov/2021		
Calibrated By:	Masood Khan 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 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)
PRE0135115	Data Acquisition Electronics	SPEAG	DAE4	1438	12 Apr 2021	12
PRE0178314	Probe	SPEAG	EX3DV4	7496	16 Mar 2021	12
PRE0133692	Dipole	SPEAG	D750V3	SN1011	15 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	22 Mar 2021	12
PRE0151154	Vector Network Analyser	Rhode & Schwarz	ZND 1328.5170K92	100151	23 Mar 2021	12
ULEID212645	Calibration Kit	Rhode & Schwarz	ZN-Z135 (f)	101005	22 Oct 2021	12
PRE0178154	Signal Generator	Rhode & Schwarz	SMB 100A	175325	25 Mar 2021	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:	cDASY16.0.0.116
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	15 mm (with spacer)
Frequency:	750 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	750	21.2 °C	21 °C	21.1 °C	21 °C	ϵ_r	41.94	42.29	± 5%
						σ	0.89	0.90	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	2.1 W/Kg	8.36 W/Kg	+16.80 / -16.43%
	SAR averaged over 10g	1.39 W/Kg	5.53 W/Kg	+16.72 / -16.42%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	46.26 + 0.86j Ω	± 3.01
	Return Loss	27.89	± 2.97

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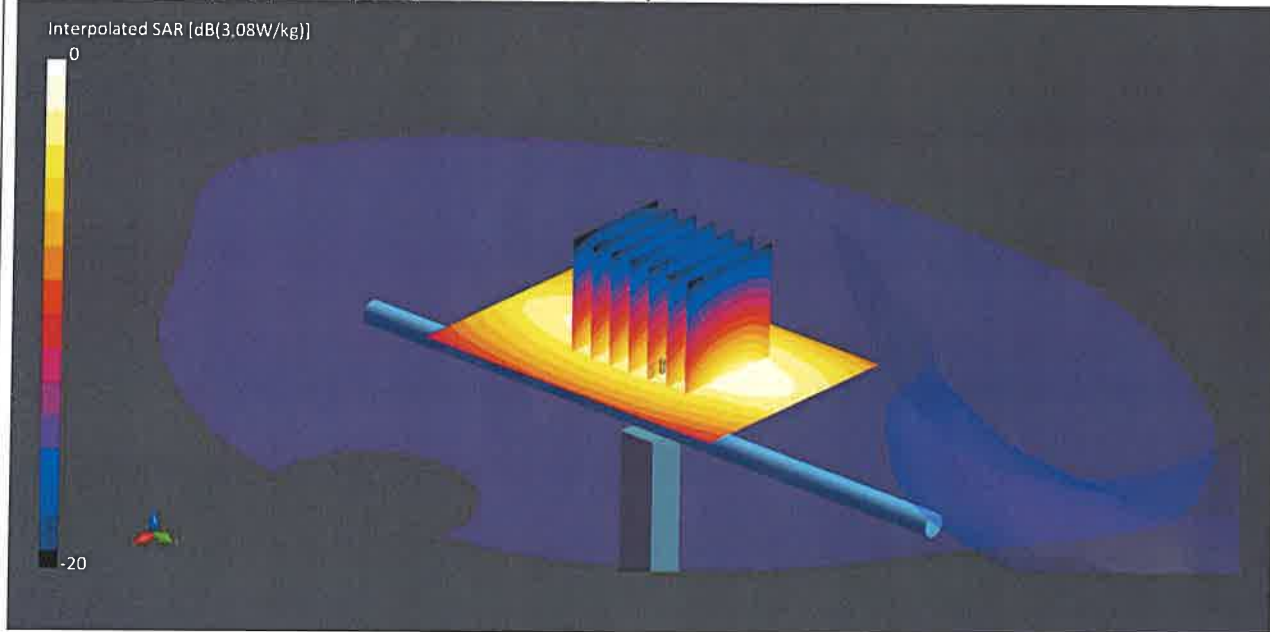
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DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D750V3; Type: Dipole; Serial: SN1071;



Communication System: CW UID: 0; Frequency: 750.0 MHz; Duty Cycle: 1;
Medium: HSL; Site65_23Nov2021_030728_Head - 750 900 1800 1900 5GHz 5%; Medium
parameters used: $f = 750.0$ MHz; $\sigma = 0.9$ S/m; $\epsilon_r = 42.3$; $\rho = 1000$ kg/m³; $\Delta\epsilon_r = 0.85$ %; $\Delta\sigma = 0.62$ %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(10.34, 10.34, 10.34); Calibrated: 16 Mar 2021
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 12 Apr 2021
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY6.14.0.959

Area Scan (60x90): Interpolated grid: $dx=15$ mm, $dy=15$ mm

Zoom Scan1(30x30x30): Measurement grid: $dx=6$ mm, $dy=6$ mm, $dz=1.5$ mm; Grading Ratio: 1.5; Reference Value = 2.450 V/m; Power Drift = 0.01 dB

Minimum horizontal 3dB distance: 18.8 mm;

Vertical M2/M1 Ratio: 89.5 %;

SAR(1 g) = 2.100 W/kg; SAR(10 g) = 1.390 W/kg

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Impedance Measurement Plot for Head Stimulating Liquid (HSL)

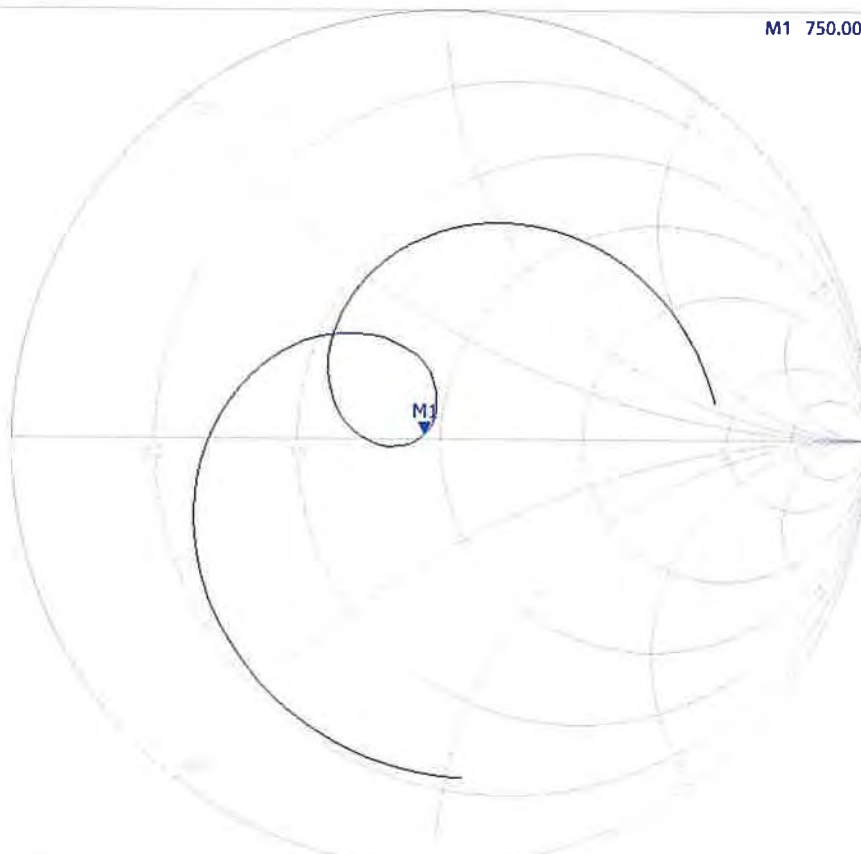


11/24/2021 6:13:20 PM
1328.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal

1

M1 750.000000 MHz 46.257 Ω
j862.844 m Ω
183.101155 pH



Ch1 Center 750 MHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

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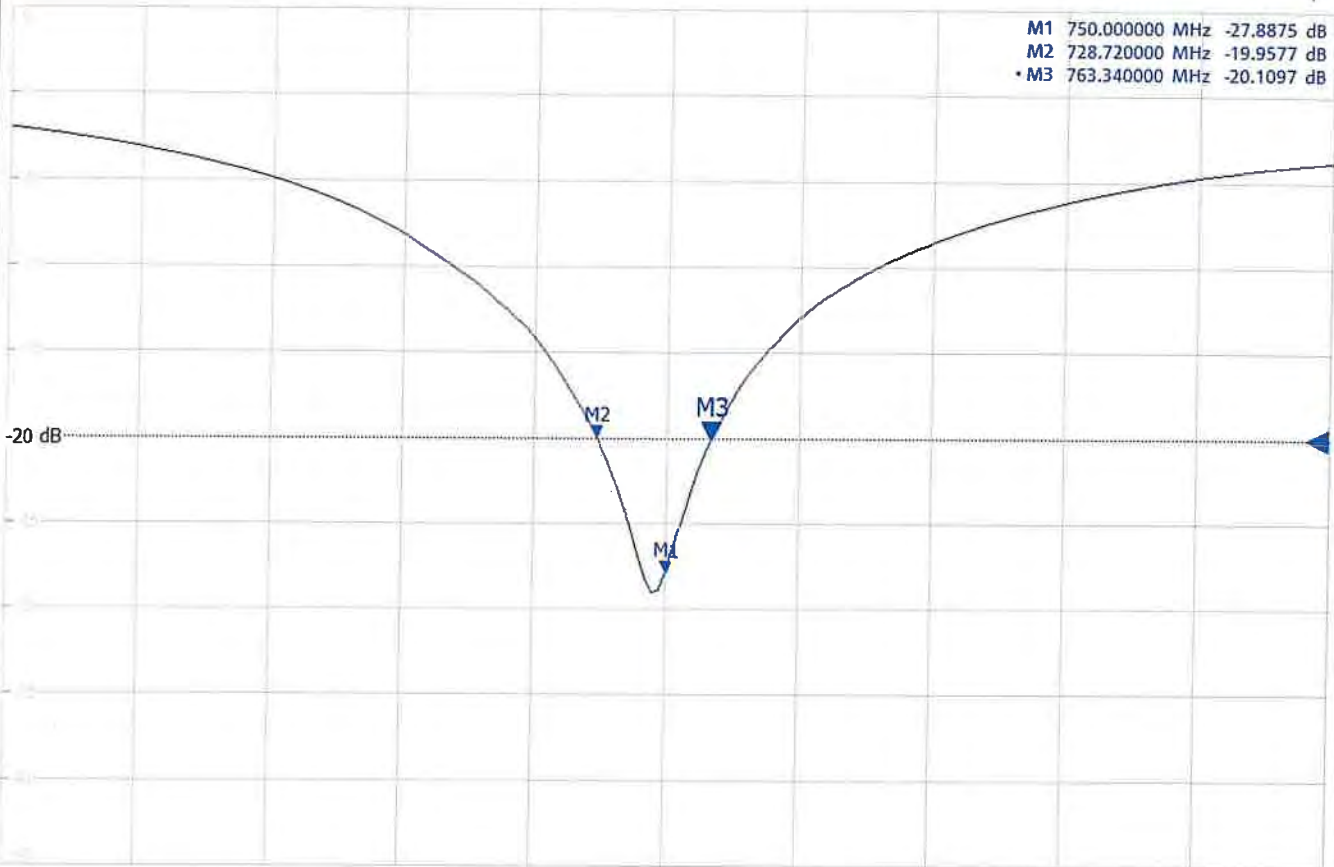
Return Loss Measurement Plot for Head Stimulating Liquid (HSL)

11/24/2021 6:12:54 PM
1328.5170K92-100151-MV

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

1

M1 750.000000 MHz -27.8875 dB
M2 728.720000 MHz -19.9577 dB
• M3 763.340000 MHz -20.1097 dB



Ch1 Center 750 MHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

Calibration Certificate Label:

	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312100 Certificate Number: 13685241JD01A Instrument ID: 1071 Calibration Date: 24/Nov/2021 Calibration Due Date:
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	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312100 Certificate Number: 13685241JD01A Instrument ID: 1071 Calibration Date: 24/Nov/2021 Calibration Due Date:
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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: **D835V2-4d142_Aug21**

