

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 10/Oct/2017

CERTIFICATE NUMBER : 11903941JD01A



5248

UL VS LTD
PAVILION A
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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:	29/Sep/2017
Manufacturer:	Speag		
Type/Model Number:	D900V2		
Serial Number:	1d143		
Calibration Date:	05/Oct/2017		
Calibrated By:	Chanthu Thevarajah Laboratory Engineer		

Signature:

.....

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

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

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The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2005**: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
2. **IEC 62209-2:2010**: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)
3. **IEEE 1528: 2013**: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques
4. FCC KDB Publication Number: "KDB865664 D01 SAR Measurement 100 MHz to 6 GHz"
5. **SPEAG DASY4/ DASY5 System Handbook**

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2546	Data Acquisition Electronics	SPEAG	DAE4	1435	10 Feb 2017	12
A2110	Data Acquisition Electronics	SPEAG	DAE4	431	18 Nov 2016	12
A2587	Probe	SPEAG	ES3DV3	3341	14 Aug 2017	12
A2201	Dipole	SPEAG	D900V2	035	14 Feb 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
PRE0151441	Power Sensor	Rhode & Schwarz	NRP8S	102481	16 Nov 2016	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	22 Nov 2016	12
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	02 Dec 2016	12
M1908	Signal Generator	Rhode & Schwarz	SMIQ 03B	1125.555.03	08 Nov 2016	12

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SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F14/5T5ZA1/A/01
DASY Version:	DASY 52 (v52.8.8.1258)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	15 mm (with spacer)
Frequency:	900 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	900	23.0 °C	22.0 °C	20.0°C	22.0°C	ϵ_r	41.50	41.34	± 5%
						σ	0.97	0.93	± 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	2.58 W/Kg	10.27 W/Kg	± 17.57%
	SAR averaged over 10g	1.66 W/Kg	6.60 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	51.089 Ω 1.01 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	30.67	± 2.03 dB

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Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	900	22.0 °C	22.0 °C	22.0°C	22.0°C	ϵ_r	55.00	53.32	± 5%
						σ	1.05	1.02	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	2.75 W/Kg	10.94 W/Kg	± 18.06%
	SAR averaged over 10g	1.79 W/Kg	7.12 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	54.09 Ω 2.03 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	25.35	± 2.03 dB

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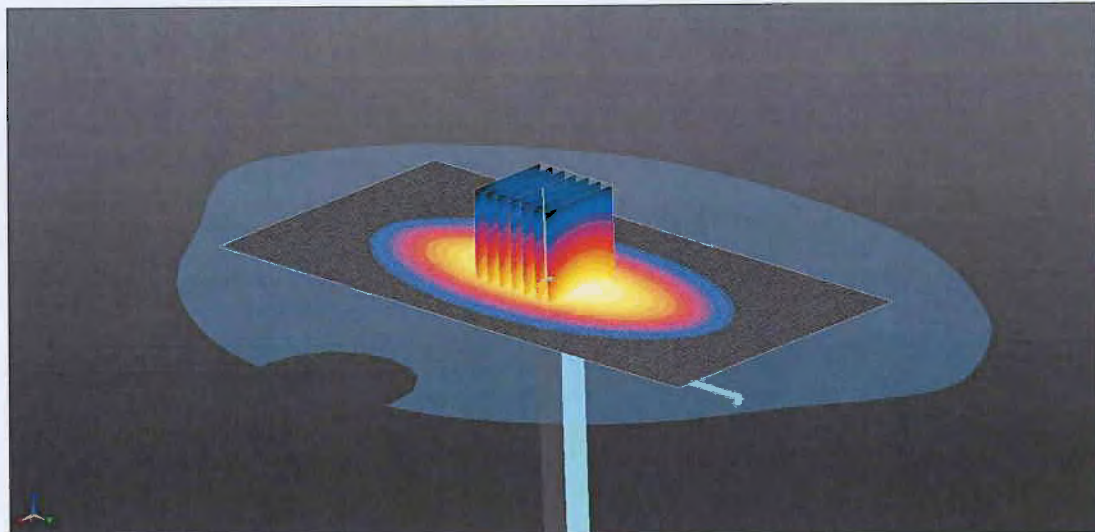
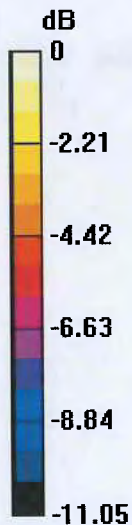
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DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: Dipole 900 MHz; SN: 1d143; Type: D900V2; Serial: SN1d143



0 dB = 3.02 W/kg = 4.80 dBW/kg

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

Medium: 900 MHz HSL Medium parameters used: $f = 900$ MHz; $\sigma = 0.934$ S/m; $\epsilon_r = 41.343$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(6.32, 6.32, 6.32); Calibrated: 14/08/2017;

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

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

- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx

- ; SEMCAD X Version 14.6.10 (7372)

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

Maximum value of SAR (interpolated) = 3.03 W/kg

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

Reference Value = 58.75 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 3.90 W/kg

