

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 23/May/2017

CERTIFICATE NUMBER : 11762345JD01A



5248

UL VS LTD
PAVILION A
ASHWOOD PARK, ASHWOOD WAY
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RG23 8BG, UK
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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:	09/May/2017
Manufacturer:	Speag		
Type/Model Number:	D750V3		
Serial Number:	1024		
Calibration Date:	12/May/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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UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11762345JD01A

Page 2 of 10

The calibration methods and procedures used were as detailed in:

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

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2110	Data Acquisition Electronics	SPEAG	DAE4	431	18 Nov 2016	12
A2587	Probe	SPEAG	ES3DV3	3341	29 Aug 2016	12
A1985	Dipole	SPEAG	D750V3	1011	14 Feb 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
PRE0151441	Power Sensor	Rhode & Schwarz	NRP8S	102481	16 Nov 2016	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	26 Sept 2016	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	22 Nov 2016	12
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	09 May 2017	12
M1768	Signal Generator	Rhode & Schwarz	SME06	837633/001	08 Nov 2016	12

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UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11762345JD01A

Page 3 of 10

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: RX90L
Robot Serial Number:	F00/SD89A1/A/01
DASY Version:	DASY 4 (v4.7.80)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	15 mm (with spacer)
Frequency:	750 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	750	21.0 °C	21.0 °C	21.0°C	21.0°C	ϵ_r	41.96	41.29	± 5%
						σ	0.89	0.91	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	2.13 W/Kg	8.47 W/Kg	± 17.57%
	SAR averaged over 10g	1.39 W/Kg	5.53 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	47.67 Ω 2.80 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	28.12	± 2.03 dB

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CERTIFICATE
NUMBER :
11762345JD01A

Page 4 of 10

Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	750	21.0 °C	21.0 °C	21.0°C	21.0°C	ϵ_r	55.55	53.75	± 5%
						σ	0.96	0.97	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	2.16 W/Kg	8.59 W/Kg	± 18.06%
	SAR averaged over 10g	1.42 W/Kg	5.65 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	51.39 Ω 3.87 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	28.60	± 2.03 dB

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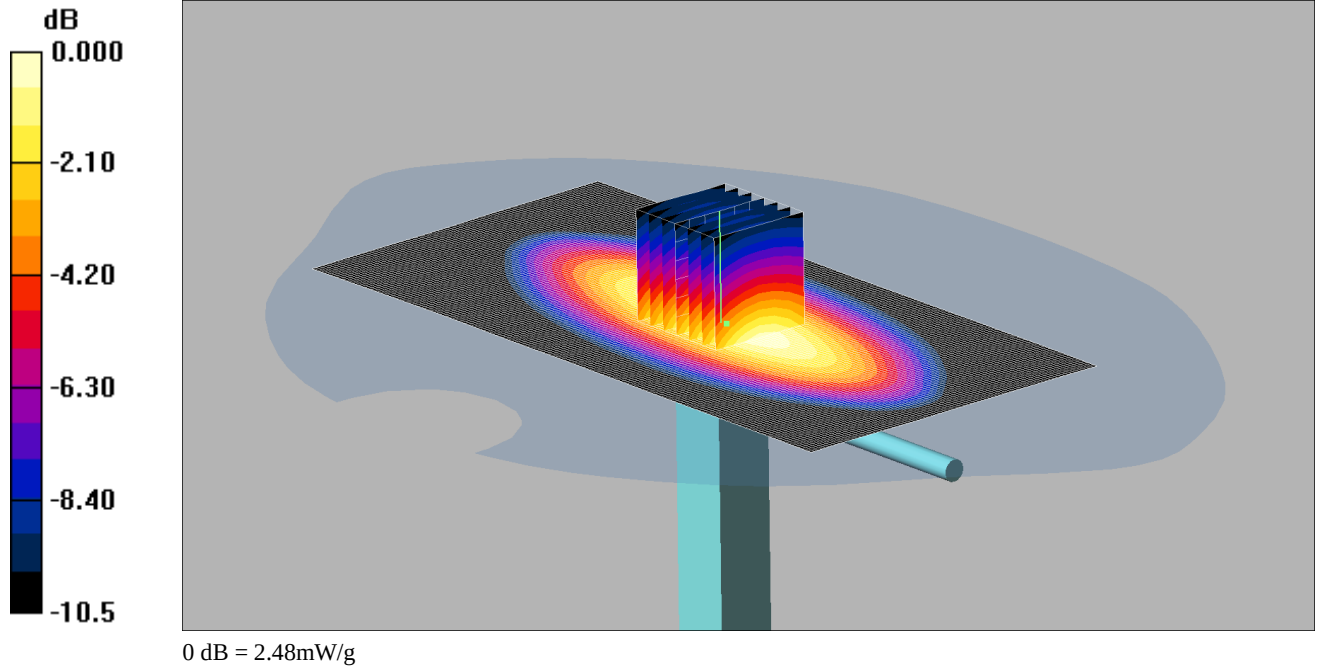
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CERTIFICATE
NUMBER :
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Page 5 of 10

DASY Validation Scan for Head Stimulating Liquid (HSL)

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



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

Medium: 750 MHz HSL Medium parameters used: $f = 750 \text{ MHz}$; $\sigma = 0.91 \text{ mho/m}$; $\epsilon_r = 41.3$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY4 Configuration:

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

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

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

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

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

d=15mm, Pin=250mW/Area Scan (81x161x1): Measurement grid: $dx=12\text{mm}$, $dy=12\text{mm}$

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

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

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

Peak SAR (extrapolated) = 3.15 W/kg

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

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

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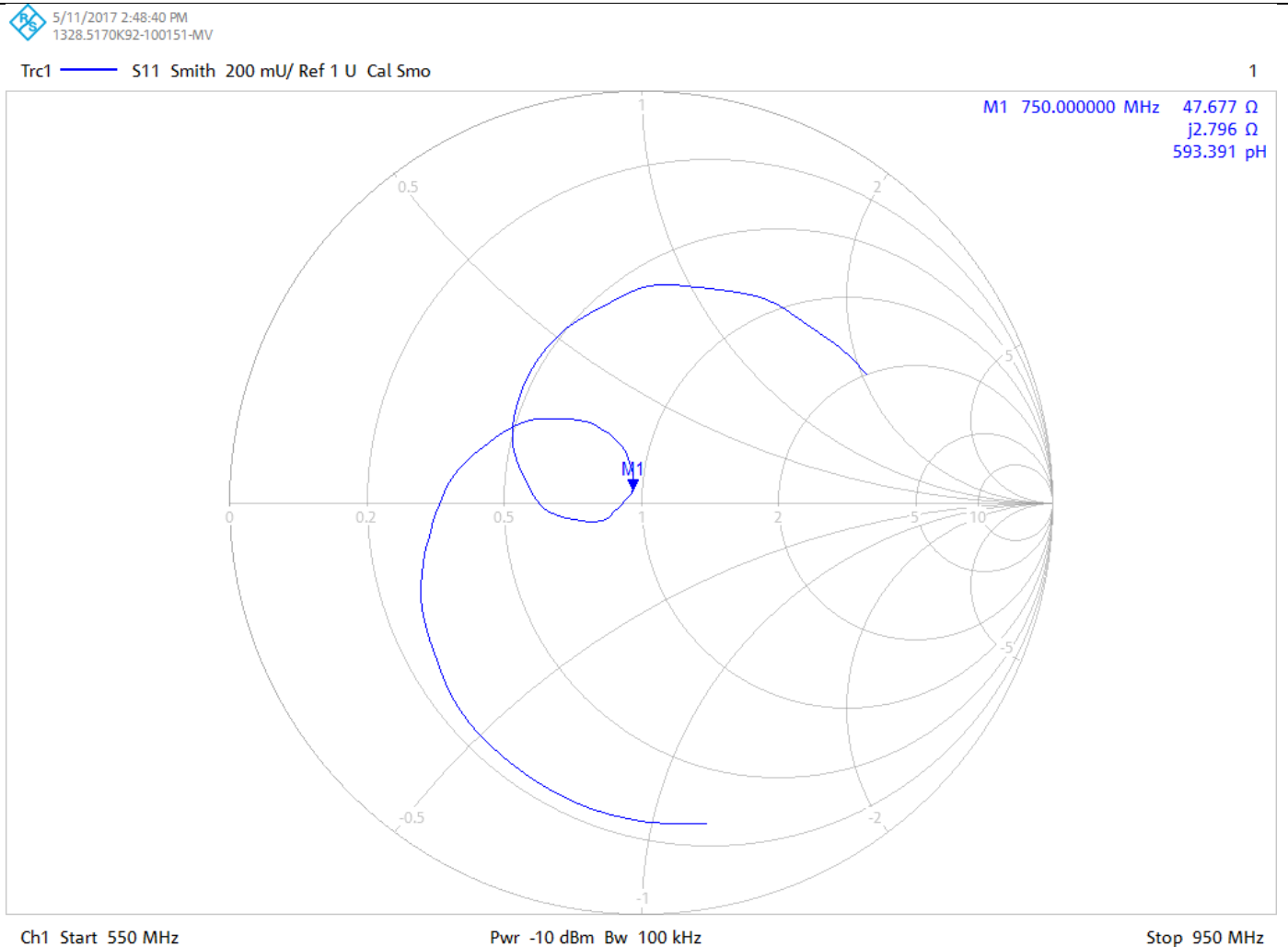
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Page 6 of 10

Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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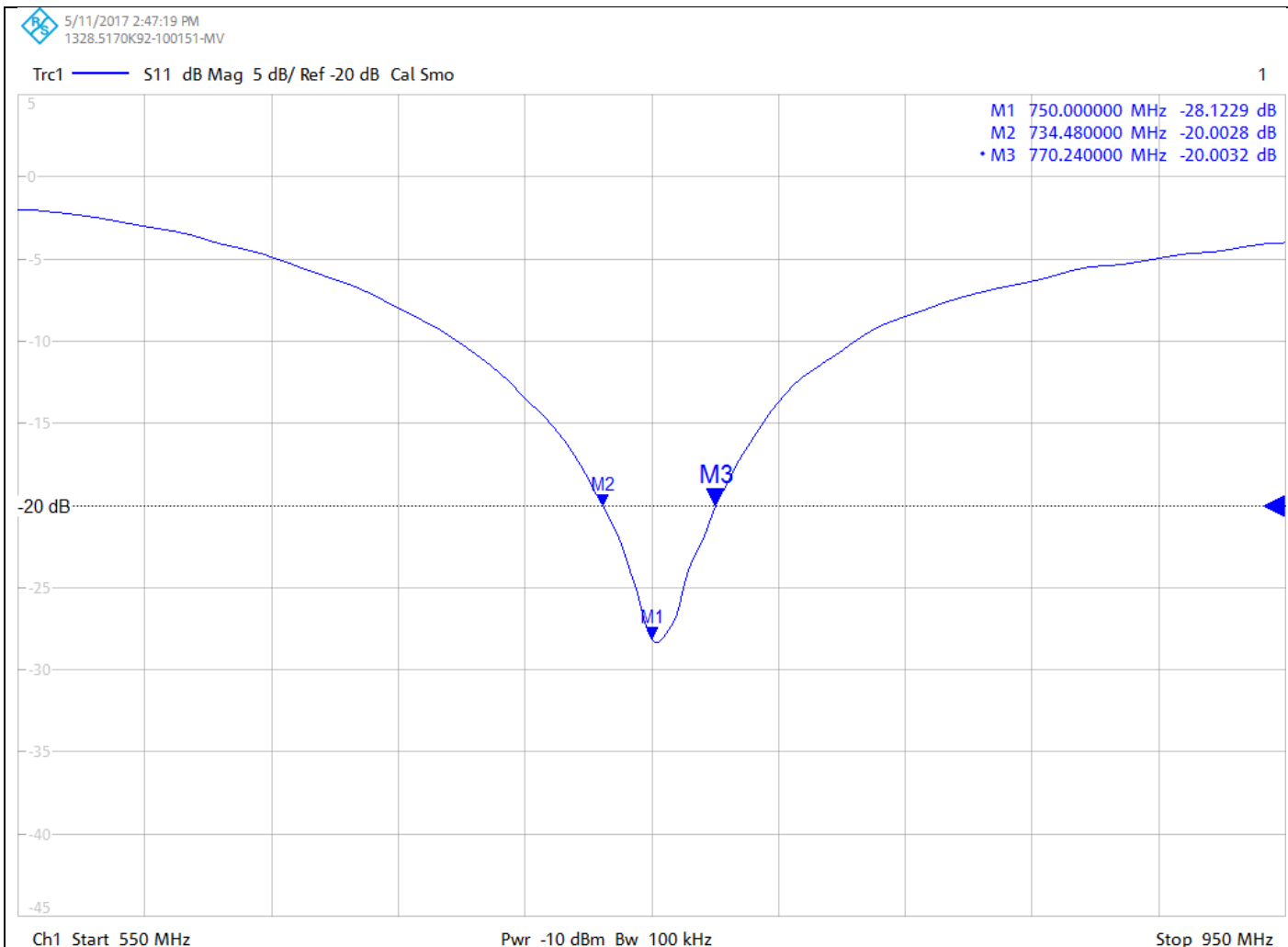
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Page 7 of 10

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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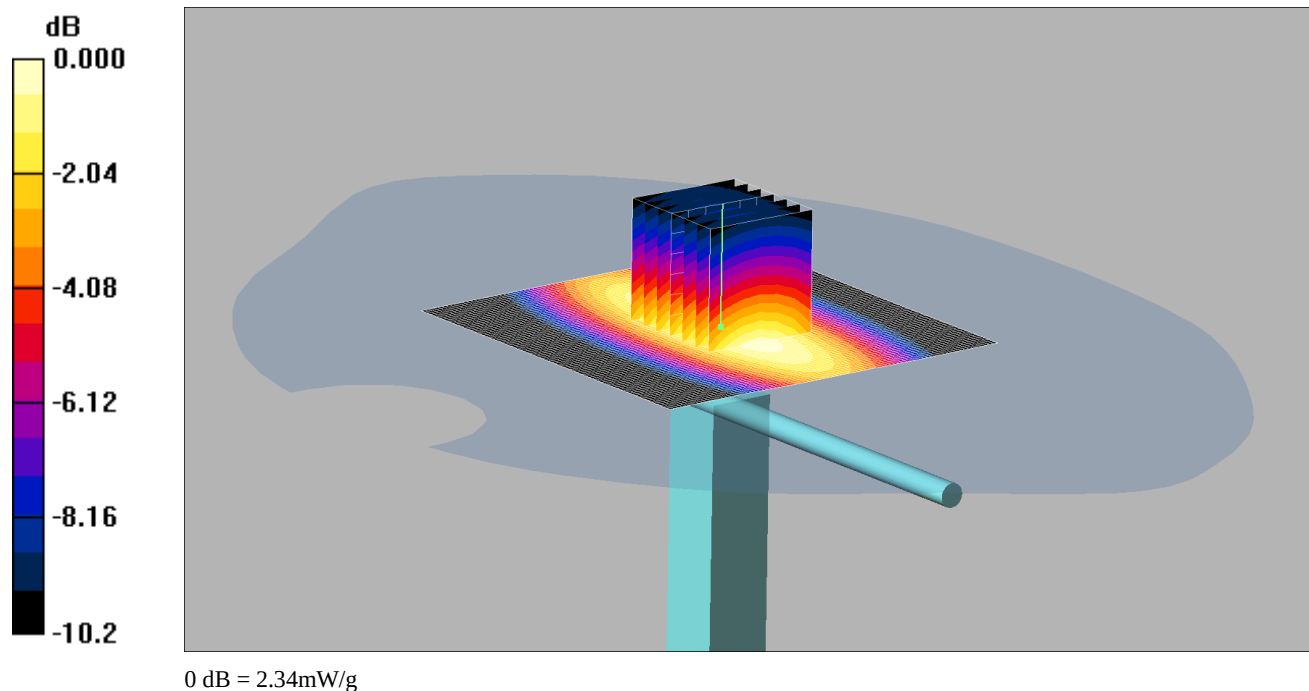
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CERTIFICATE
NUMBER :
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Page 8 of 10