CALIBRATION CERTIFICATE

Object **D835V2 - SN:4d142**

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

Calibration date: **August 10, 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 $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	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

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

Issued: August 10, 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:

- a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- b) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- c) DASY 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 source is mounted in a touch configuration below the center marking of the flat phantom.
- *Return Loss:* This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. 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	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	835 MHz $\pm$ 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	41.5	0.90 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	41.6 $\pm$ 6 %	0.92 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	2.45 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	9.64 W/kg $\pm$ 17.0 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	1.59 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	6.28 W/kg $\pm$ 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	50.4 Ω - 4.9 j Ω
Return Loss	- 26.2 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.394 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
-----------------	-------

DASY5 Validation Report for Head TSL

Date: 10.08.2021

Test Laboratory: SPEAG, Zurich, Switzerland

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

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

Medium parameters used: $f = 835 \text{ MHz}$; $\sigma = 0.92 \text{ S/m}$; $\epsilon_r = 41.6$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(9.69, 9.69, 9.69) @ 835 MHz; Calibrated: 28.12.2020
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 02.11.2020
- Phantom: Flat Phantom 4.9 (front); Type: QD 00L P49 AA; Serial: 1001
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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

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

Reference Value = 63.24 V/m; Power Drift = -0.01 dB

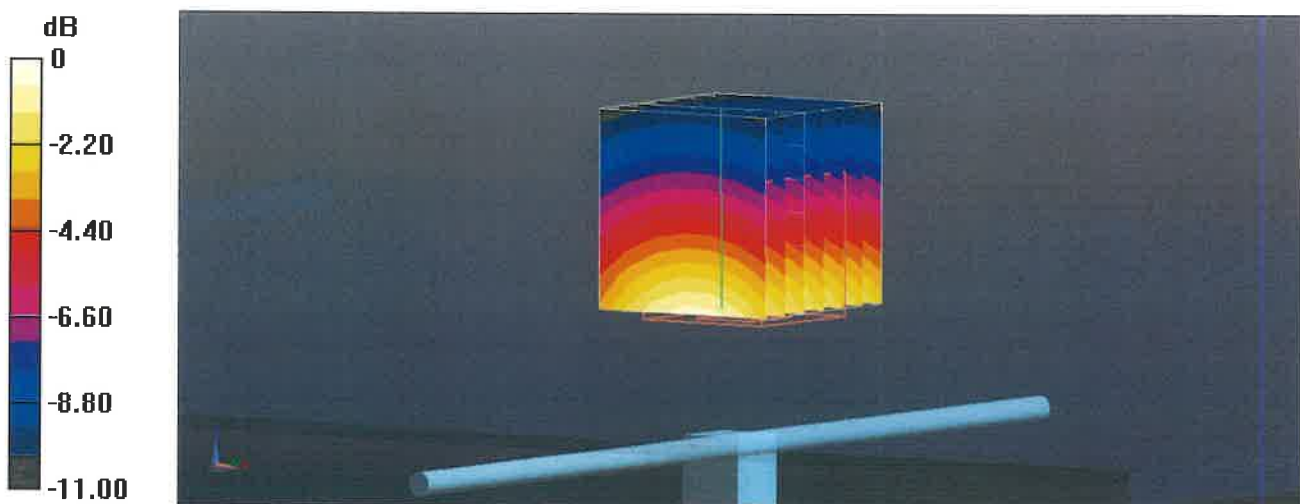
Peak SAR (extrapolated) = 3.66 W/kg

SAR(1 g) = 2.45 W/kg; SAR(10 g) = 1.59 W/kg

Smallest distance from peaks to all points 3 dB below = 16 mm

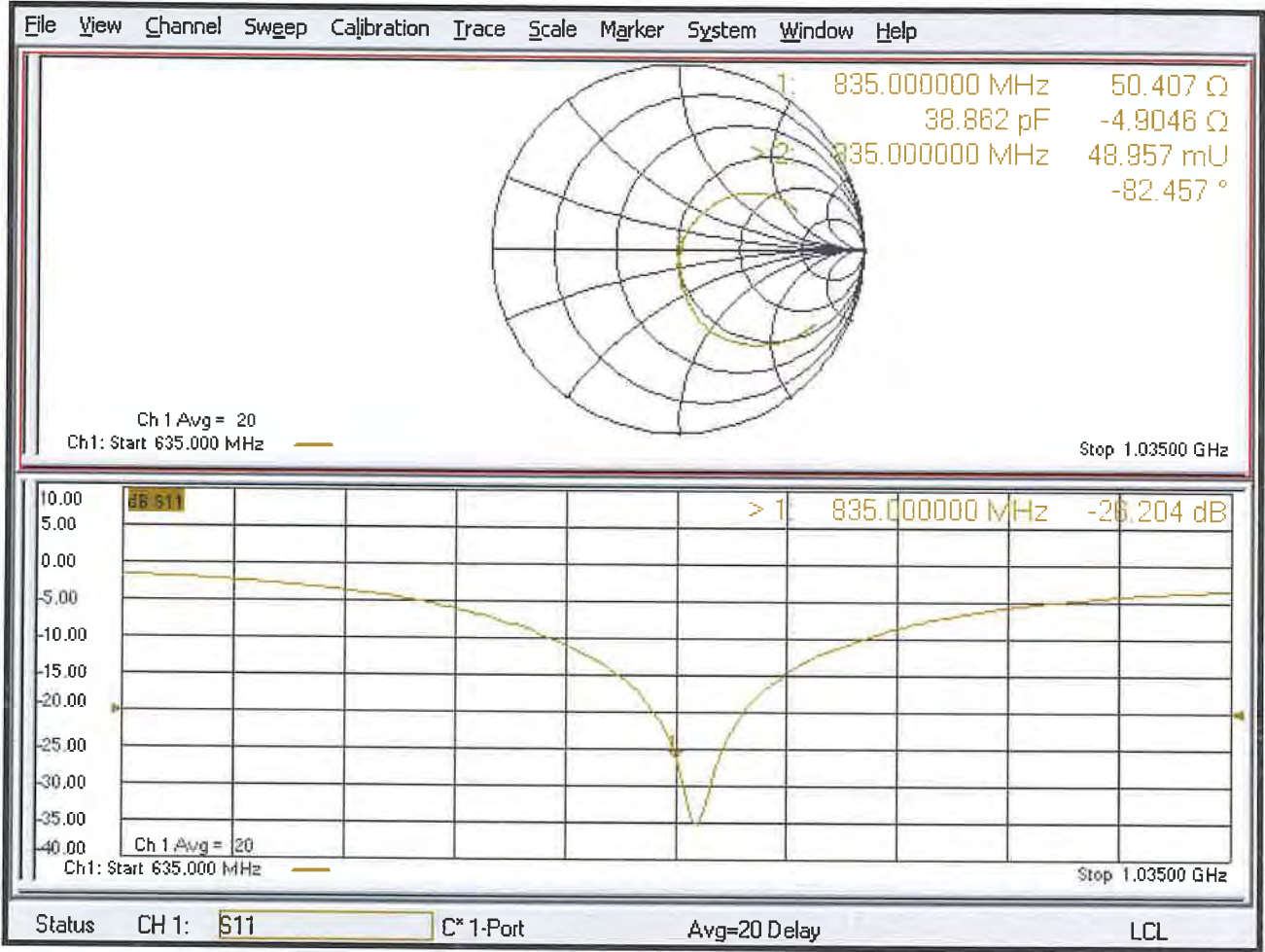
Ratio of SAR at M2 to SAR at M1 = 66.7%

Maximum value of SAR (measured) = 3.25 W/kg



0 dB = 3.25 W/kg = 5.12 dBW/kg

Impedance Measurement Plot for Head TSL



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Email: LST.UK.Calibration@ul.com



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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:	D1750V2		
Serial Number:	1050		
Calibration Date:	13/April/2021		
Calibrated By:	Ravish Foolchund 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%

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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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
PRE0131610	Dipole Antenna	SPEAG	D1800V2	2d009	16 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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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:	1750 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	1750	20.0 °C	19.8 °C	19.8°C	19.8°C	ϵ'	40.08	39.83	± 5%
						σ	1.37	1.35	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	9.31 W/Kg	37.06 W/Kg	+16.80% / -16.43%
	SAR averaged over 10g	4.99 W/Kg	19.87 W/Kg	+16.72% / -16.42%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	50.19 Ω - 0.067 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	-54.08 dB	± 3.34 dB

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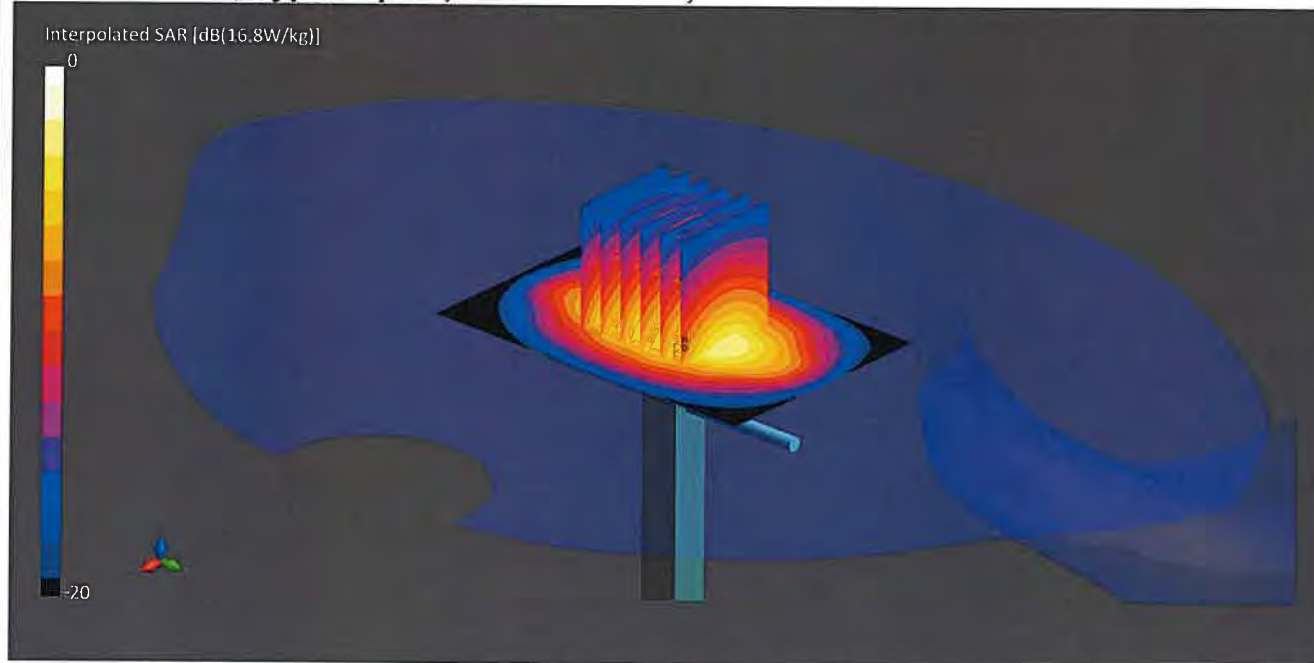
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DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1750V2; Type: Dipole; Serial: SN1050;



Communication System: CW UID: 0; Frequency: 1750.0 MHz; Duty Cycle: 1;
Medium: HSL; Site65_12Apr2021_115940_Head - 1750 1800 1900 2300 2450 2600 5%;
Medium parameters used: $f = 1750.0$ MHz; $\sigma = 1.35$ S/m; $\epsilon_r = 39.8$; $\rho = 1000$ kg/m³; $\Delta\epsilon_r = -0.62$ %; $\Delta\sigma = -1.80$ %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: ES3DV3 - SN3335; ConvF(5.25, 5.25, 5.25); 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 (60x90): Interpolated grid: $dx=15$ mm, $dy=15$ mm

Zoom Scan1(30x30x30): Measurement grid: $dx=6$ mm, $dy=6$ mm, $dz=1.5$ mm; Grading Ratio: 1.5; Reference Value = 11.810 V/m; Power Drift = 0.00 dB

Minimum horizontal 3dB distance: 10.8 mm;