SAR(1 g) = 2.58 W/kg; SAR(10 g) = 1.66 W/kg

Maximum value of SAR (measured) = 3.02 W/kg

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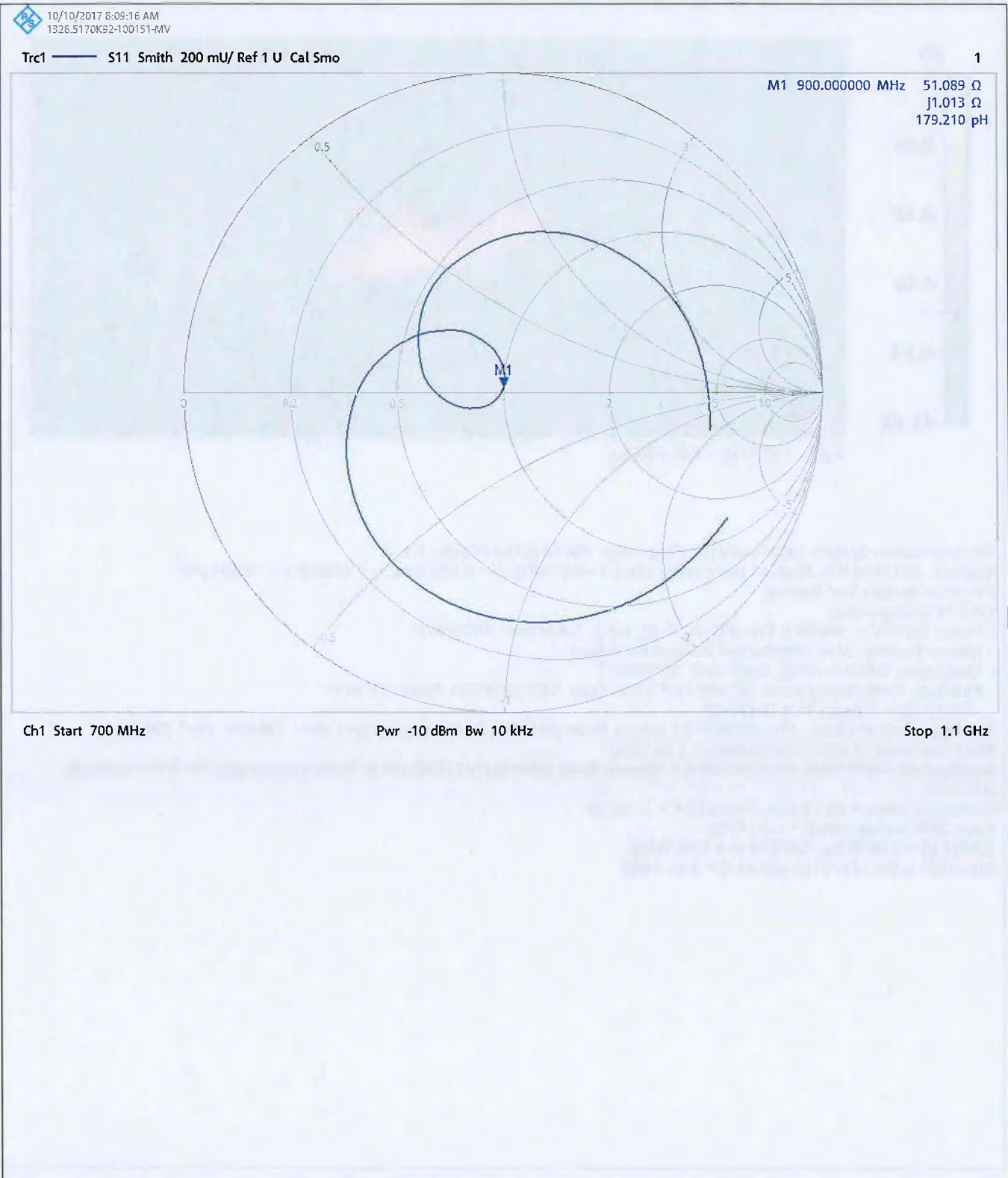
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Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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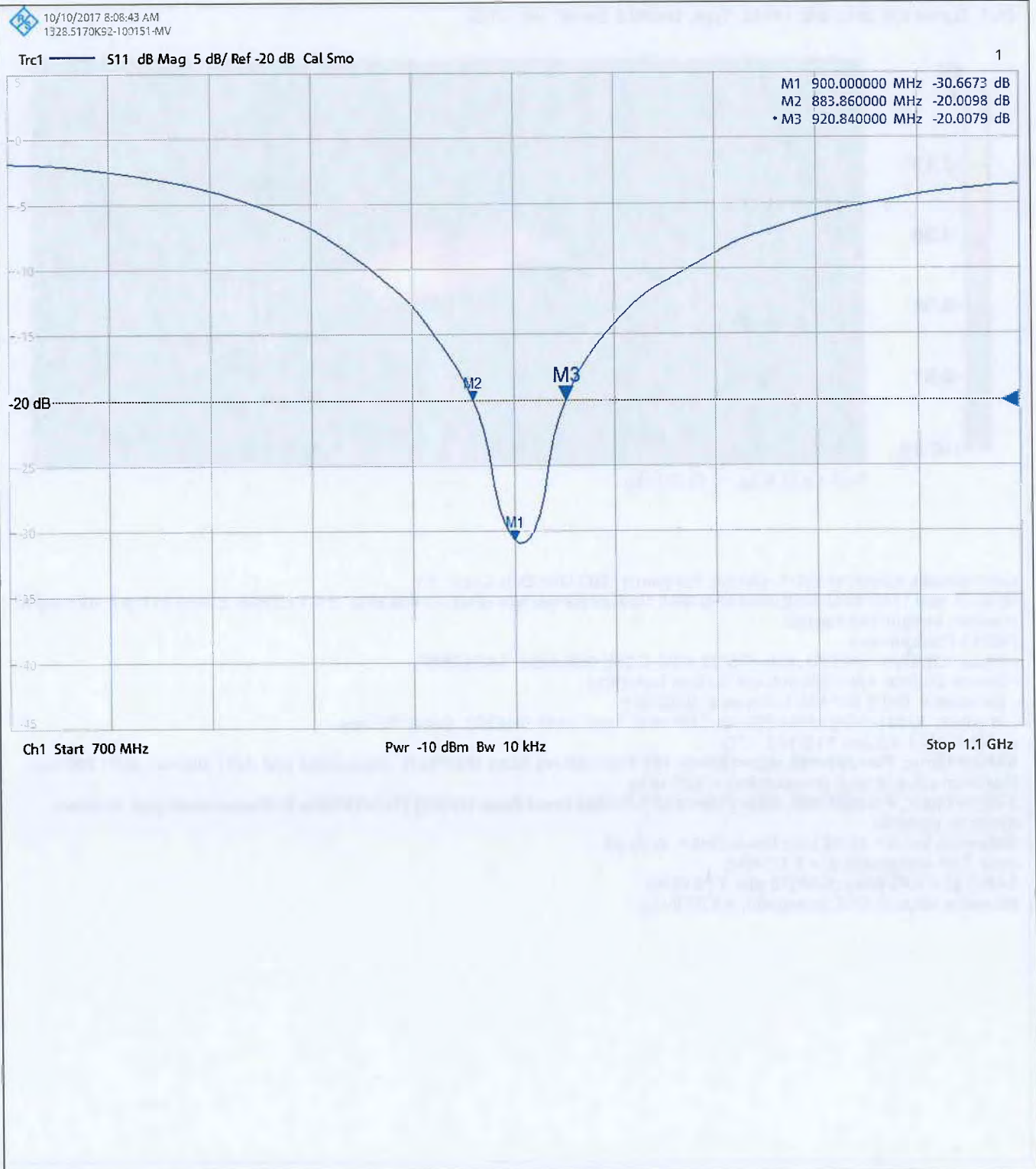