DASY Validation Scan for Body Stimulating Liquid (MSL)

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



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

Medium: 750 MHz MSL Medium parameters used: $f = 750$ MHz; $\sigma = 0.97$ mho/m; $\epsilon_r = 53.8$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

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

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

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

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

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

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

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

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

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

Peak SAR (extrapolated) = 3.23 W/kg

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

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

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Page 9 of 10

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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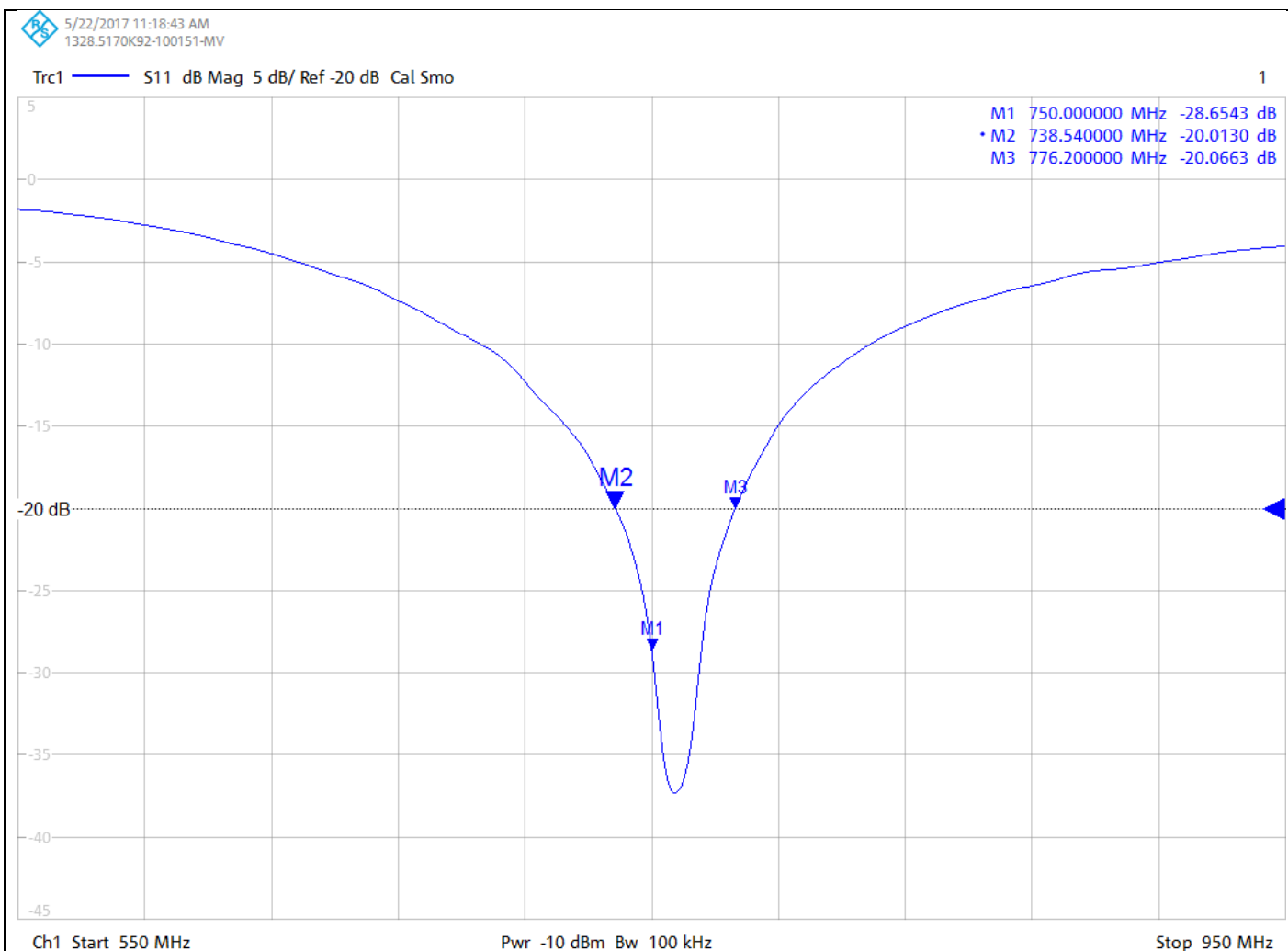
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Page 10 of 10

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



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	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11762345JD01A Instrument ID: 1024 Calibration Date: 12/May/2017 Calibration Due Date:
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	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11762345JD01A Instrument ID: 1024 Calibration Date: 12/May/2017 Calibration Due Date:
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	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11762345JD01A Instrument ID: 1024 Calibration Date: 12/May/2017 Calibration Due Date:
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CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 29/Nov/2017

CERTIFICATE NUMBER : 11903932JD01B



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Email: LST.UK.Calibration@ul.com



Page 1 of 10

APPROVED SIGNATORY

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

Naseer Mirza

Customer :

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

Equipment Details:

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

Signature:

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

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

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

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Page 2 of 10

The calibration methods and procedures used were as detailed in:

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

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2546	Data Acquisition Electronics	SPEAG	DAE4	1435	10 Feb 2017	12
A2545	Probe	SPEAG	ES3DV4	3395	04 May 2017	12
PRE0159049	Dipole	SPEAG	D835V2	438	28 April 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
M1855	Power Sensor	Rhode & Schwarz	NRP-Z51	103246	08 Nov 2017	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	10 Oct 2017	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	22 Nov 2016	24
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	02 Dec 2016	12
M1838	Signal Generator	Rhode & Schwarz	SME06	831377/005	30 Mars 2017	12

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UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
11903932JD01B

Page 3 of 10

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F14/5T5ZA1/A/01
DASY Version:	DASY 52 (v52.8.8.1258)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	15 mm (with spacer)
Frequency:	835 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	835	21.0 °C	21.0 °C	20.5°C	21.0°C	ϵ_r	41.50	41.73	± 5%
						σ	0.90	0.94	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	2.58 W/Kg	10.27 W/Kg	± 17.57%
	SAR averaged over 10g	1.70 W/Kg	6.76 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	47.692 Ω 1.64 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	30.74	± 2.03 dB

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CERTIFICATE
NUMBER :
11903932JD01B

Page 4 of 10

Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	835	21.0 °C	21.0 °C	21.0°C	21.0°C	ϵ_r	55.20	54.37	± 5%
						σ	0.97	0.99	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	2.57 W/Kg	10.23 W/Kg	± 18.06%
	SAR averaged over 10g	1.71 W/Kg	6.80 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	46.15 Ω 5.05 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	24.49	± 2.03 dB