Vertical M2/M1 Ratio: 84.6 %;

SAR(1 g) = 9.310 W/kg; SAR(10 g) = 4.990 W/kg

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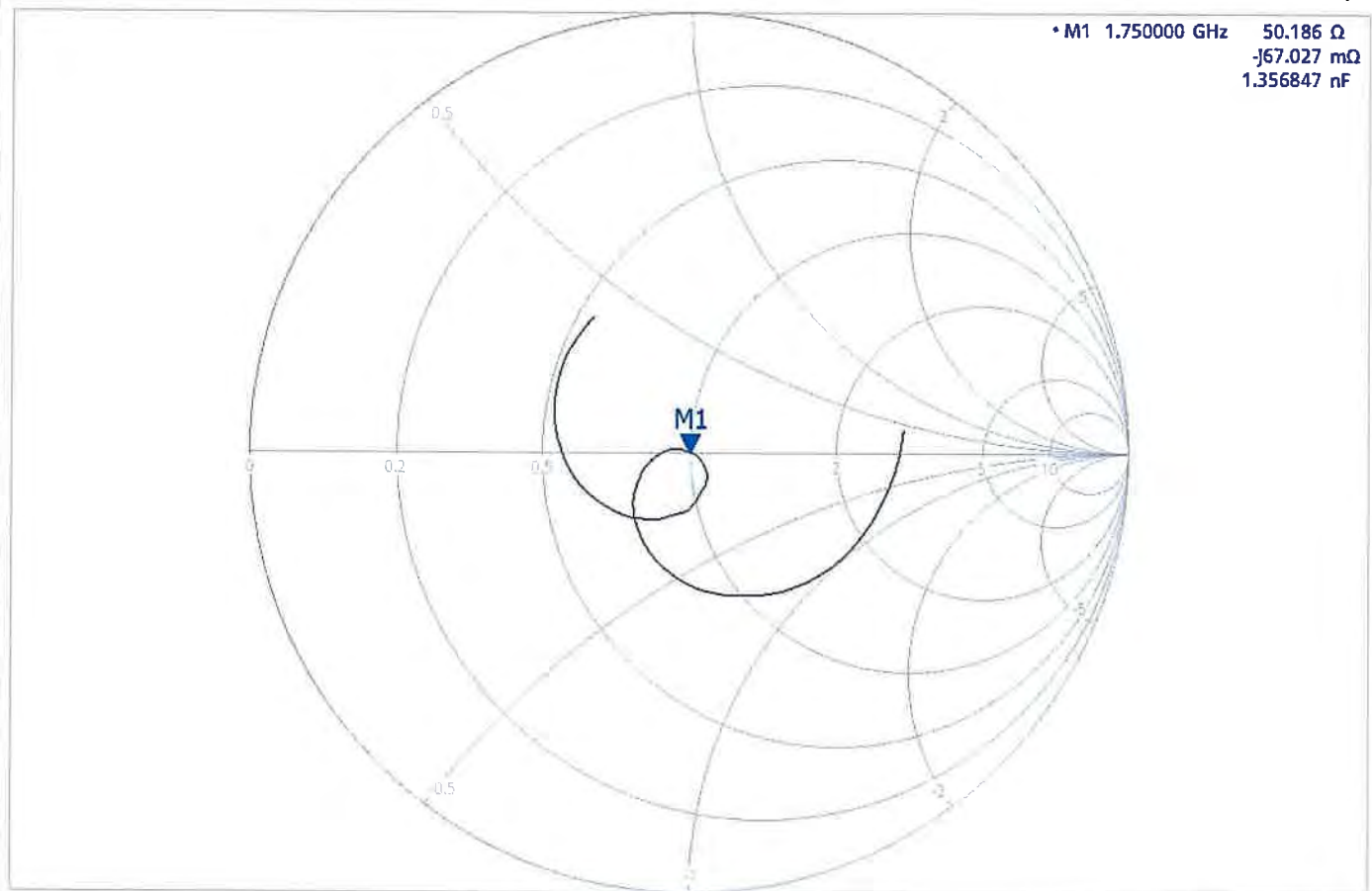
Impedance Measurement Plot for Head Stimulating Liquid (HSL)



4/13/2021 9:12:49 AM
1328.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal

1



Ch1 Center 1.75 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

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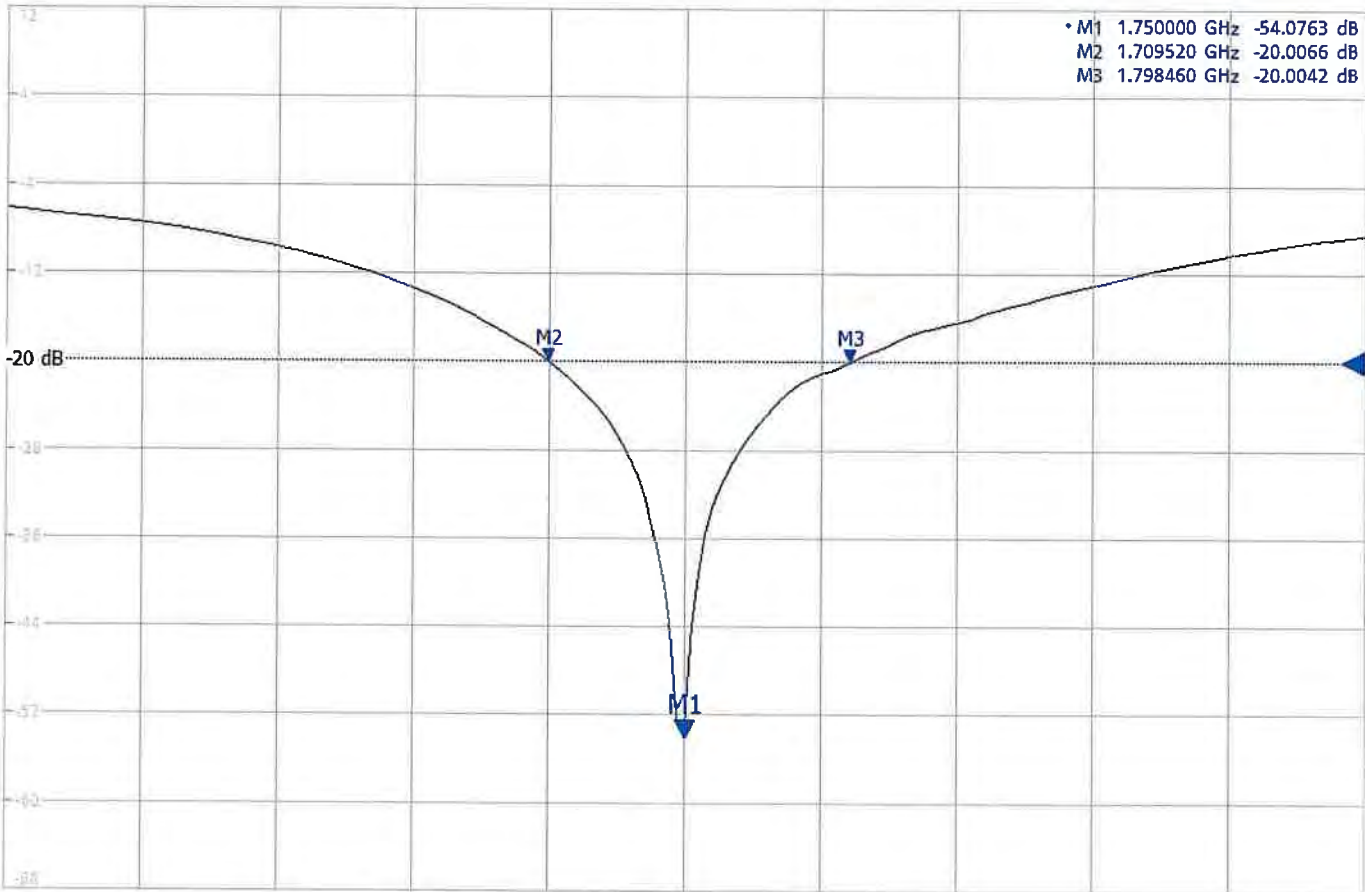
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Return Loss Measurement Plot for Head Stimulating Liquid (HSL)

4/13/2021 9:05:46 AM
1328.5170K92-100151-MV

Trc1 — S11 dB Mag 8 dB/ Ref -20 dB Cal

1



Ch1 Center 1.75 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

Calibration Certificate Label:

 5772	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697411JD01A Instrument ID: 1050 Calibration Date: 13/April/2021 Calibration Due Date:
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 5772	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697411JD01A Instrument ID: 1050 Calibration Date: 13/April/2021 Calibration Due Date:
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CERTIFICATE OF CALIBRATION

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

DATE OF ISSUE: 06/Oct/2021

CERTIFICATE NUMBER : 13697410JD01E



5772

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 10

APPROVED SIGNATORY

.....
Naseer Mirza

Customer :

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	24/Sep/2021
Manufacturer:	Speag		
Type/Model Number:	D1900V2		
Serial Number:	5d163		
Calibration Date:	29/Sep/2021		
Calibrated By:	Masood Khan 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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CERTIFICATE
NUMBER :
13697410JD01E

Page 2 of 10

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)
PRE0135115	Data Acquisition Electronics	SPEAG	DAE4	1438	12 Apr 2021	12
PRE0134817	Probe	SPEAG	ES3DV3	3335	14 Jan 2021	12
PRE0134198	Dipole	SPEAG	D19000V2	SN537	16 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	22 Mar 2021	12
M2028	Vector Network Analyser	Keysight Technologies	E5071C	MY46521873	20 Jul 2021	12
M2029	Calibration Kit	Keysight Technologies	N4691B	MY46181255	02 Aug 2021	12
M1647	Signal Generator	HP	8648C	3537A01598	03 Mar 2021	12

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CERTIFICATE
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13697410JD01E

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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:	cDASY16.0.0.116
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	10 mm (with spacer)
Frequency:	1900 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	1900	21.2 °C	20.6 °C	20.8 °C	20.5 °C	ϵ_r	40.00	40.26	± 5%
						σ	1.40	1.44	± 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	10.20 W/Kg	40.61 W/Kg	+16.80 / -16.43%
	SAR averaged over 10g	5.28 W/Kg	21.02 W/Kg	+16.72 / -16.42%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	51.95 - 4.40j Ω	± 3.01
	Return Loss	26.51	± 2.97

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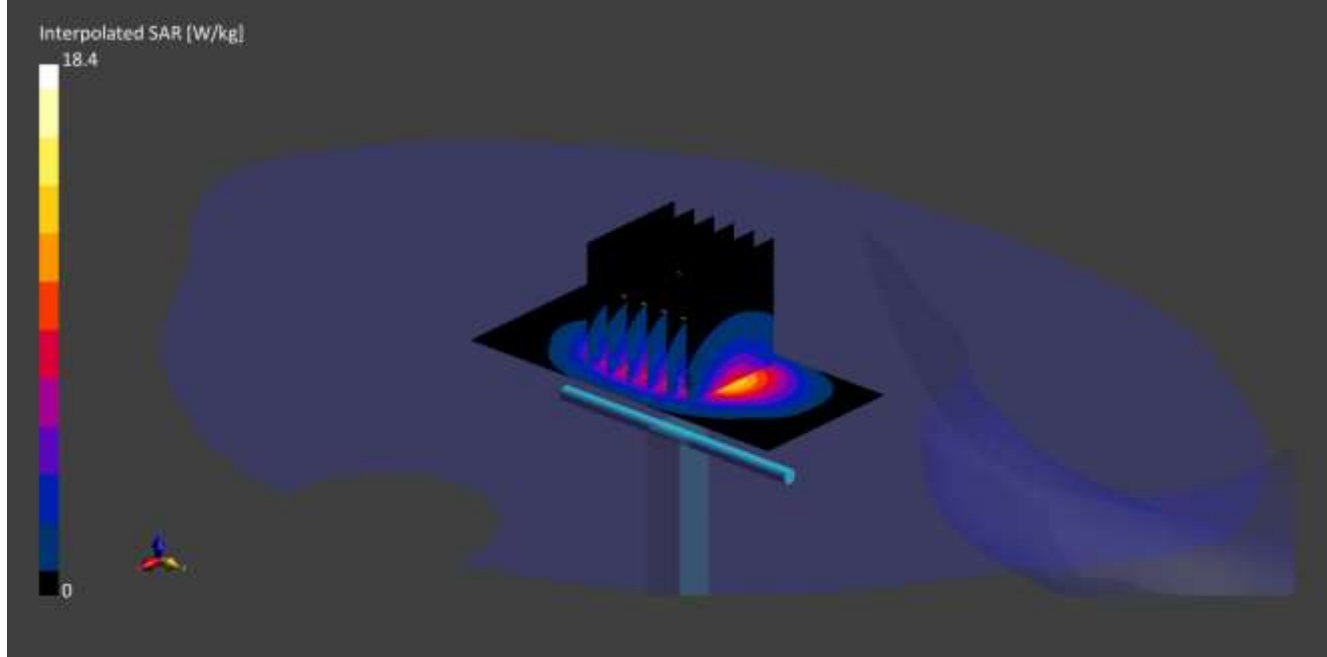
UKAS Accredited Calibration Laboratory No. 5772