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Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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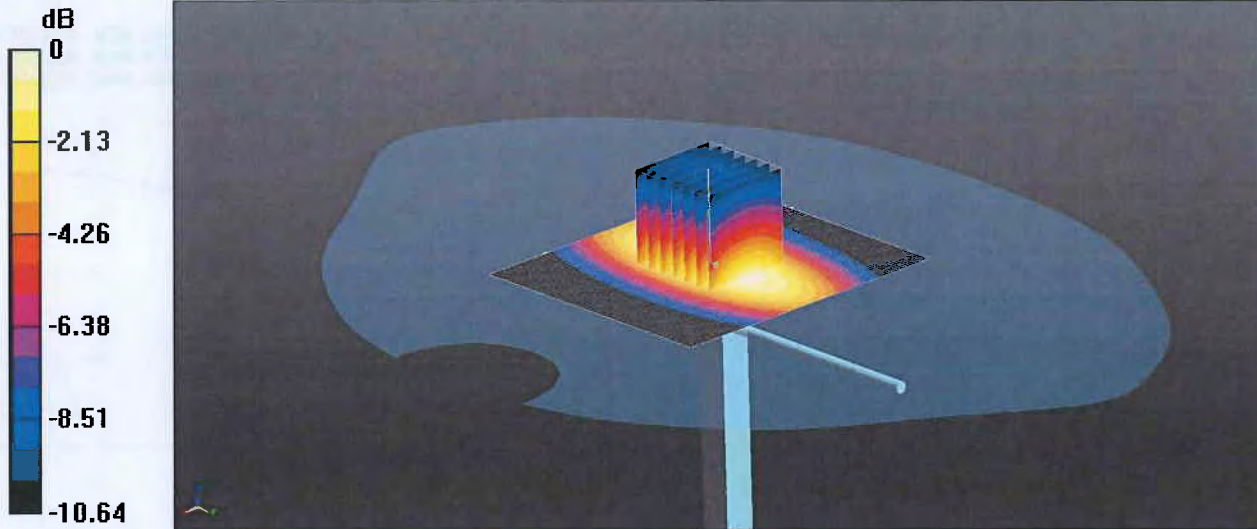
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DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 900 MHz; SN: 1d143; Type: D900V2; Serial: SN 1d143