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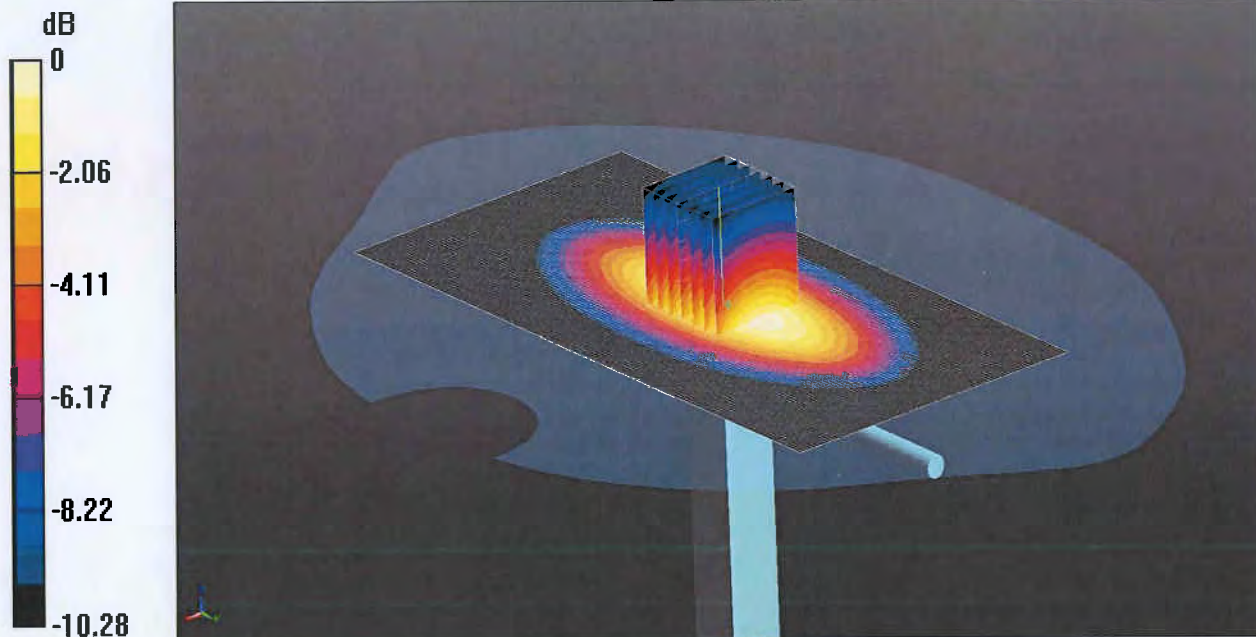
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NUMBER :
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Page 5 of 10

DASY Validation Scan for Head Stimulating Liquid (HSL)

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



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

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

Medium: 750,835,900,1800,1900 MHz HSL Medium parameters used (interpolated): $f = 835$ MHz; $\sigma = 0.944$ S/m; $\epsilon_r = 41.726$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3995; ConvF(10.16, 10.16, 10.16); Calibrated: 04/05/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=15mm, Pin=250mW 3 2/Area Scan (81x161x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

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

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

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

Peak SAR (extrapolated) = 3.83 W/kg

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

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

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CERTIFICATE
NUMBER :
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Page 6 of 10