CERTIFICATE
NUMBER :
13697410JD01E

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DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1900V2; Type: Dipole; Serial: SN5d163;



Communication System: CW UID: 0; Frequency: 1900.0 MHz; Duty Cycle: 1;
Medium: HSL; Site65_28Sep2021_082639_Head - 900 1800 1900 2300 2600 5%; Medium
parameters used: $f = 1900.0$ MHz; $\sigma = 1.44$ S/m; $\epsilon_r = 40.3$; $\rho = 1000$ kg/m³; $\Delta\epsilon_r = 0.66$ %; $\Delta\sigma = 2.96$ %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: ES3DV3 - SN3335; ConvF(5.13, 5.13, 5.13); Calibrated: 14 Jan 2021
- Sensor-Surface: 3 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 12 Apr 2021
- Phantom: Twin-SAM V8.0 (30deg probe tilt); Serial: 1945
- Measurement SW: cDASY16.0.0.116

Area Scan (40x90): Interpolated grid: $dx=10$ mm, $dy=15$ mm

Zoom Scan1(30x30x30): Measurement grid: $dx=6$ mm, $dy=6$ mm, $dz=1.5$ mm; Grading Ratio: 1.5; Reference Value = 12.810 V/m; Power Drift = 0.02 dB

Minimum horizontal 3dB distance: 10.7 mm;

Vertical M2/M1 Ratio: 83.9 %;

SAR(1 g) = 10.200 W/kg; SAR(10 g) = 5.280 W/kg

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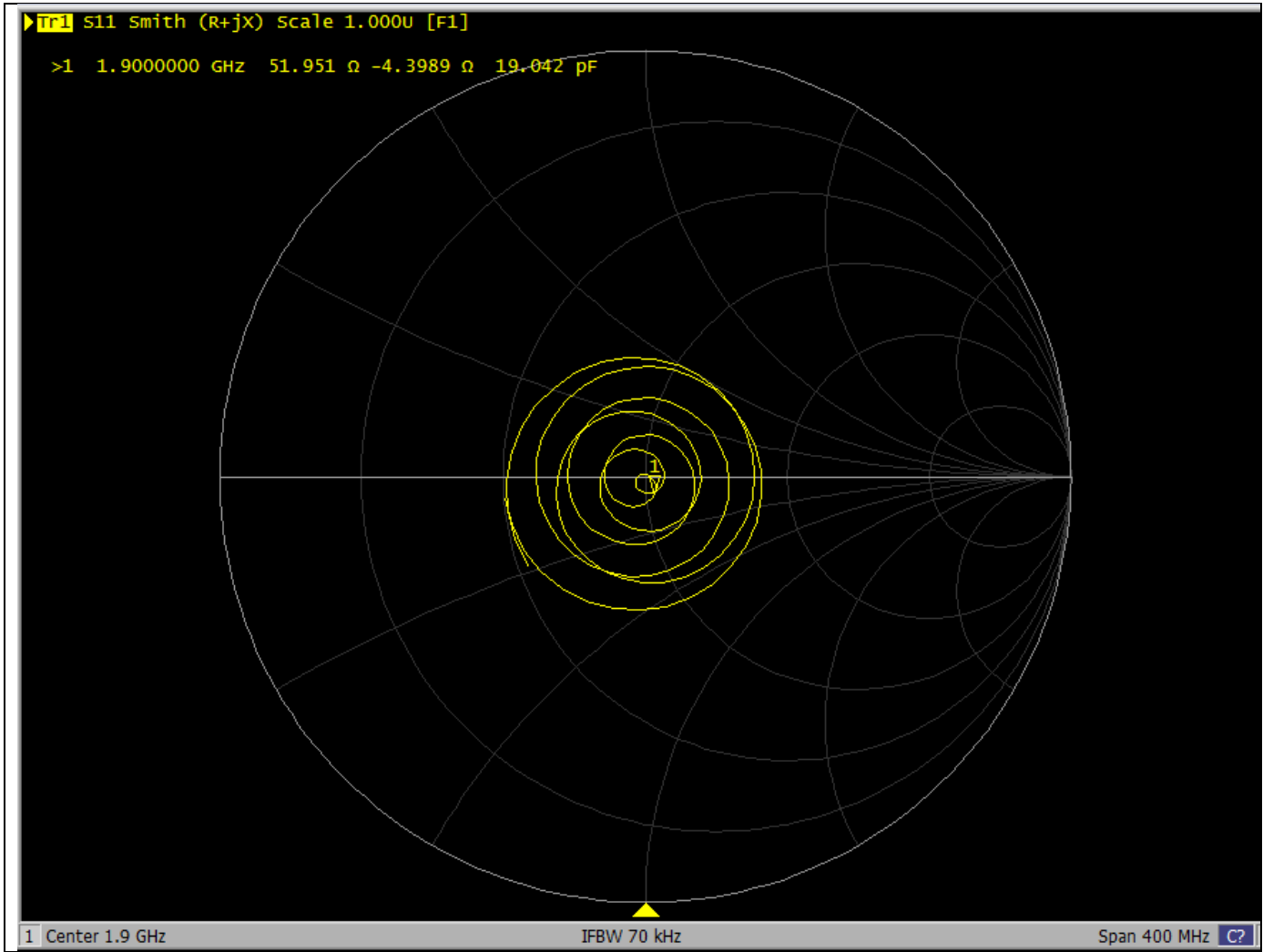
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Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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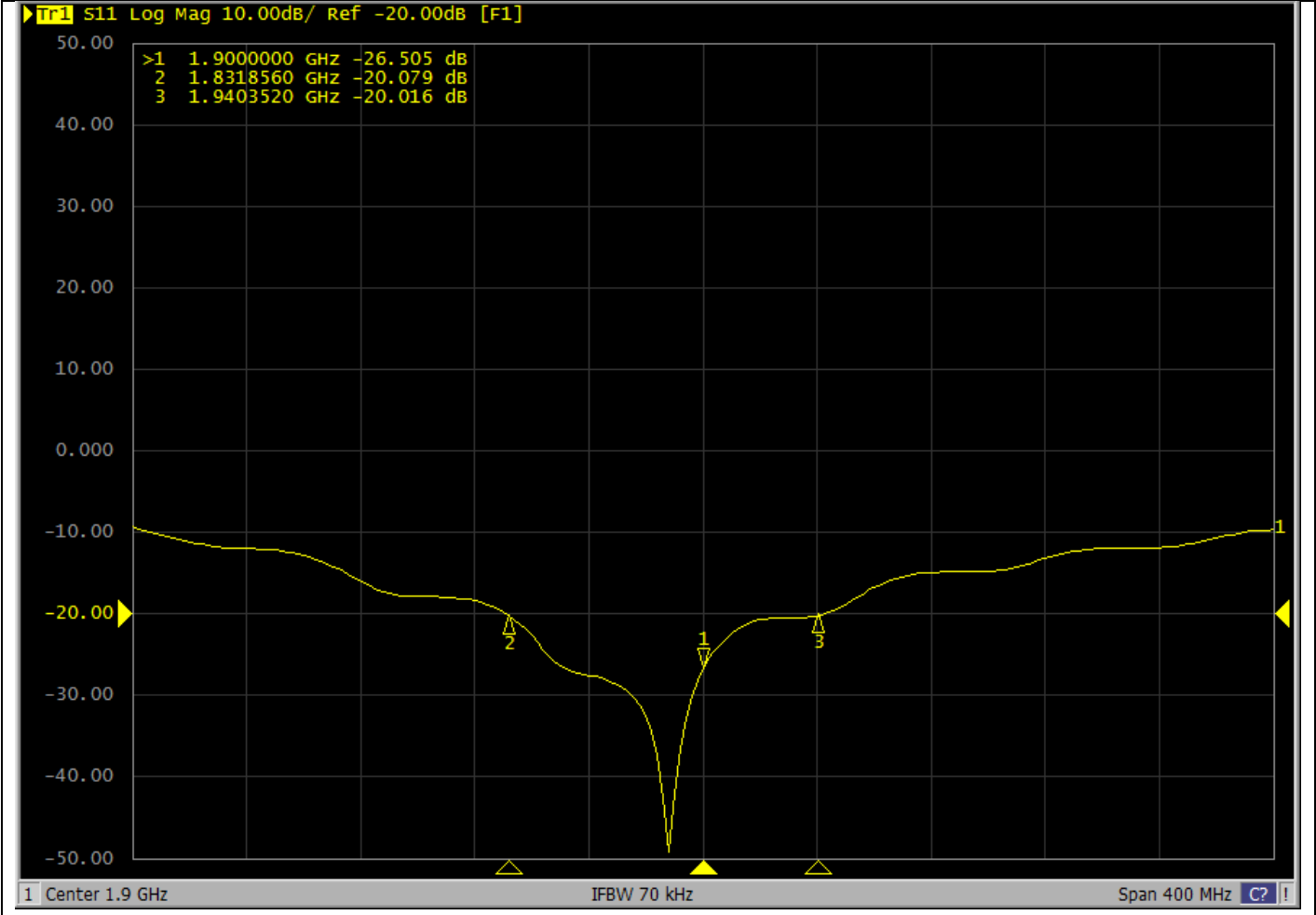
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NUMBER :
13697410JD01E

Page 7 of 10

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



Calibration Certificate Label:

	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697410JD01E Instrument ID: 5d163 Calibration Date: 29/Sep/2021 Calibration Due Date:
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	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697410JD01E Instrument ID: 5d163 Calibration Date: 29/Sep/2021 Calibration Due Date:
---	---

CERTIFICATE OF CALIBRATION

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

DATE OF ISSUE: 13/April/2021 CERTIFICATE NUMBER : 13697411JD01E



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

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 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%

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)
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

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UKAS Accredited Calibration Laboratory No. 5772

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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	ϵ_r	39.20	38.75	± 5%
						σ	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 Ω - 0.17 j Ω	± 0.28 Ω ± 0.044 j Ω
	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/m³; $\Delta\epsilon_r = -1.16$ %; $\Delta\sigma = 1.39$ %; 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

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Impedance Measurement Plot for Head Stimulating Liquid (HSL)