0 dB = 2.97 W/kg = 4.73 dBW/kg

Communication System: UID 0, CW (0); Frequency: 900 MHz; Duty Cycle: 1:1
Medium: 900, 1750, 1800, 1900, 2600 MHz MSL Medium parameters used: $f = 900$ MHz; $\sigma = 1.02$ S/m; $\epsilon_r = 53.317$; $\rho = 1000$ kg/m³
Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(6.24, 6.24, 6.24); Calibrated: 14/08/2017;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

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

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

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

Reference Value = 55.18 V/m; Power Drift = -0.10 dB

Peak SAR (extrapolated) = 4.12 W/kg

SAR(1 g) = 2.75 W/kg; SAR(10 g) = 1.79 W/kg

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

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Impedance Measurement Plot for Body Stimulating Liquid (MSL)

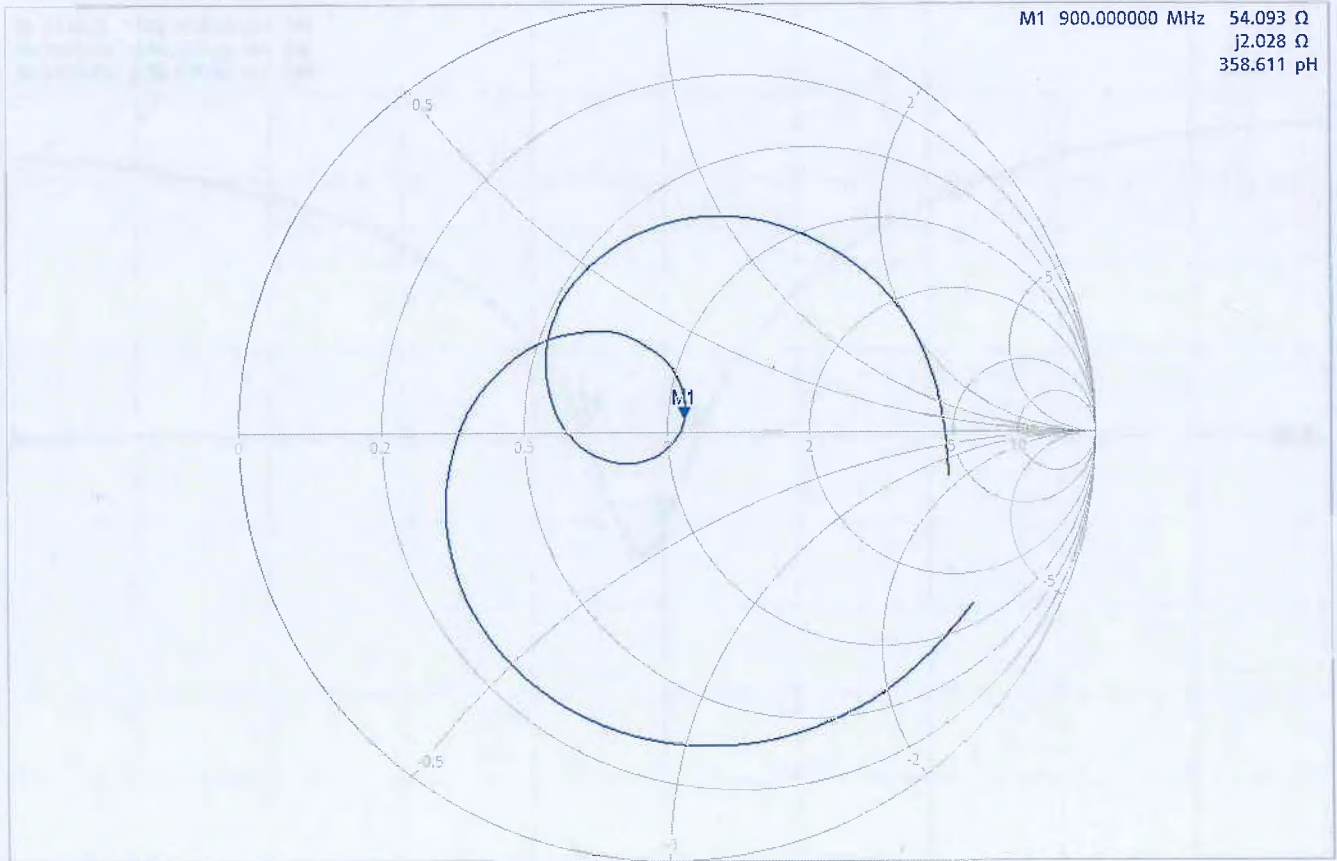


10/9/2017 2:34:21 PM
1328.5170K92-100151-MV

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

1

M1 900.000000 MHz 54.093 Ω
j2.028 Ω
358.611 pF



Ch1 Start 700 MHz

Pwr -10 dBm Bw 10 kHz

Stop 1.1 GHz

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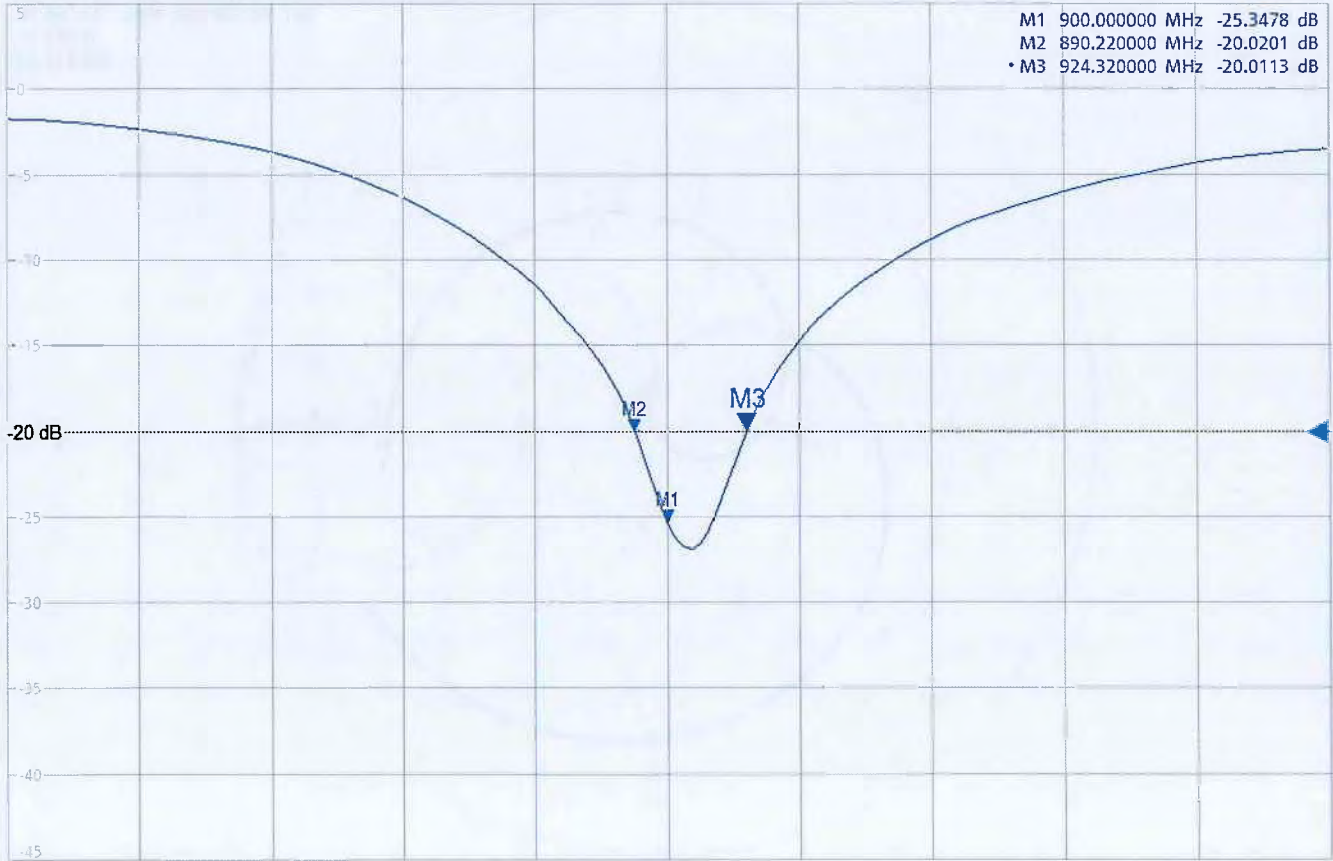
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Return Loss Measurement Plot for Body Stimulating Liquid (MSL)

10/9/2017 2:33:24 PM
1328.5170K92-100151-MV

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

1




Ch1 Start 700 MHz


Pwr -10 dBm Bw 10 kHz

Stop 1.1 GHz

Calibration Certificate Label:

	<p>UL VS LTD - Tel: +44 (0) 1256312000</p> <p>Certificate Number: 11903941JD01A</p> <p>Instrument ID: 1d143</p> <p>Calibration Date: 05/Oct/2017</p> <p>Calibration Due Date:</p>
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	<p>UL VS LTD - Tel: +44 (0) 1256312000</p> <p>Certificate Number: 11903941JD01A</p> <p>Instrument ID: 1d143</p> <p>Calibration Date: 05/Oct/2017</p> <p>Calibration Due Date:</p>
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	<p>UL VS LTD - Tel: +44 (0) 1256312000</p> <p>Certificate Number: 11903941JD01A</p> <p>Instrument ID: 1d143</p> <p>Calibration Date: 05/Oct/2017</p> <p>Calibration Due Date:</p>
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DATE OF ISSUE: 10/Oct/2017

CERTIFICATE NUMBER : 11903941JD01D



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APPROVED SIGNATORY

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Naseer Mirza

Customer :