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

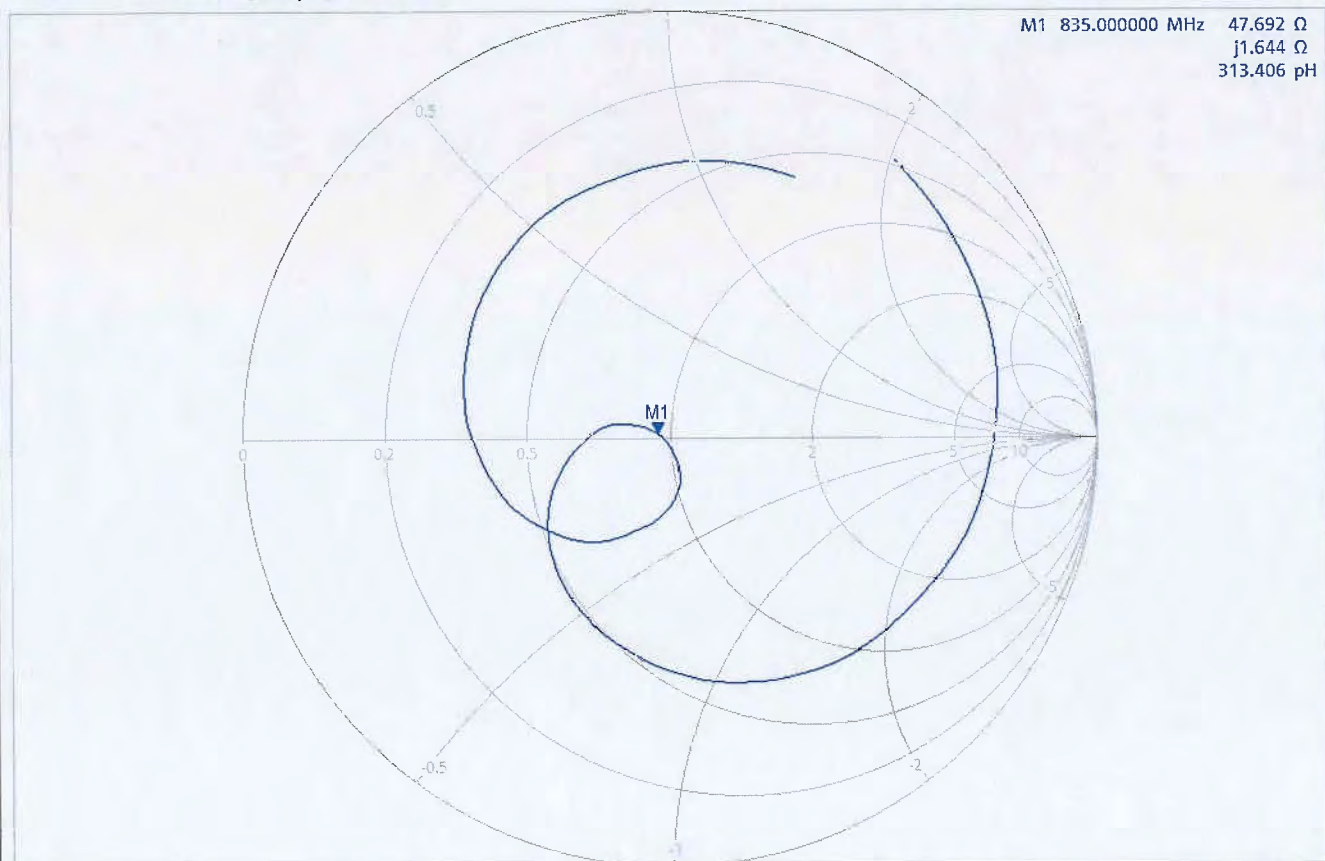


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1326.5170K92-100151-MV

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

1

M1 835.000000 MHz 47.692 Ω
j1.644 Ω
313.406 pF



Ch1 Start 635 MHz

Pwr -10 dBm Bw 10 kHz

Stop 1.035 GHz

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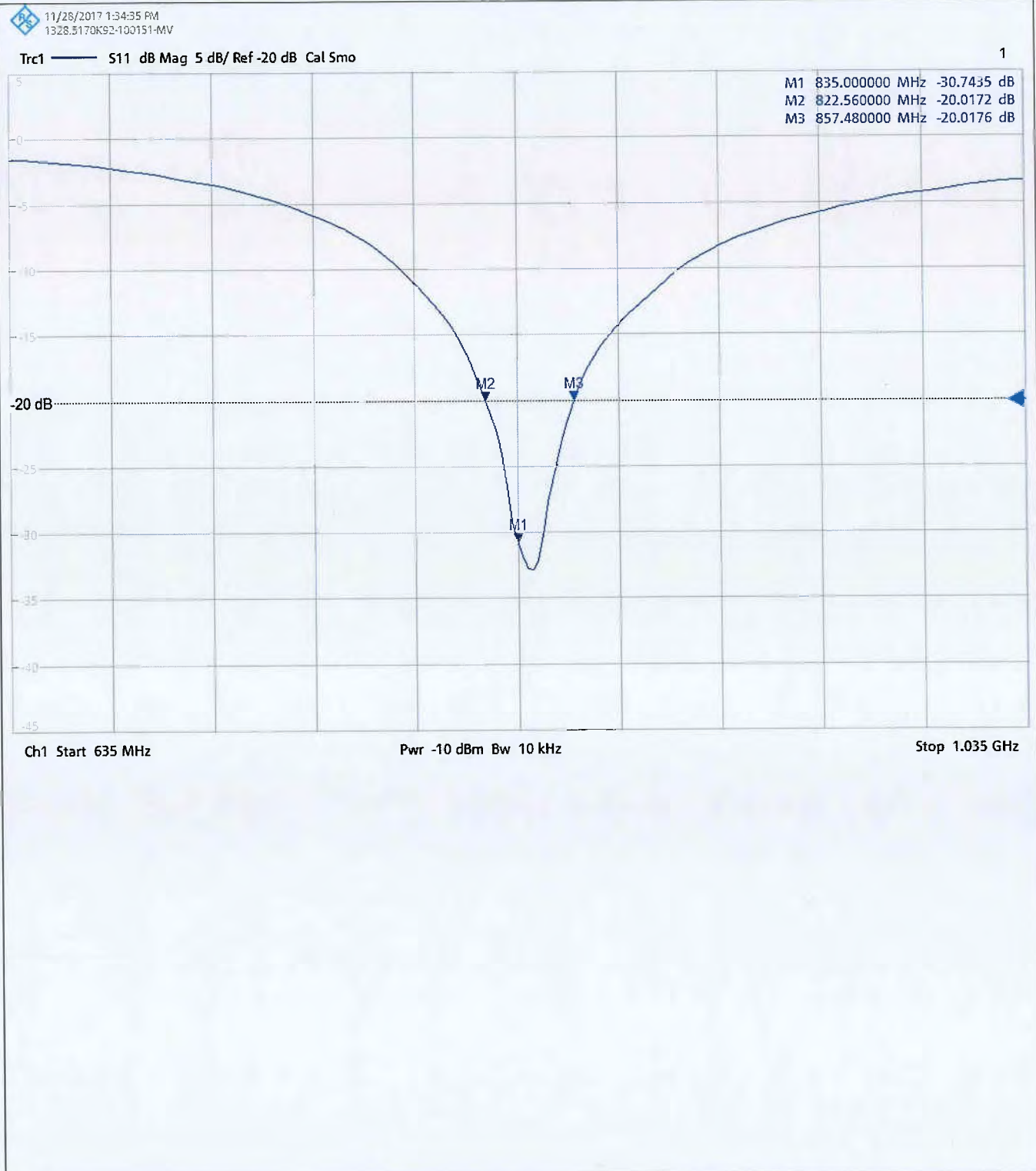
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NUMBER :
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Page 7 of 10

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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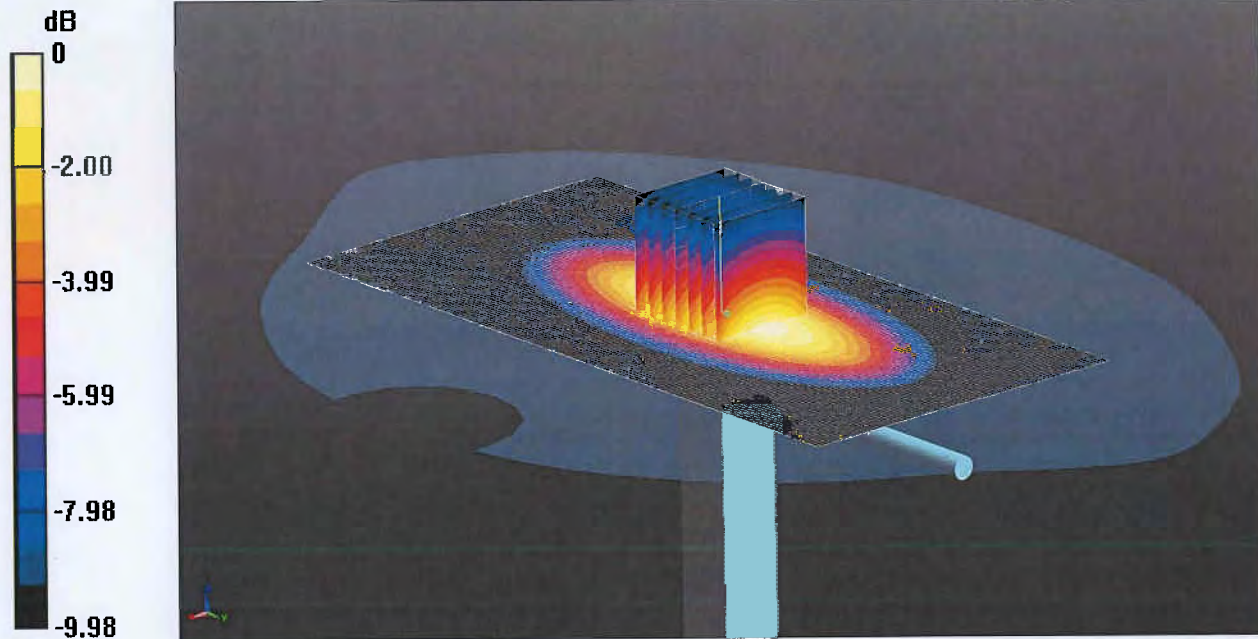
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CERTIFICATE
NUMBER :
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Page 8 of 10

DASY Validation Scan for Body Stimulating Liquid (MSL)

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



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

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

Medium: MSL(750,835,900,1800,1900,5G) Medium parameters used (interpolated): $f = 835$ MHz; $\sigma = 0.992$ S/m; $\epsilon_r = 54.368$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY5 Configuration:

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

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

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

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

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

Peak SAR (extrapolated) = 3.78 W/kg

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

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

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Page 9 of 10

Impedance Measurement Plot for Body Stimulating Liquid (MSL)