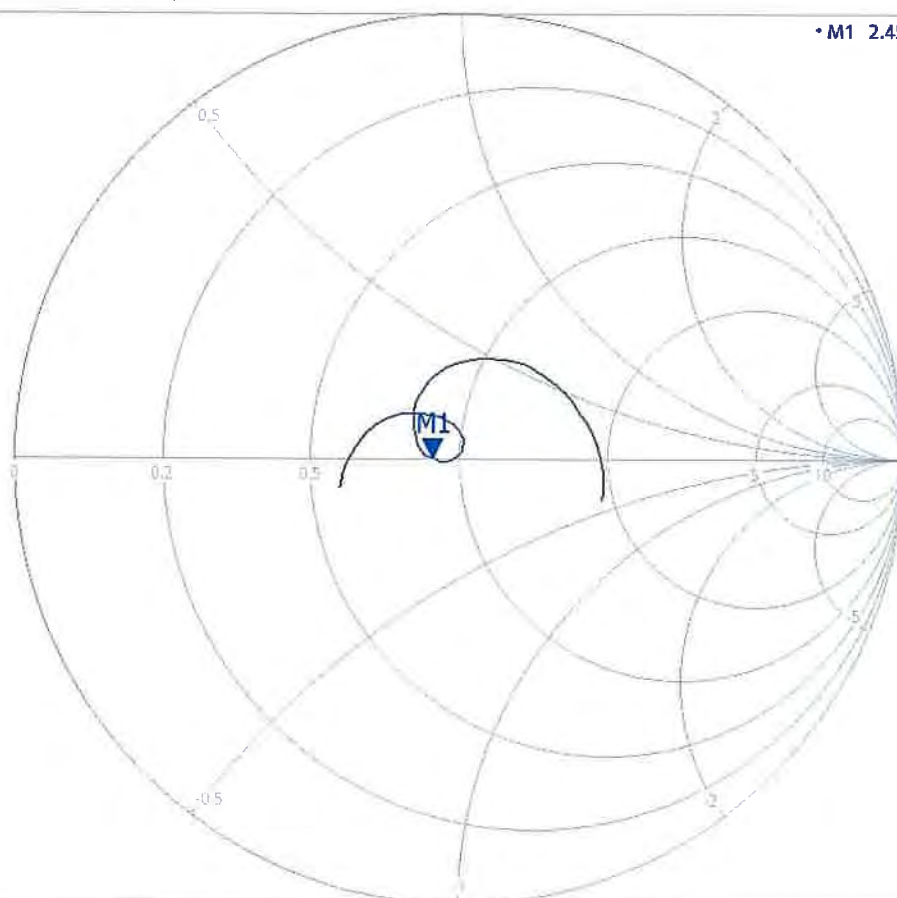


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Trc1 — S11 Smth 200 mU/ Ref 1 U Cal

1

• M1 2.450000 GHz 44.551 Ω
j172.374 m Ω
11.197622 pH



Ch1 Center 2.45 GHz

Pwr -10 dBm Bw 10 kHz

Span 400 MHz

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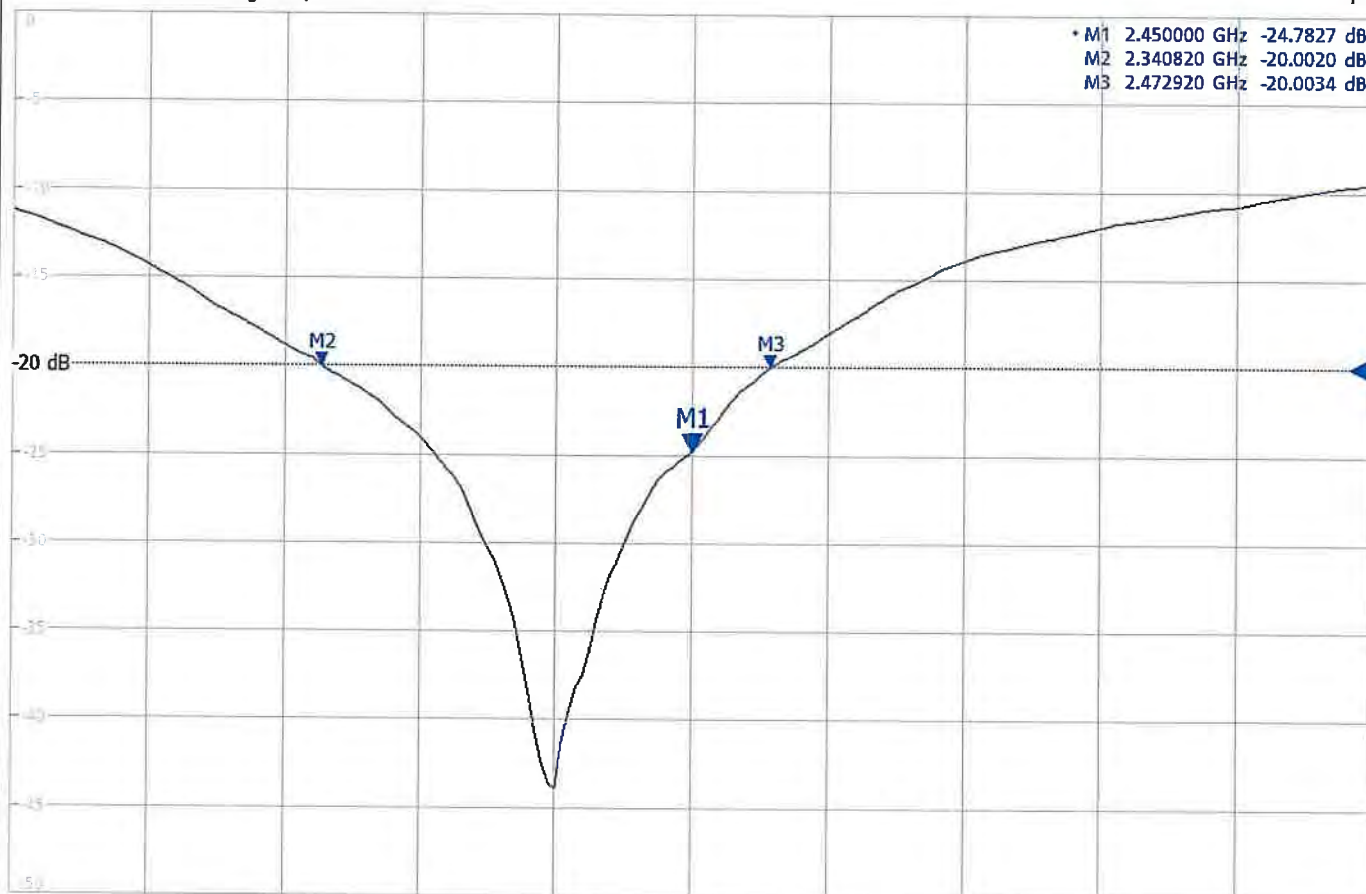
Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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:

 5772	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697411JD01E Instrument ID: 899 Calibration Date: 13/April/2021 Calibration Due Date:
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 5772	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697411JD01E Instrument ID: 899 Calibration Date: 13/April/2021 Calibration Due Date:
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DATE OF ISSUE: 13/April/2021

CERTIFICATE NUMBER : 13697411JD01F



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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

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:	D2600V2		
Serial Number:	1036		
Calibration Date:	13/April/2021		
Calibrated By:	Ravish Foolchund 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%

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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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
PRE0134263	Dipole Antenna	SPEAG	D2600V2	1046	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

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CERTIFICATE
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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:	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	20.0 °C	19.8 °C	19.8°C	19.8°C	ϵ_r	39.00	38.48	± 5%
						σ	1.96	1.94	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	13.90 W/Kg	55.34 W/Kg	+16.80% / -16.43%
	SAR averaged over 10g	6.26 W/Kg	24.92 W/Kg	+16.72% / -16.42%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	52.11 Ω - 4.70 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	-25.95 dB	± 2.97 dB

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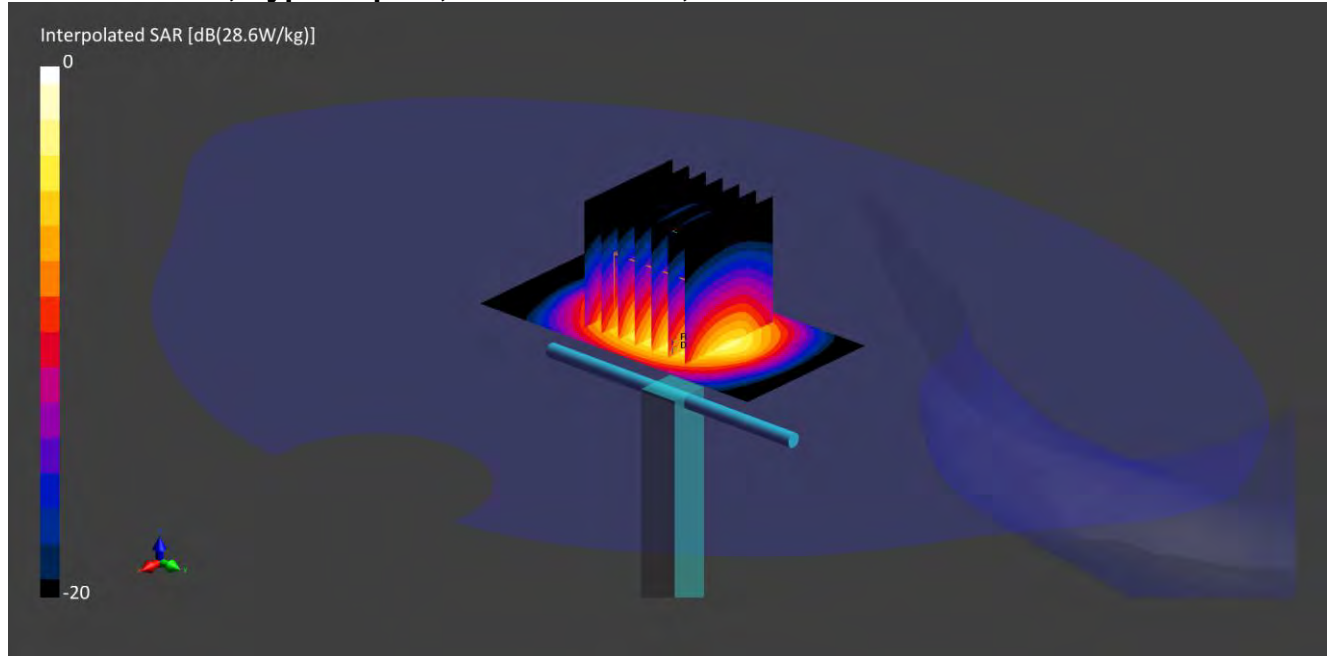
UKAS Accredited Calibration Laboratory No. 5772

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NUMBER :
13697411JD01F

Page 4 of 6

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D2600V2; Type: Dipole; Serial: SN1036;



Communication System: CW UID: 0; Frequency: 2600.0 MHz; Duty Cycle: 1;
Medium: HSL; Site65_12Apr2021_115940_Head - 1750 1800 1900 2300 2450 2600 5%;
Medium parameters used: $f = 2600.0$ MHz; $\sigma = 1.94$ S/m; $\epsilon_r = 38.5$; $\rho = 1000$ kg/m³; $\Delta\epsilon_r = -1.35$ %; $\Delta\sigma = -0.97$ %; No correction

Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: ES3DV3 - SN3335; ConvF(4.44, 4.44, 4.44); 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 = 18.890 V/m; Power Drift = -0.01 dB

Minimum horizontal 3dB distance: 9.0 mm;

Vertical M2/M1 Ratio: 80.7 %;