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	29/Sep/2017
Manufacturer:	Speag		
Type/Model Number:	D1900V2		
Serial Number:	5d163		
Calibration Date:	05/Oct/2017		
Calibrated By:	Chanthu Thevarajah Laboratory Engineer		

Signature:

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

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

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The calibration methods and procedures used were as detailed in:

1. **IEC 62209-1:2005**: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
2. **IEC 62209-2:2010**: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)
3. **IEEE 1528: 2013**: IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques
4. FCC KDB Publication Number: **"KDB865664 D01 SAR Measurement 100 MHz to 6 GHz"**
5. **SPEAG DASY4/ DASY5 System Handbook**

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2546	Data Acquisition Electronics	SPEAG	DAE4	1435	10 Feb 2017	12
A2587	Probe	SPEAG	ES3DV3	3341	14 Aug 2017	12
A2200	Dipole	SPEAG	D1900V2	537	09 Feb 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
PRE0151441	Power Sensor	Rhode & Schwarz	NRP8S	102481	16 Nov 2016	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	26 Sept 2016	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	22 Nov 2016	12
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	02 Dec 2016	12
M1908	Signal Generator	Rhode & Schwarz	SMIQ 03B	1125.555.03	08 Nov 2016	12

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SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F14/5T5ZA1/A/01
DASY Version:	DASY 52 (v52.8.8.1258)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	10 mm (with spacer)
Frequency:	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	23.0 °C	22.0 °C	21.0°C	22.0°C	ϵ_r	40.00	39.71	± 5%
						σ	1.40	1.36	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	9.74 W/Kg	38.77 W/Kg	± 17.57%
	SAR averaged over 10g	5.05 W/Kg	20.10 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	50.143 Ω -3.33 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	29.77	± 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	1900	22.0 °C	22.0 °C	22.0°C	22.0°C	ϵ_r	53.30	52.22	± 5%
						σ	1.52	1.57	± 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	10.80 W/Kg	42.99 W/Kg	± 18.06%
	SAR averaged over 10g	5.52 W/Kg	21.97 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	52.90 Ω -5.74 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	24.03	± 2.03 dB

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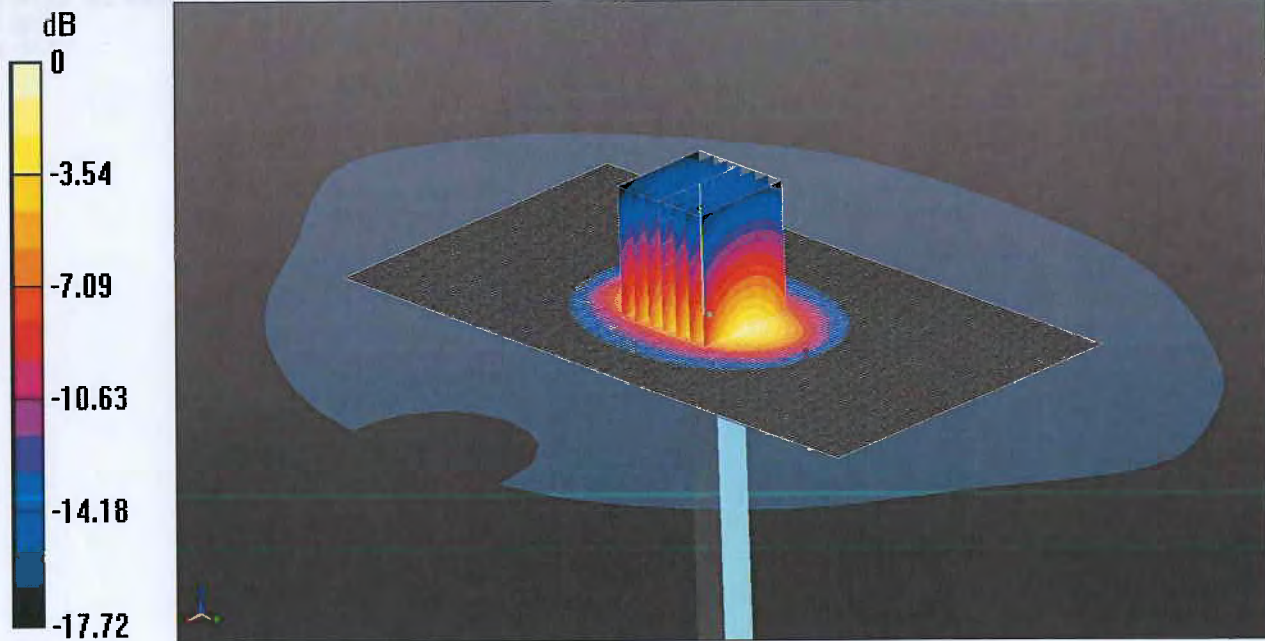
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DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1900V2 - SN5d163; Type: D1900V2; Serial: SN5d163



0 dB = 12.3 W/kg = 10.90 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1900 MHz; Duty Cycle: 1:1

Medium: 1900 MHz HSL Medium parameters used: $f = 1900$ MHz; $\sigma = 1.36$ S/m; $\epsilon_r = 39.711$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(5.28, 5.28, 5.28); Calibrated: 14/08/2017;

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

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

- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx

- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW 2/Area Scan (81x151x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 12.7 W/kg

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

Reference Value = 98.37 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 17.9 W/kg

SAR(1 g) = 9.74 W/kg; SAR(10 g) = 5.05 W/kg

Maximum value of SAR (measured) = 12.3 W/kg

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Impedance Measurement Plot for Head Stimulating Liquid (HSL)