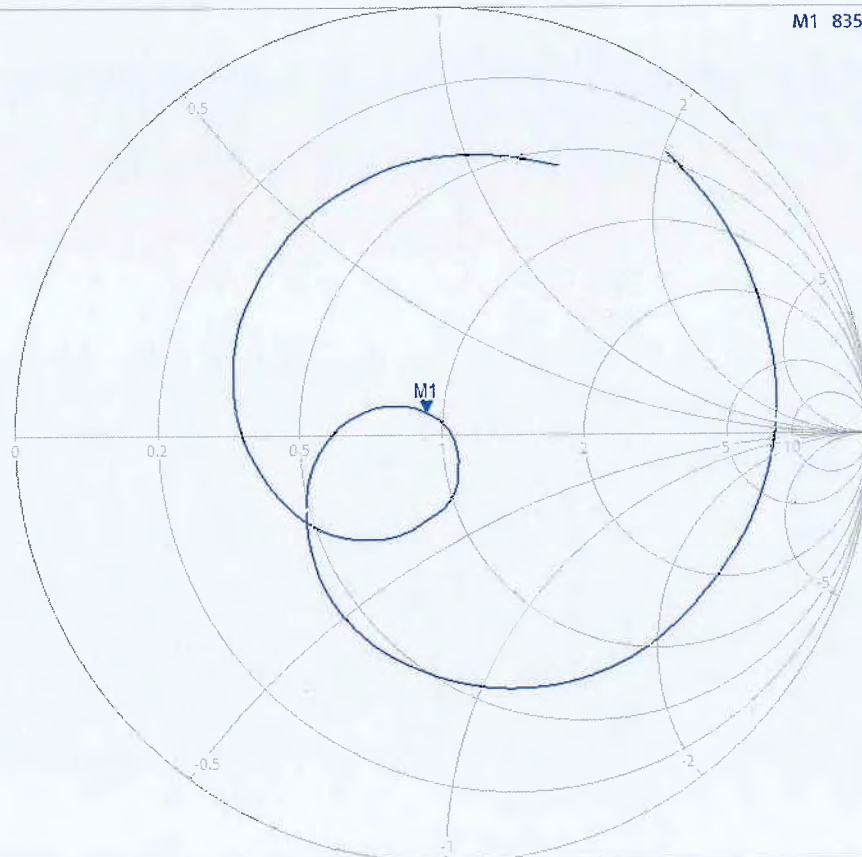


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1328.5170K92-100151-MV

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

1

M1 835.000000 MHz 46.153 Ω
j5.050 Ω
962.581 pF



Ch1 Start 635 MHz

Pwr -10 dBm Bw 10 kHz

Stop 1.035 GHz

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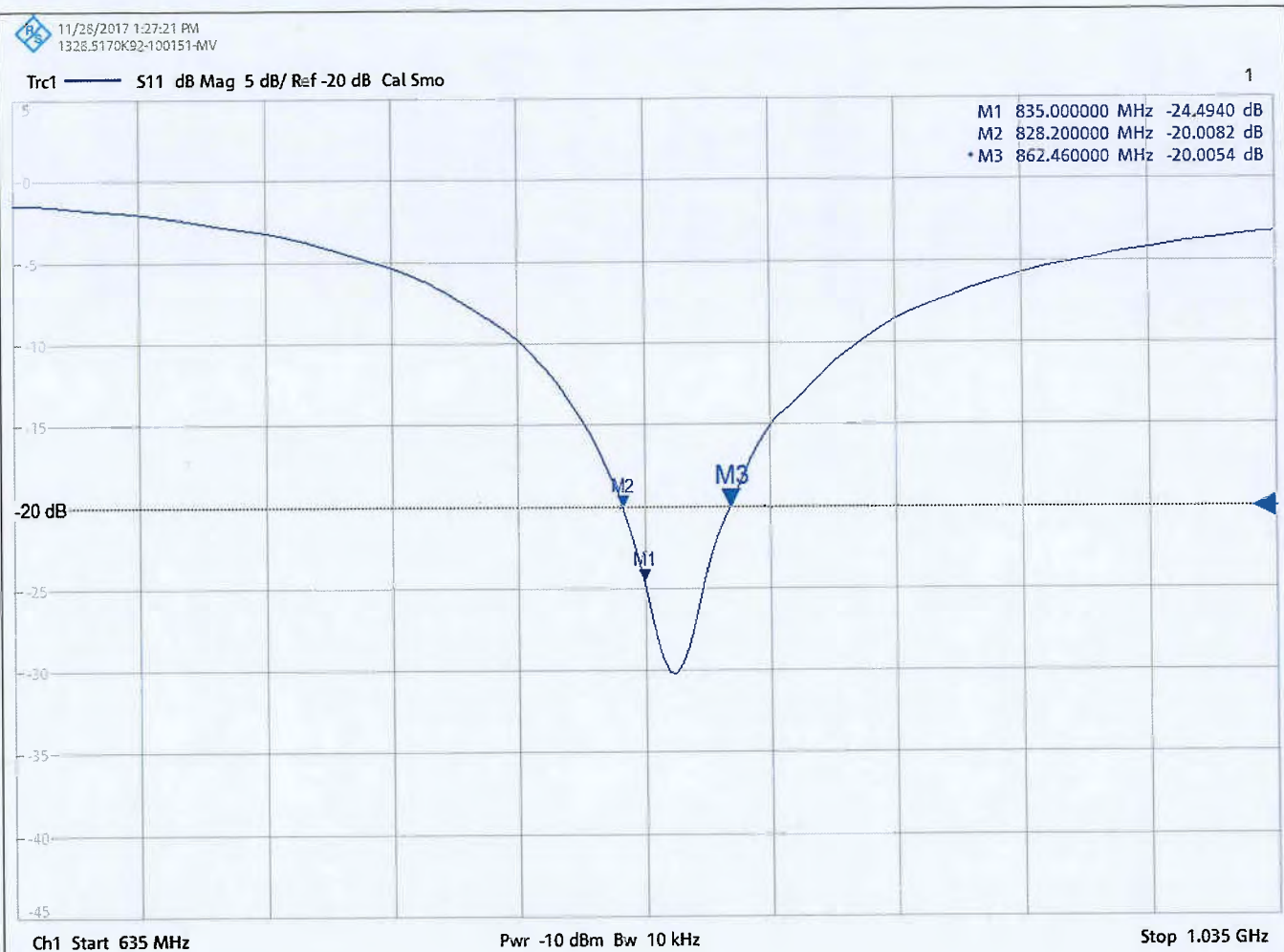
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Page 10 of 10

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

 5248	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903932JD01B Instrument ID: 4d002 Calibration Date: 21/Nov/2017 Calibration Due Date:
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 5248	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903932JD01B Instrument ID: 4d002 Calibration Date: 21/Nov/2017 Calibration Due Date:
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CERTIFICATE OF CALIBRATION

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DATE OF ISSUE: 10/Oct/2017

CERTIFICATE NUMBER : 11903941JD01B



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Page 1 of 10

APPROVED SIGNATORY

Naseer Mirza

Customer :

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	29/Sep/2017
Manufacturer:	Speag		
Type/Model Number:	D1750V2		
Serial Number:	1077		
Calibration Date:	05/Oct/2017		
Calibrated By:	Chanthu Thevarajah 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.

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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NUMBER :
11903941JD01B

Page 2 of 10

The calibration methods and procedures used were as detailed in:

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

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2546	Data Acquisition Electronics	SPEAG	DAE4	1435	10 Feb 2017	12
A2587	Probe	SPEAG	ES3DV3	3341	14 Aug 2017	12
A1236	Dipole	SPEAG	D1800V2	2d009	09 Feb 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
PRE0151441	Power Sensor	Rhode & Schwarz	NRP8S	102481	16 Nov 2016	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	26 Sept 2016	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	22 Nov 2016	12
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	02 Dec 2016	12
M1908	Signal Generator	Rhode & Schwarz	SMIQ 03B	1125.555.03	08 Nov 2016	12

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Page 3 of 10

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F14/5T5ZA1/A/01
DASY Version:	DASY 52 (v52.8.8.1258)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	10 mm (with spacer)
Frequency:	1750 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	1750	23.0 °C	23.0 °C	20.0°C	20.0°C	ϵ_r	40.10	40.38	± 5%
						σ	1.37	1.39	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	9.11 W/Kg	36.26 W/Kg	± 17.57%
	SAR averaged over 10g	4.86 W/Kg	19.34 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	49.21 Ω -0.63 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	-36.48	± dB

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Page 4 of 10

Dielectric Property Measurements – Body Simulating Liquid (MSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Body	1750	22.0 °C	22.0 °C	22.0°C	22.0°C	ϵ_r	53.40	52.41	± 5%
						σ	1.49	1.47	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	SAR Measured	250 mW Input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	9.38 W/Kg	37.34 W/Kg	± 18.06%
	SAR averaged over 10g	5.02 W/Kg	19.98 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

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

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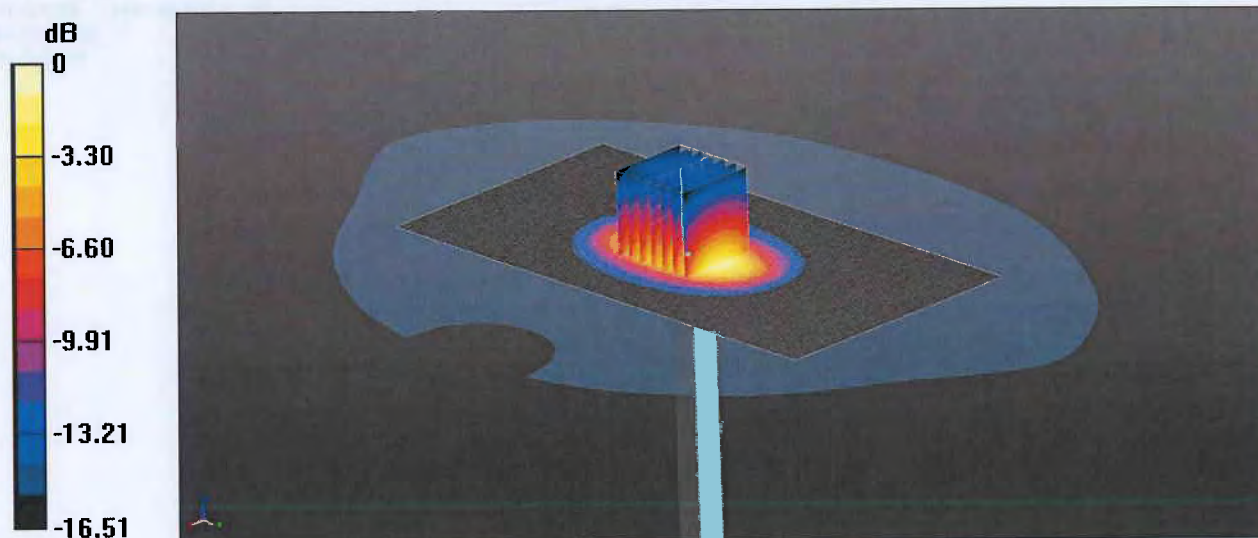
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Page 5 of 10