SAR(1 g) = 13.900 W/kg; SAR(10 g) = 6.260 W/kg

CERTIFICATE OF CALIBRATION

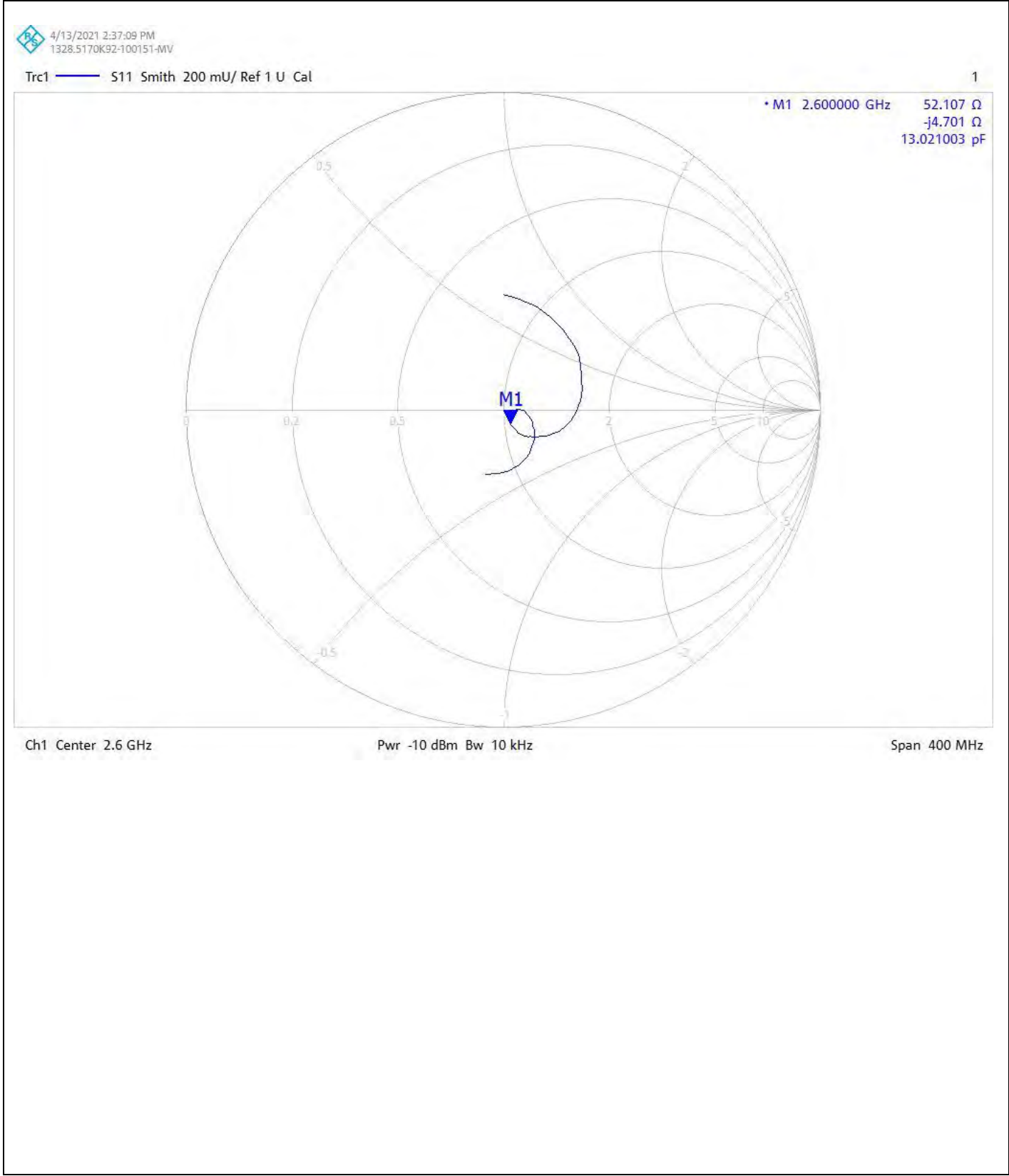
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UKAS Accredited Calibration Laboratory No. 5772

CERTIFICATE
NUMBER :
13697411JD01F

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Impedance Measurement Plot for Head Stimulating Liquid (HSL)



CERTIFICATE OF CALIBRATION

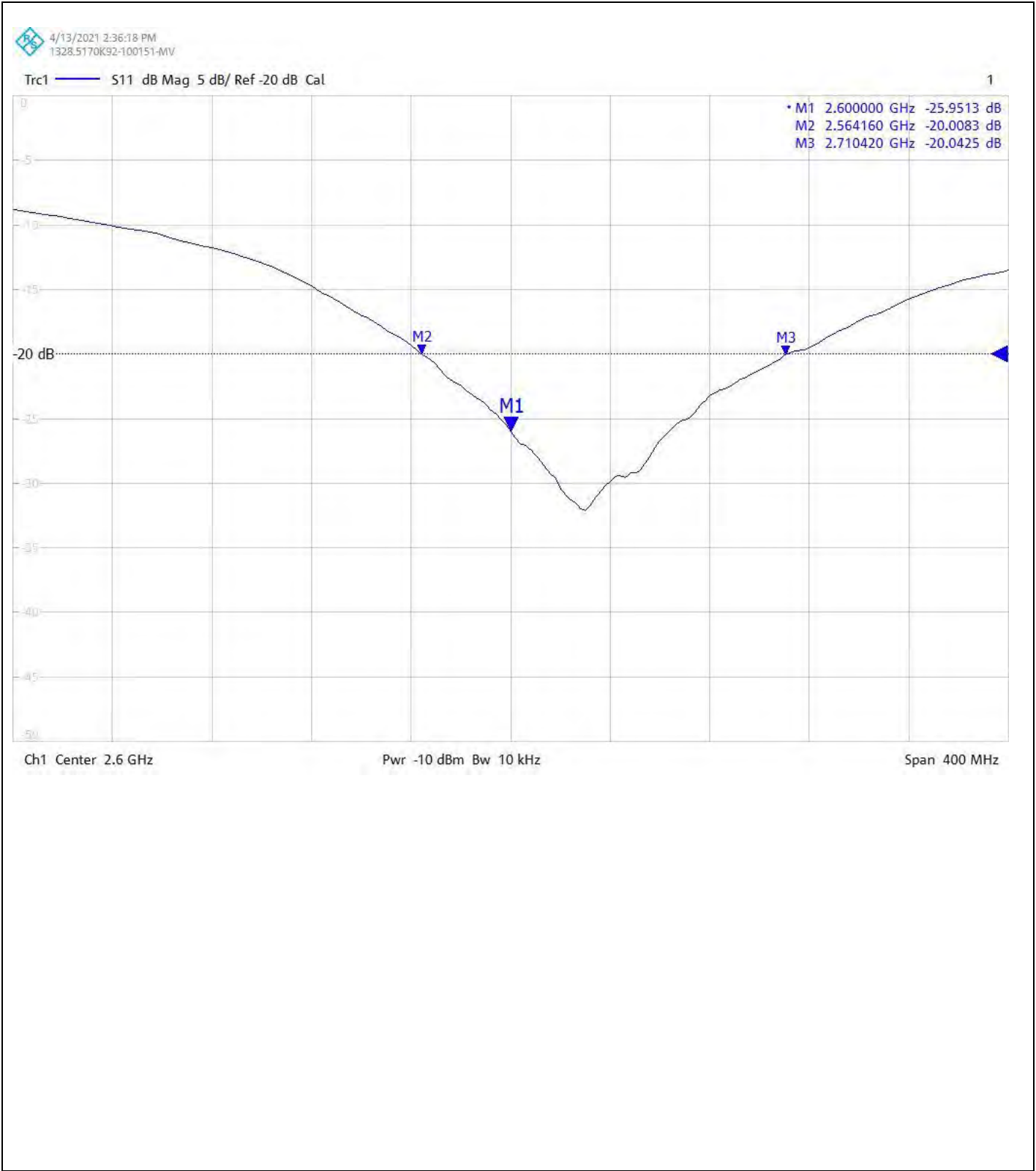
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NUMBER :
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Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



Calibration Certificate Label:

 5772	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697411JD01F Instrument ID: 1036 Calibration Date: 13/April/2021 Calibration Due Date:
 5772	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697411JD01F Instrument ID: 1036 Calibration Date: 13/April/2021 Calibration Due Date:
 5772	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312000 Certificate Number: 13697411JD01F Instrument ID: 1036 Calibration Date: 13/April/2021 Calibration Due Date:



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: **D5GHzV2-1138_Aug21**

CALIBRATION CERTIFICATE

Object **D5GHzV2 - SN:1138**

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

Calibration date: **August 19, 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 $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	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: **Jeton Kastrati** **Laboratory Technician**

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

Issued: August 19, 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:

- IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices - Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- DASY 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 source is mounted in a touch configuration below the center marking of the flat phantom.
- Return Loss:** This parameter is measured with the source positioned under the liquid filled phantom (as described in the measurement condition clause). The Return Loss ensures low reflected power. 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	DASY52	V52.10.4
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5250 MHz $\pm$ 1 MHz 5600 MHz $\pm$ 1 MHz 5800 MHz $\pm$ 1 MHz	

Head TSL parameters at 5250 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.71 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	35.6 $\pm$ 6 %	4.60 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5250 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.95 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.3 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.27 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.6 W/kg $\pm$ 19.5 % (k=2)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 $\pm$ 0.2) °C	35.1 $\pm$ 6 %	4.95 mho/m $\pm$ 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.23 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.0 W/kg $\pm$ 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.2 W/kg $\pm$ 19.5 % (k=2)

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	34.8 ± 6 %	5.16 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.04 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	80.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.26 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.6 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5250 MHz

Impedance, transformed to feed point	50.7 Ω - 6.3 j Ω
Return Loss	- 24.1 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	55.3 Ω - 0.6 j Ω
Return Loss	- 25.9 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	56.1 Ω - 0.6 j Ω
Return Loss	- 24.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 ns
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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; $\sigma = 4.6$ S/m; $\epsilon_r = 35.6$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5600$ MHz; $\sigma = 4.95$ S/m; $\epsilon_r = 35.1$; $\rho = 1000$ kg/m³,

Medium parameters used: $f = 5800$ MHz; $\sigma = 5.16$ S/m; $\epsilon_r = 34.8$; $\rho = 1000$ kg/m³

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: 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(1535); SEMCAD X 14.6.14(7501)

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5250 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 77.71 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 27.0 W/kg

SAR(1 g) = 7.95 W/kg; SAR(10 g) = 2.27 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 70.8%

Maximum value of SAR (measured) = 17.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 77.43 V/m; Power Drift = -0.02 dB

Peak SAR (extrapolated) = 30.4 W/kg

SAR(1 g) = 8.23 W/kg; SAR(10 g) = 2.33 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

Ratio of SAR at M2 to SAR at M1 = 68%

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

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0:

Measurement grid: $dx=4$ mm, $dy=4$ mm, $dz=1.4$ mm

Reference Value = 75.31 V/m; Power Drift = -0.01 dB

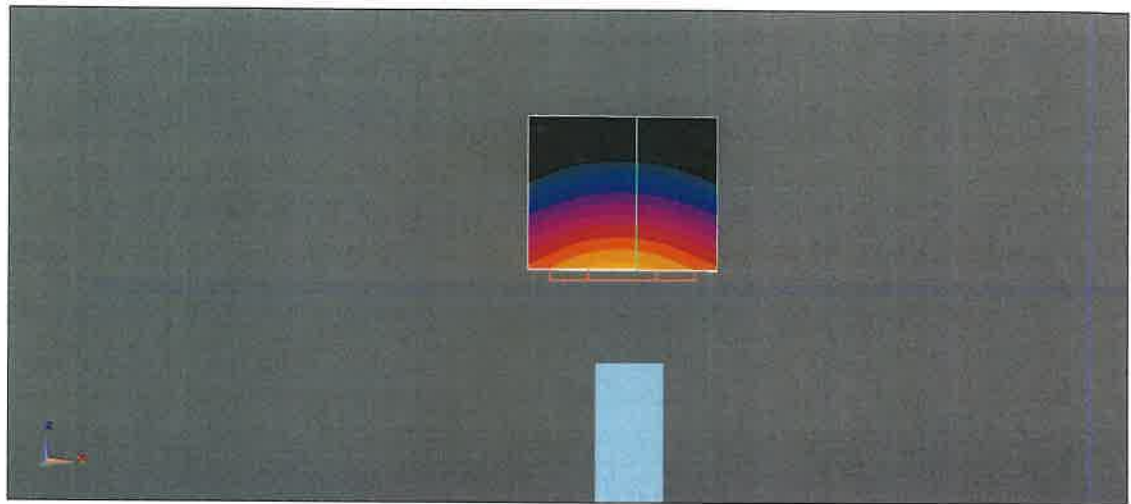
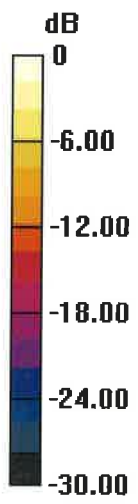
Peak SAR (extrapolated) = 31.5 W/kg