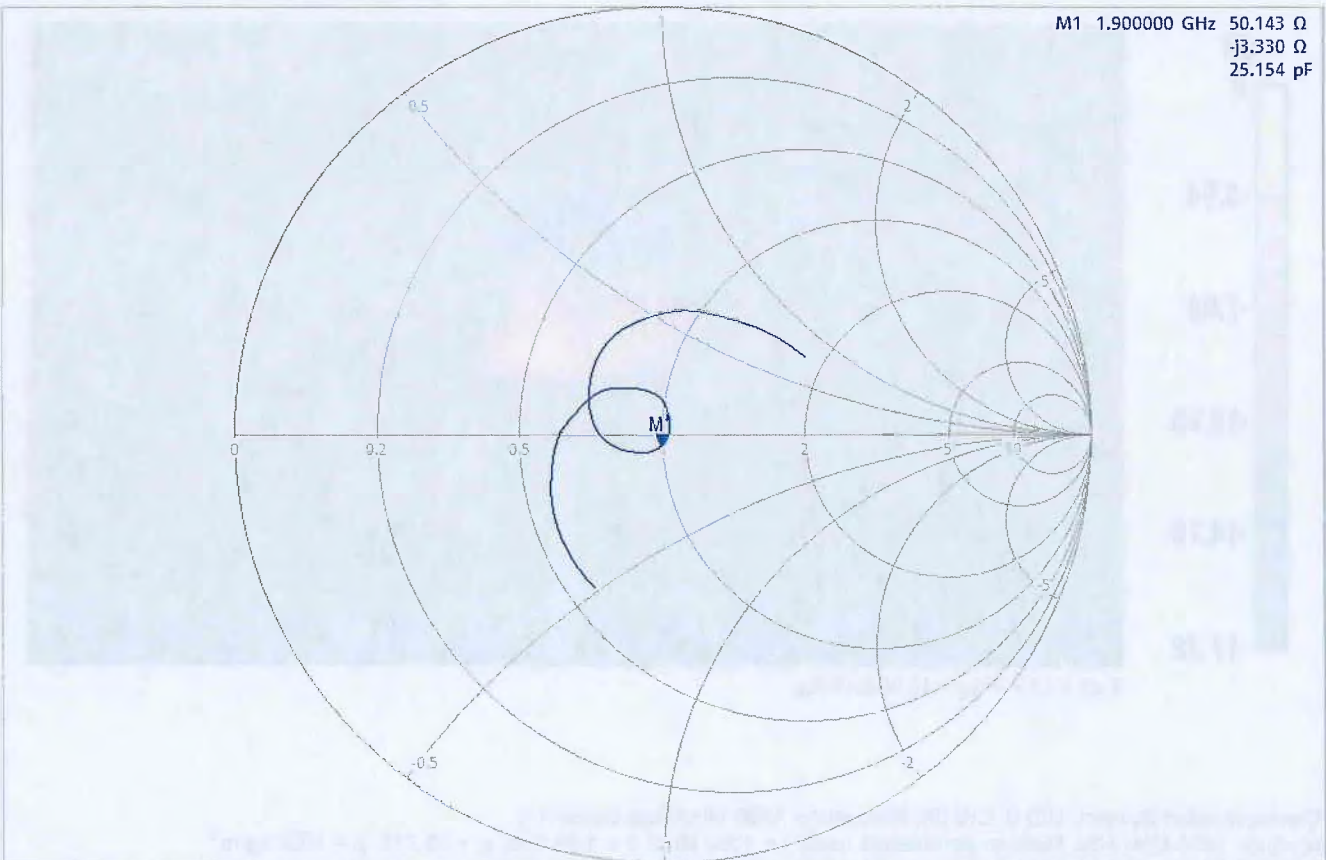


10/10/2017 1:00:08 PM
1325.5170K92-100151-MV

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

1

M1 1.900000 GHz 50.143 Ω
-j3.330 Ω
25.154 pF



Ch1 Start 1.7 GHz

Pwr -10 dBm Bw 10 kHz

Stop 2.1 GHz

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Return Loss Measurement Plot for Head Stimulating Liquid (HSL)

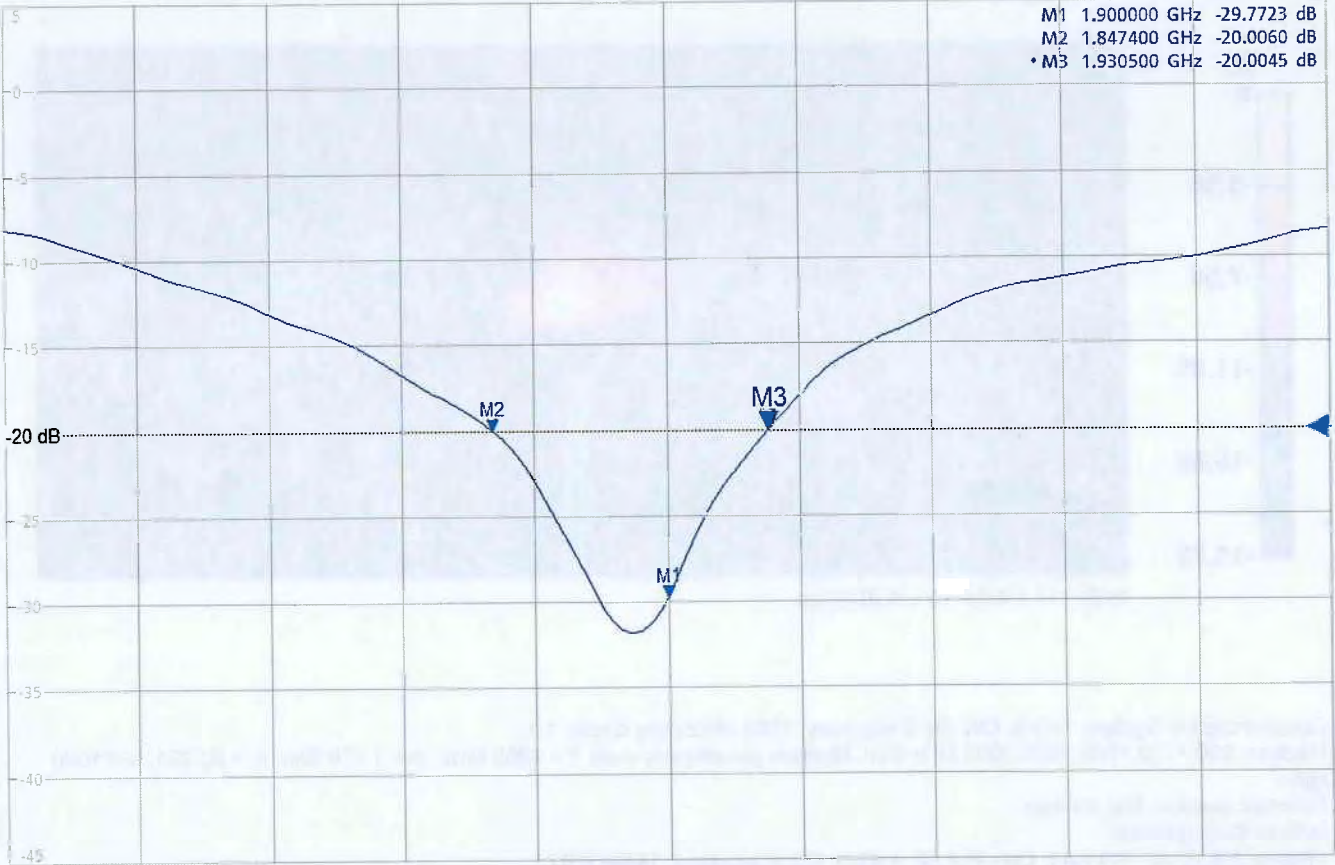


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1328.5170K92-100151-MV

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

1

M1	1.900000 GHz	-29.7723 dB
M2	1.847400 GHz	-20.0060 dB
M3	1.930500 GHz	-20.0045 dB