DASY Validation Scan for Head Stimulating Liquid (HSL)

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



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

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

Medium: 1750 1800 MHz HSL Medium parameters used: $f = 1750$ MHz; $\sigma = 1.393$ S/m; $\epsilon_r = 40.378$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(5.47, 5.47, 5.47); Calibrated: 14/08/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

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

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

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

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

Peak SAR (extrapolated) = 16.3 W/kg

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

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

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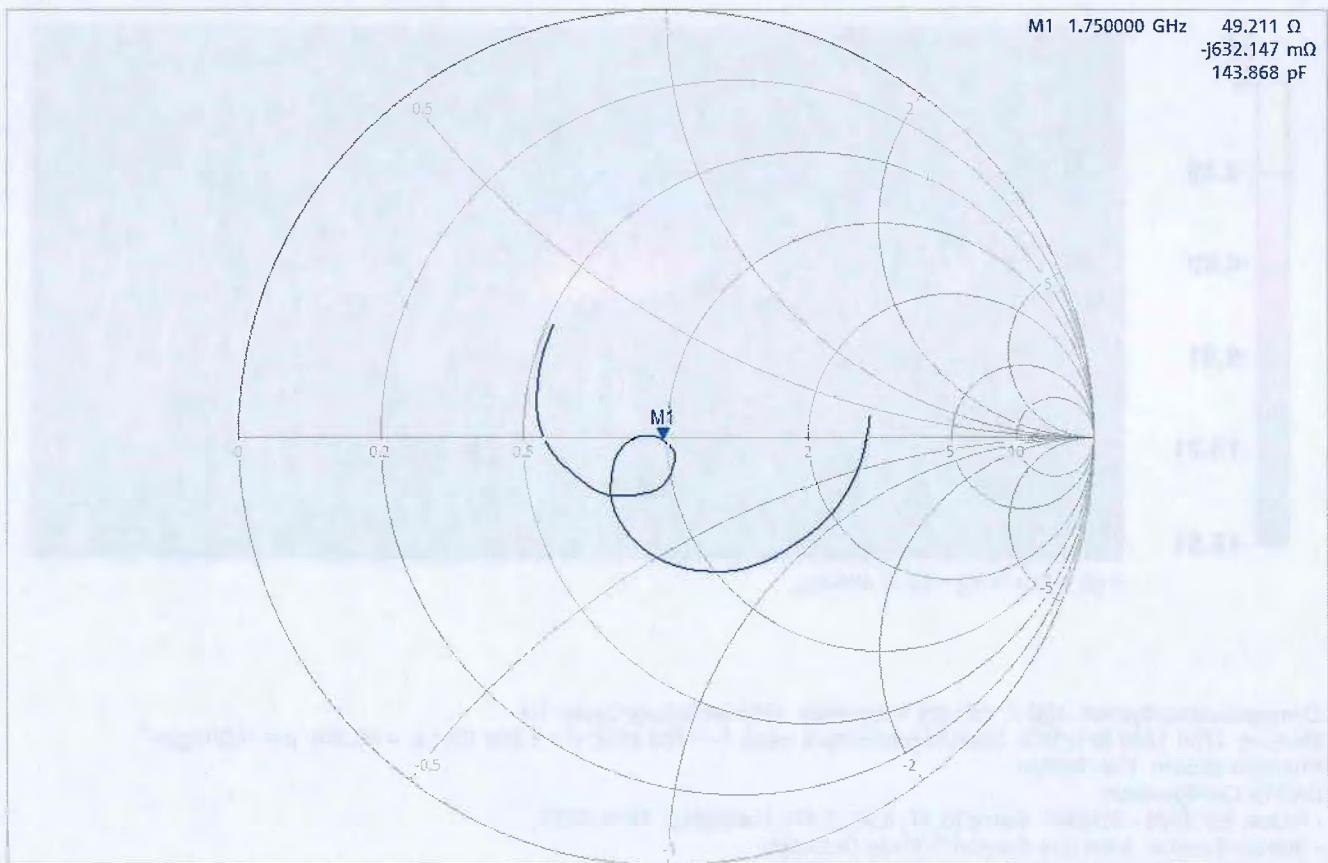
Page 6 of 10

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

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

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

1



Ch1 Start 1.55 GHz

Pwr -10 dBm Bw 10 kHz

Stop 1.95 GHz

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Return Loss Measurement Plot for Head Stimulating Liquid (HSL)

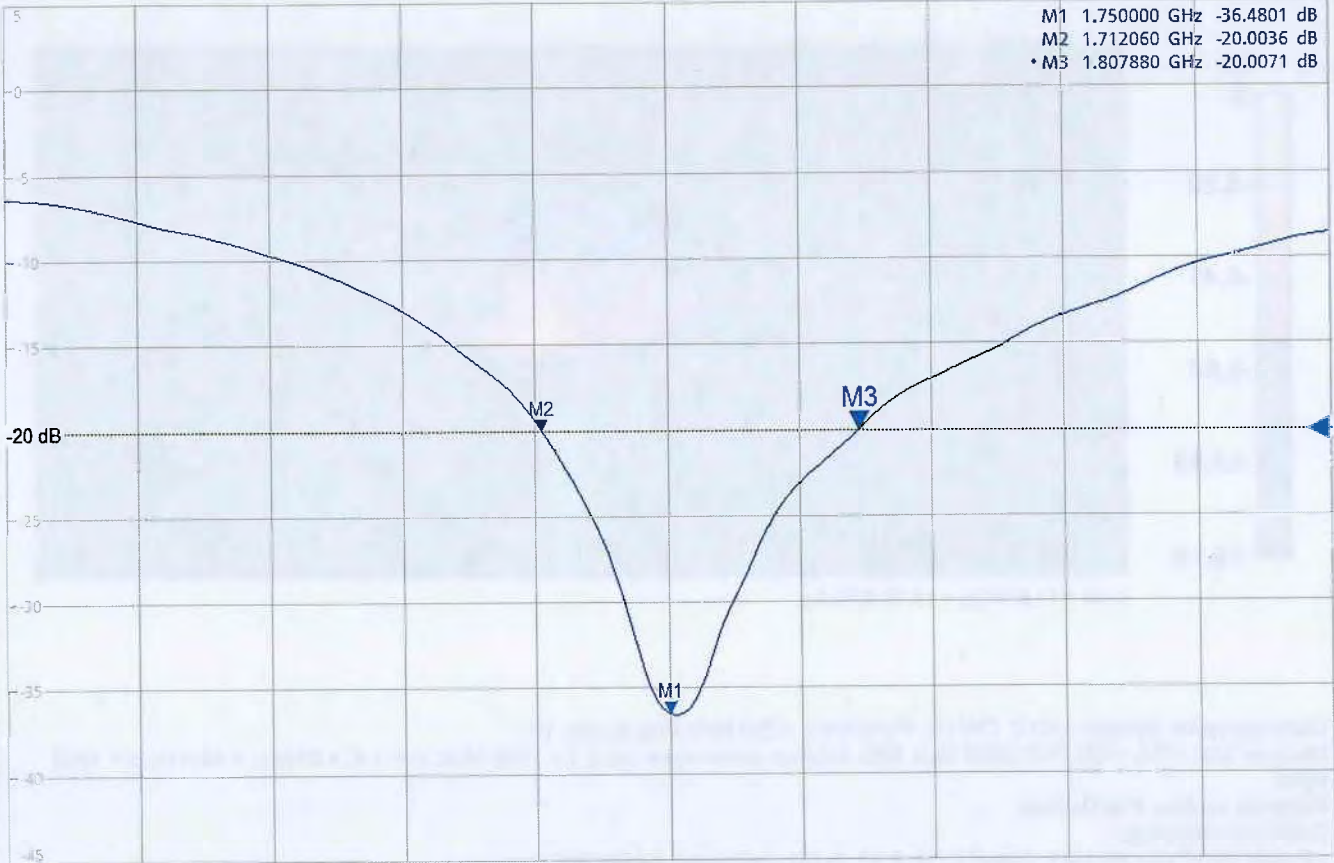


10/10/2017 9:08:41 AM
1328.5170K92-100151-MV

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

1

M1 1.750000 GHz -36.4801 dB
M2 1.712060 GHz -20.0036 dB
• M3 1.807880 GHz -20.0071 dB