SAR(1 g) = 8.04 W/kg; SAR(10 g) = 2.27 W/kg

Smallest distance from peaks to all points 3 dB below = 7.2 mm

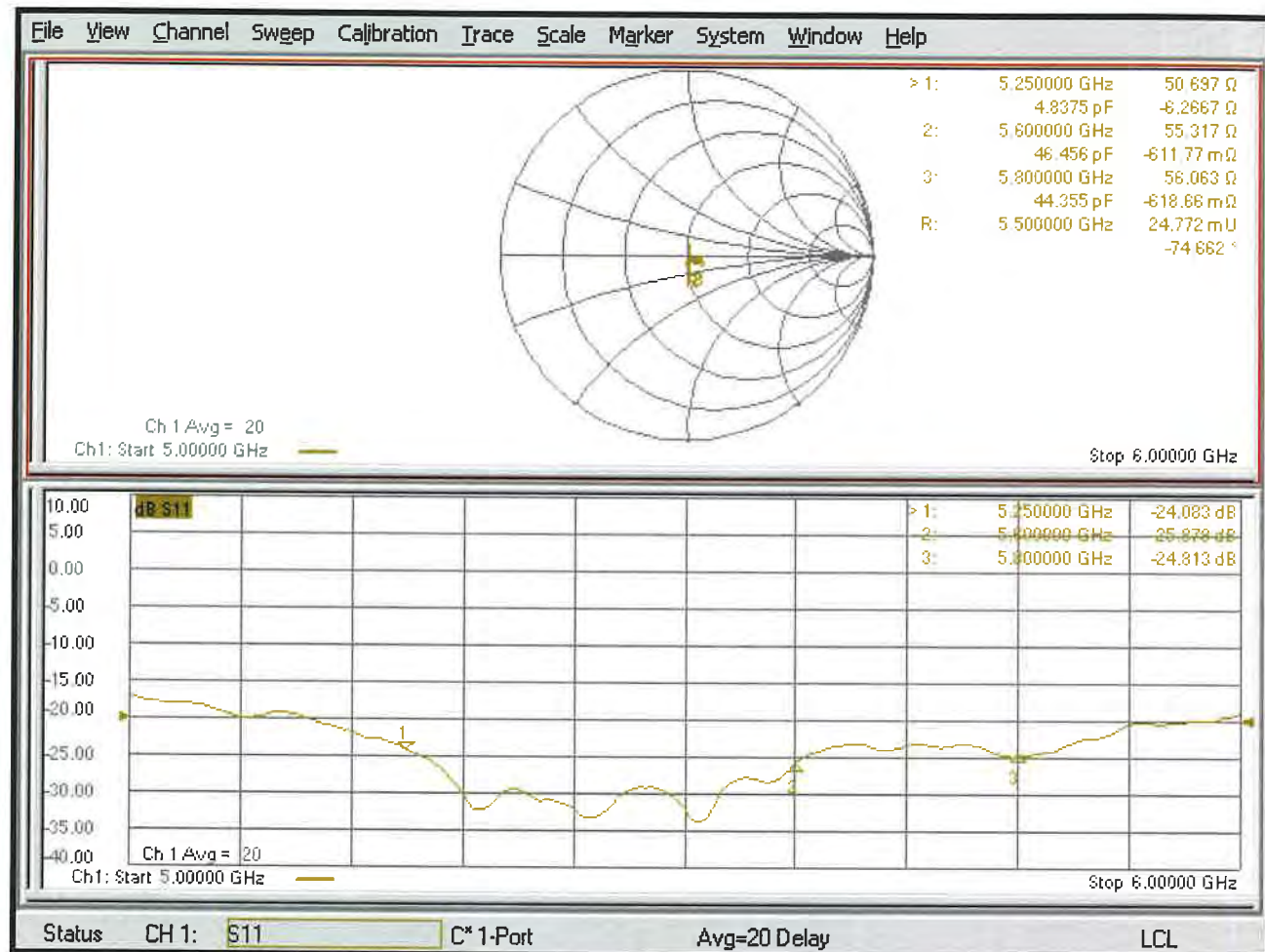
Ratio of SAR at M2 to SAR at M1 = 65.8%

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



0 dB = 17.9 W/kg = 12.52 dBW/kg

Impedance Measurement Plot for Head TSL



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DATE OF ISSUE: 29/Nov/2021

CERTIFICATE NUMBER : 13685241JD01E



5772

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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:	19/Nov/2021
Manufacturer:	SPEAG		
Type/Model Number:	D5GHzV2		
Serial Number:	1168		
Calibration Date:	24/Nov/2021		
Calibrated By:	Masood Khan 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)
PRE0135115	Data Acquisition Electronics	SPEAG	DAE4	1438	12 Apr 2021	12
PRE0178314	Probe	SPEAG	EX3DV4	7496	16 Mar 2021	12
PRE0132081	Dipole	SPEAG	D5GHzV2	SN1016	9 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	22 Mar 2021	12
PRE0151154	Vector Network Analyser	Rhode & Schwarz	ZND 1328.5170K92	100151	23 Mar 2021	12
ULEID212645	Calibration Kit	Rhode & Schwarz	ZN-Z135 (f)	101005	22 Oct 2021	12
PRE0178154	Signal Generator	Rhode & Schwarz	SMB 100A	175325	25 Mar 2021	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:	cDASY16.0.0.116
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	21.2 °C	21 °C	21.1 °C	21 °C	ϵ_r	35.93	35.83	± 5%
						σ	4.71	4.66	± 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	7.36 W/Kg	73.6 W/Kg	+16.77 / -16.70%
	SAR averaged over 10g	2.12 W/Kg	21.2 W/Kg	±16.70%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	60.19 + 3.72j Ω	± 3.01
	Return Loss	20.19	± 2.93

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	21.2 °C	21 °C	21.1 °C	21 °C	ϵ_r	35.53	35.15	± 5%
						σ	5.065	5.059	± 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	8.17 W/Kg	81.7 W/Kg	+16.77 / -16.70%
	SAR averaged over 10g	2.33 W/Kg	23.3 W/Kg	±16.70%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	45.95 + 4.75j Ω	± 3.01
	Return Loss	23.66	± 2.93

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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	21.2 °C	21 °C	21.1 °C	21 °C	ϵ_r	35.36	34.85	± 5%
						σ	5.22	5.23	± 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	7.7 W/Kg	77.0 W/Kg	+16.77 / -16.70%
	SAR averaged over 10g	2.21 W/Kg	22.1 W/Kg	±16.70%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	59.36 – 4.05j Ω	± 3.01
	Return Loss	20.64	± 2.93

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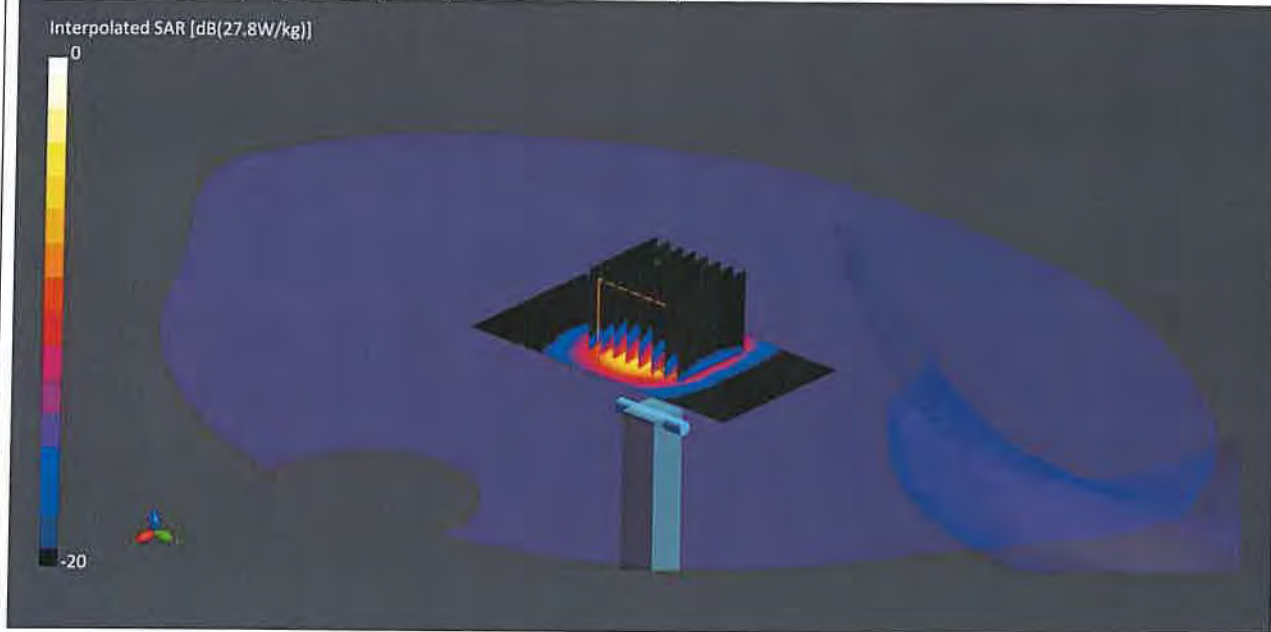
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DASY Validation Scan for Head Stimulating Liquid (HSL)

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



Communication System: CW UID: 0; Frequency: 5250.0 MHz; Duty Cycle: 1;
Medium: HSL; Site65_24Nov2021_001812_Head - 5GHz 5%; Medium parameters used: $f = 5250.0$ MHz; $\sigma = 4.66$ S/m; $\epsilon_r = 35.8$; $\rho = 1000$ kg/m³; $\Delta\epsilon_r = -0.28$ %; $\Delta\sigma = -1.02$ %; No correction
Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(5.24, 5.24, 5.24); Calibrated: 16 Mar 2021
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 12 Apr 2021
- 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 = 11.240 V/m; Power Drift = 0.03 dB

Minimum horizontal 3dB distance: 7.5 mm;

Vertical M2/M1 Ratio: 65.8 %;

SAR(1 g) = 7.360 W/kg; SAR(10 g) = 2.120 W/kg

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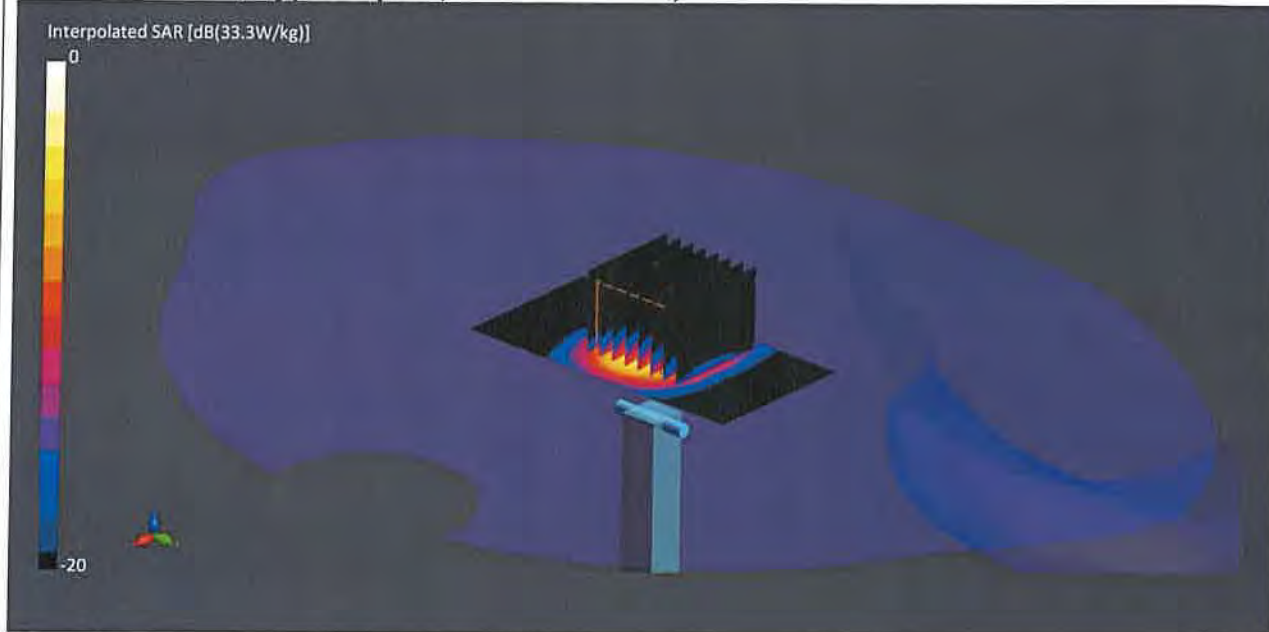
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DASY Validation Scan for Head Stimulating Liquid (HSL)