Ch1 Start 1.7 GHz

Pwr -10 dBm Bw 10 kHz

Stop 2.1 GHz

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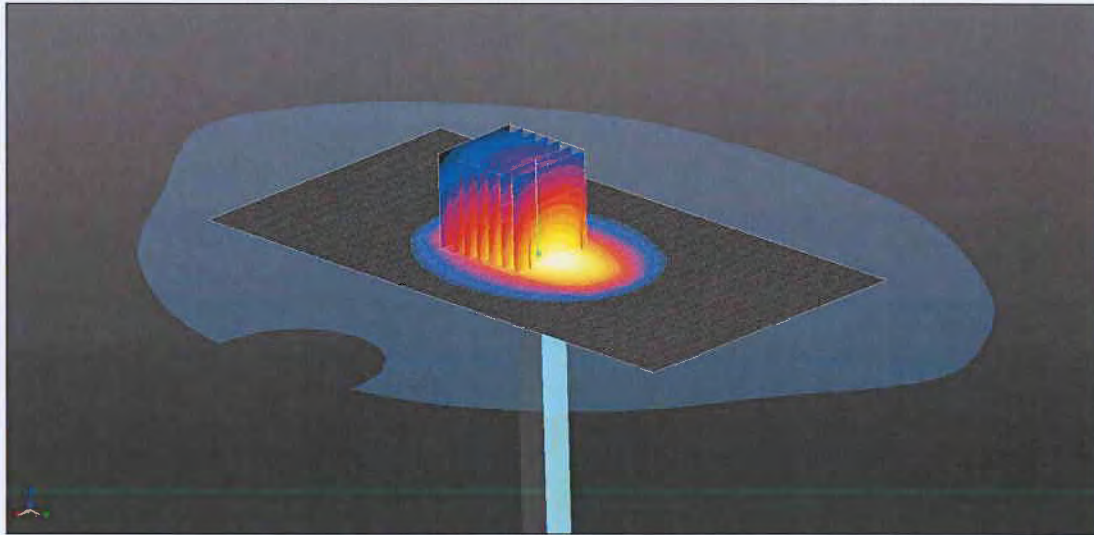
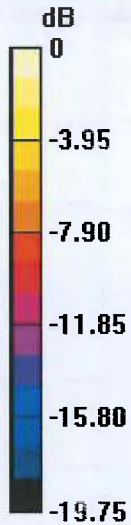
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DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: SN5d163



0 dB = 13.5 W/kg = 11.30 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1900 MHz; Duty Cycle: 1:1

Medium: 900,1750,1800,1900,2600 MHz MSL Medium parameters used: $f = 1900$ MHz; $\sigma = 1.576$ S/m; $\epsilon_r = 52.221$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(4.92, 4.92, 4.92); Calibrated: 14/08/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

SAR/d=10mm, Pin=250mW 2/Area Scan (81x151x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 14.3 W/kg

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

Reference Value = 97.36 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 19.5 W/kg

SAR(1 g) = 10.8 W/kg; SAR(10 g) = 5.52 W/kg

Maximum value of SAR (measured) = 13.5 W/kg

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Impedance Measurement Plot for Body Stimulating Liquid (MSL)

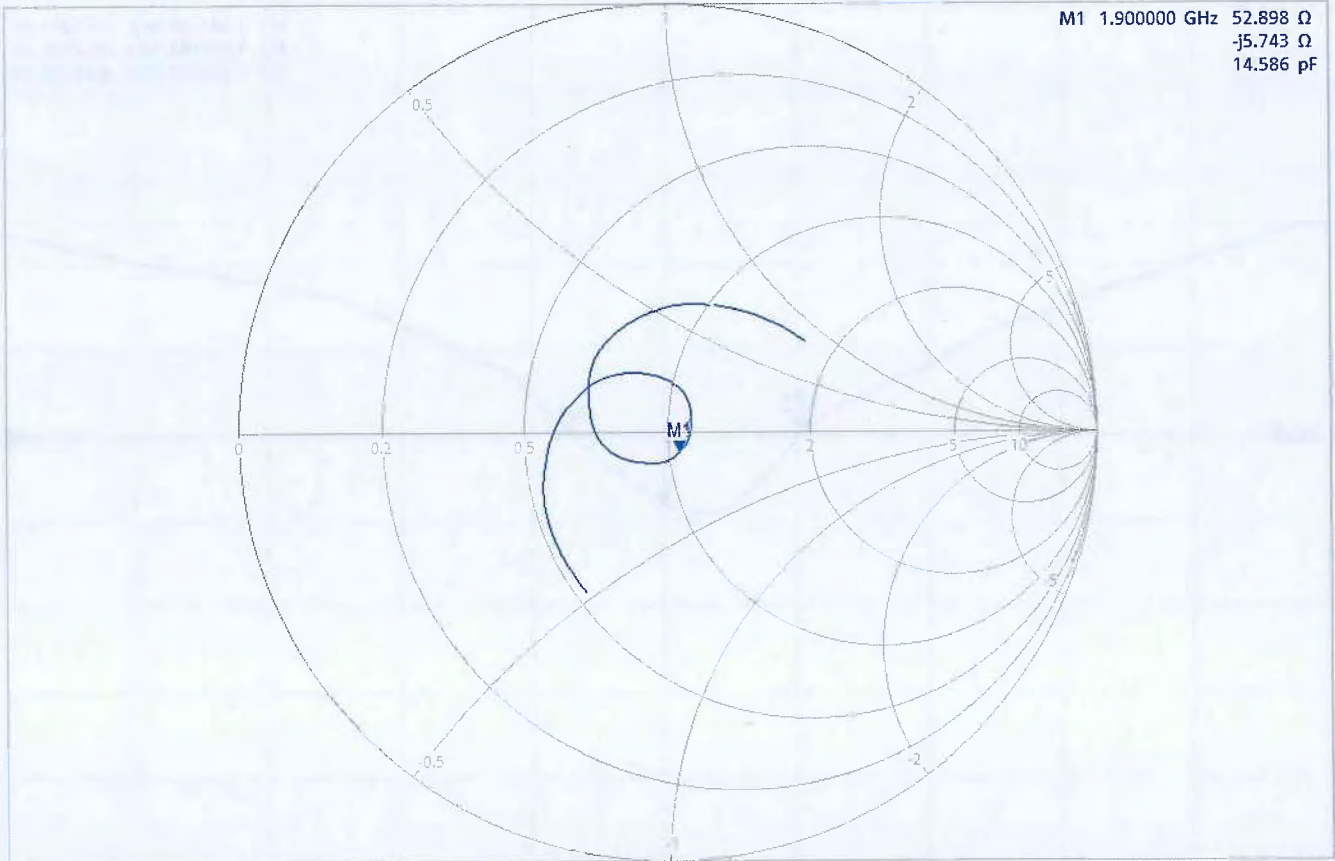


10/9/2017 2:01:07 PM
1326.5170K92-100151-MV

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

1

M1 1.900000 GHz 52.898 Ω
-j5.743 Ω
14.586 pF



Ch1 Start 1.7 GHz

Pwr -10 dBm Bw 10 kHz

Stop 2.1 GHz

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903941JD01D

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Return Loss Measurement Plot for Body Stimulating Liquid (MSL)

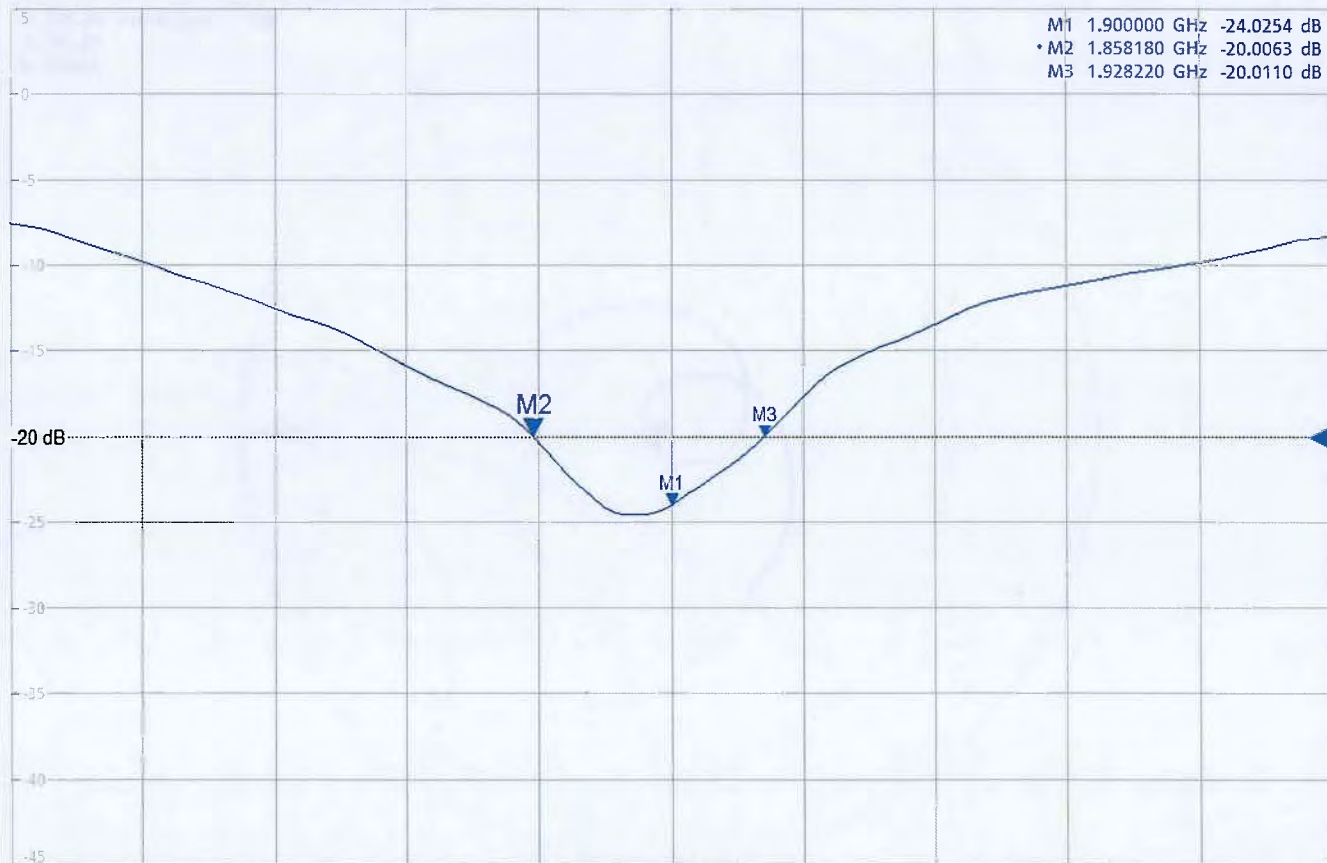


10/9/2017 1:59:36 PM
1328.5170K92-100151-MV

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

1

M1 1.900000 GHz -24.0254 dB
• M2 1.858180 GHz -20.0063 dB
M3 1.928220 GHz -20.0110 dB



Ch1 Start 1.7 GHz


Pwr -10 dBm Bw 10 kHz

Stop 2.1 GHz

Calibration Certificate Label:

 <p>UKAS CALIBRATION 5248</p>	<p>UL VS LTD - Tel: +44 (0) 1256312000</p> <p>Certificate Number: 11903941JD01D</p> <p>Instrument ID: 5d163</p> <p>Calibration Date: 05/Oct/2017</p> <p>Calibration Due Date:</p>
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