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



Communication System: CW UID: 0; Frequency: 5600.0 MHz; Duty Cycle: 1;
Medium: HSL; Site65_24Nov2021_001812_Head - 5GHz 5%; Medium parameters used: $f = 5600.0$ MHz; $\sigma = 5.06$ S/m; $\epsilon_r = 35.1$; $\rho = 1000$ kg/m³; $\Delta\epsilon_r = -1.07$ %; $\Delta\sigma = -0.10$ %; No correction
Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(4.7, 4.7, 4.7); Calibrated: 16 Mar 2021
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 12 Apr 2021
- 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 = 12.360 V/m; Power Drift = 0.00 dB

Minimum horizontal 3dB distance: 7.2 mm;

Vertical M2/M1 Ratio: 62.7 %;

SAR(1 g) = 8.170 W/kg; SAR(10 g) = 2.330 W/kg

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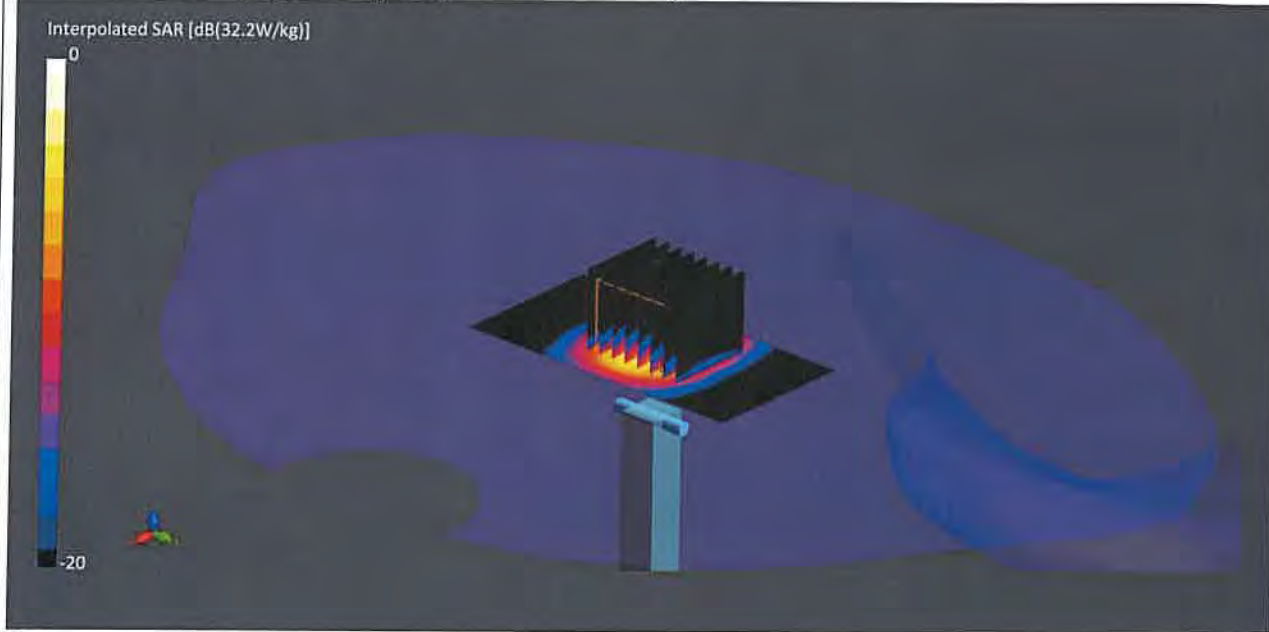
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DASY Validation Scan for Head Stimulating Liquid (HSL)

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



Communication System: CW UID: 0; Frequency: 5750.0 MHz; Duty Cycle: 1;
Medium: HSL; Site65_24Nov2021_001812_Head - 5GHz 5%; Medium parameters used: $f = 5750.0$ MHz; $\sigma = 5.23$ S/m; $\epsilon_r = 34.9$; $\rho = 1000$ kg/m³; $\Delta\epsilon_r = -1.43$ %; $\Delta\sigma = 0.30$ %; No correction
Phantom section: Flat;

DASY 6 Configuration:

- Laboratory Name: Site65;
- Probe: EX3DV4 - SN7496; ConvF(4.79, 4.79, 4.79); Calibrated: 16 Mar 2021
- Sensor-Surface: 1.4 mm; VMS + 6p
- Electronics: DAE4 - SN1438; Calibrated: 12 Apr 2021
- 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 = 11.980 V/m; Power Drift = -0.01 dB

Minimum horizontal 3dB distance: 7.5 mm;

Vertical M2/M1 Ratio: 61.8 %;

SAR(1 g) = 7.700 W/kg; SAR(10 g) = 2.210 W/kg

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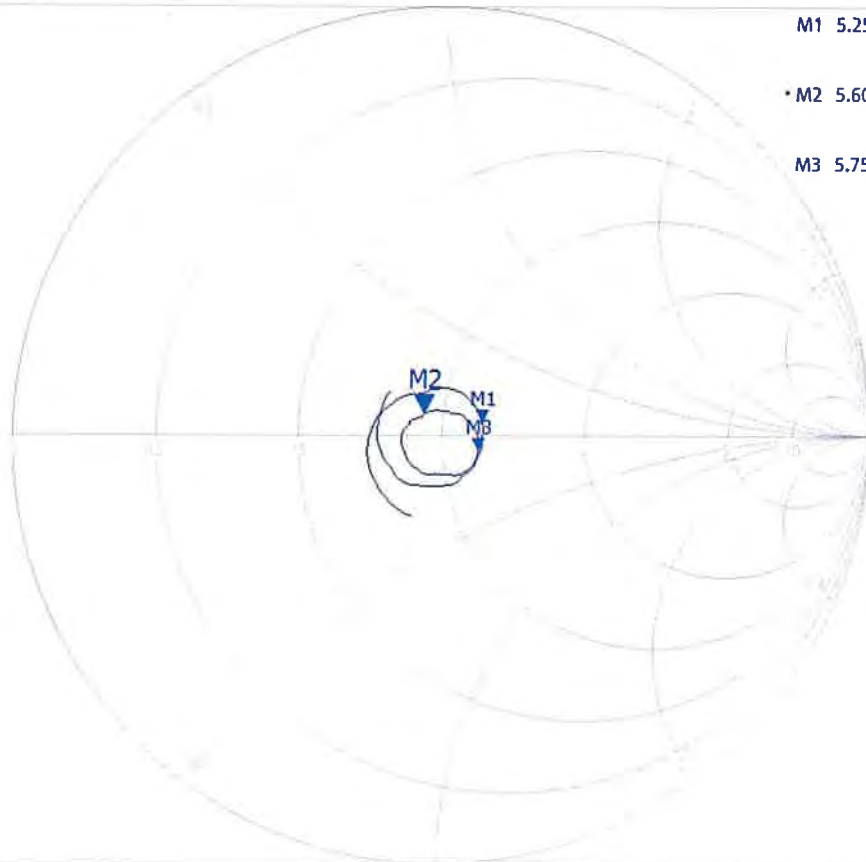
Impedance Measurement Plot for Head Stimulating Liquid (HSL)

11/24/2021 4:56:54 PM
1328.5170K92-100151-MV

Trc1 — S11 Smith 200 mU/ Ref 1 U Cal

1

M1	5.250000 GHz	60.187 Ω
		j3.721 Ω
		112.791042 pH
M2	5.600000 GHz	45.953 Ω
		j4.753 Ω
		135.083706 pH
M3	5.750000 GHz	59.361 Ω
		-j4.048 Ω
		6.837654 pF



Ch1 Start 5 GHz

Pwr -10 dBm Bw 10 kHz

Stop 6 GHz

CERTIFICATE OF CALIBRATION

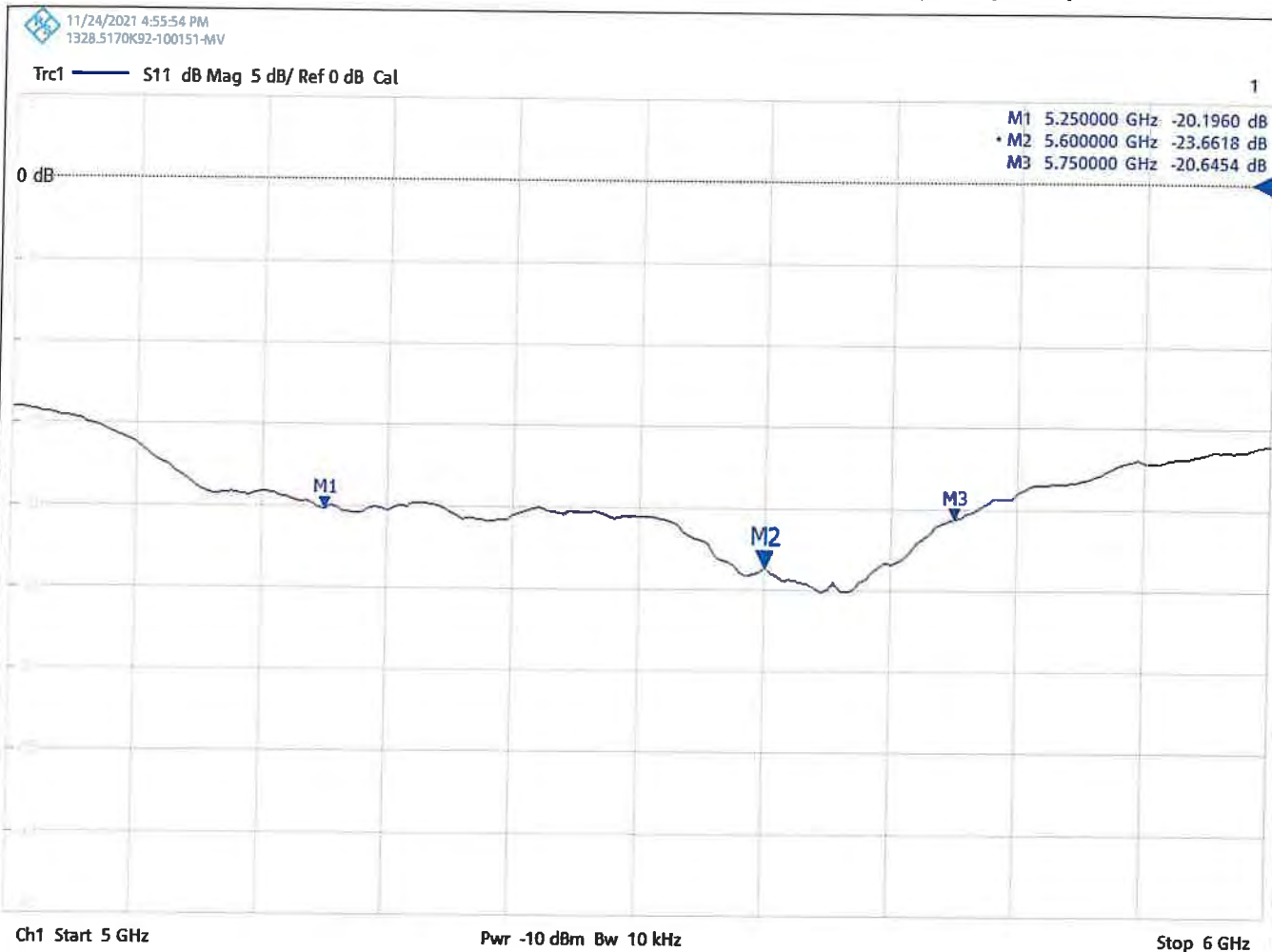
ISSUED BY UL INTERNATIONAL (UK) LTD

UKAS Accredited Calibration Laboratory No. 5772

CERTIFICATE
NUMBER :
13685241JD01E

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Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



Calibration Certificate Label:

	UL INTERNATIONAL (UK) LTD Tel: +44 (0) 1256312100 Certificate Number: 13685241JD01E Instrument ID: 1168 Calibration Date: 24/Nov/2021 Calibration Due Date:
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