Ch1 Start 1.55 GHz

Pwr -10 dBm Bw 10 kHz

Stop 1.95 GHz

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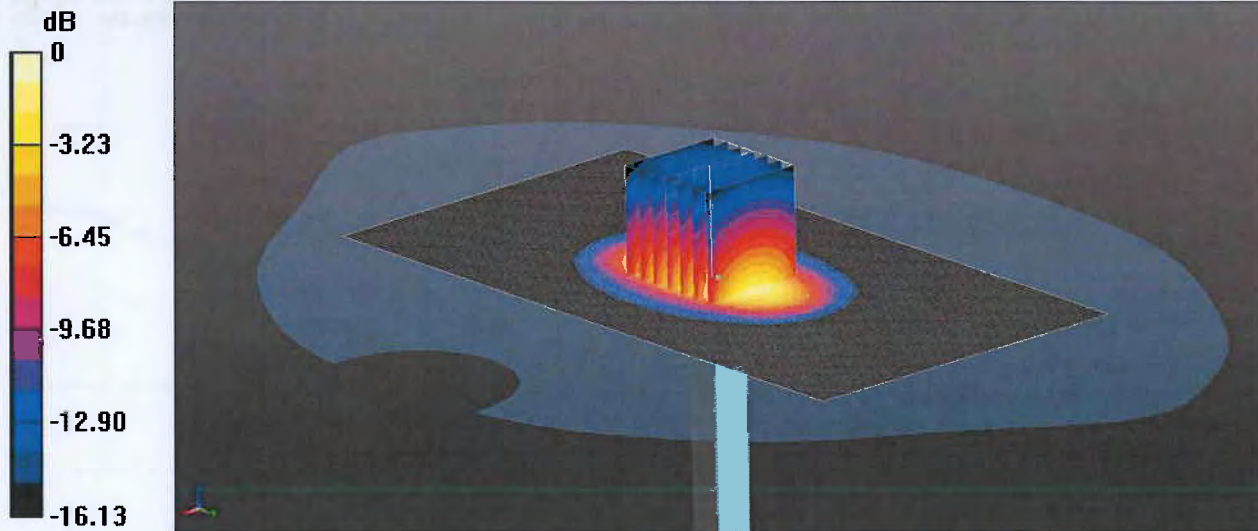
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Page 8 of 10

DASY Validation Scan for Body Stimulating Liquid (MSL)

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



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

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

Medium: 900, 1750, 1800, 1900, 2600 MHz MSL Medium parameters used: $f = 1750$ MHz; $\sigma = 1.474$ S/m; $\epsilon_r = 52.411$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(5.12, 5.12, 5.12); Calibrated: 14/08/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1435; Calibrated: 10/02/2017
- Phantom: SAM (30deg probe tilt) with CRP v5.0; Type: QD000P40CD; Serial: TP:xxxx
- ; SEMCAD X Version 14.6.10 (7372)

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

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

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

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

Peak SAR (extrapolated) = 16.5 W/kg

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

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

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Page 9 of 10

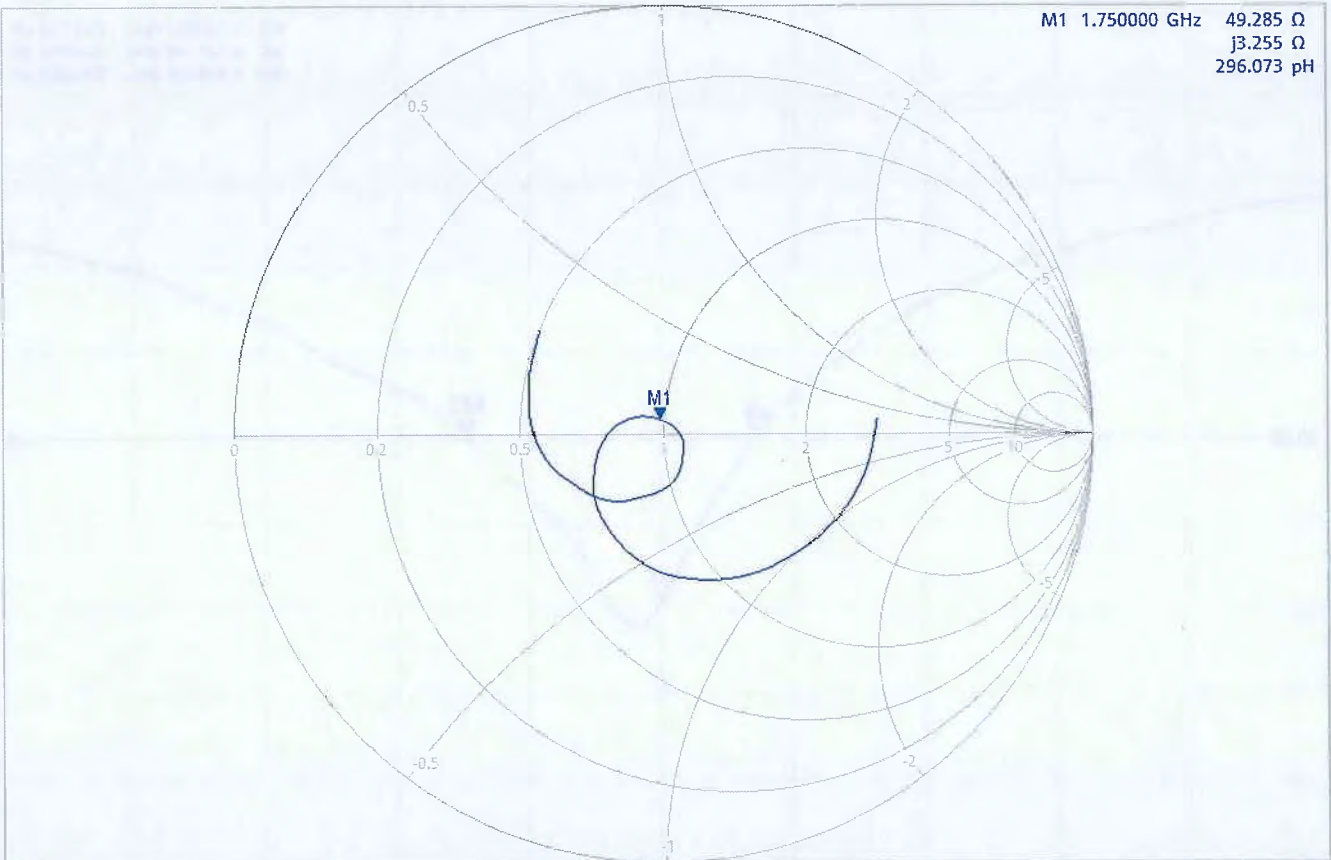
Impedance Measurement Plot for Body Stimulating Liquid (MSL)

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

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

1

M1 1.750000 GHz 49.285 Ω
j3.255 Ω
296.073 pH



Ch1 Start 1.55 GHz

Pwr -10 dBm Bw 10 kHz

Stop 1.95 GHz

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Page 10 of 10

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)

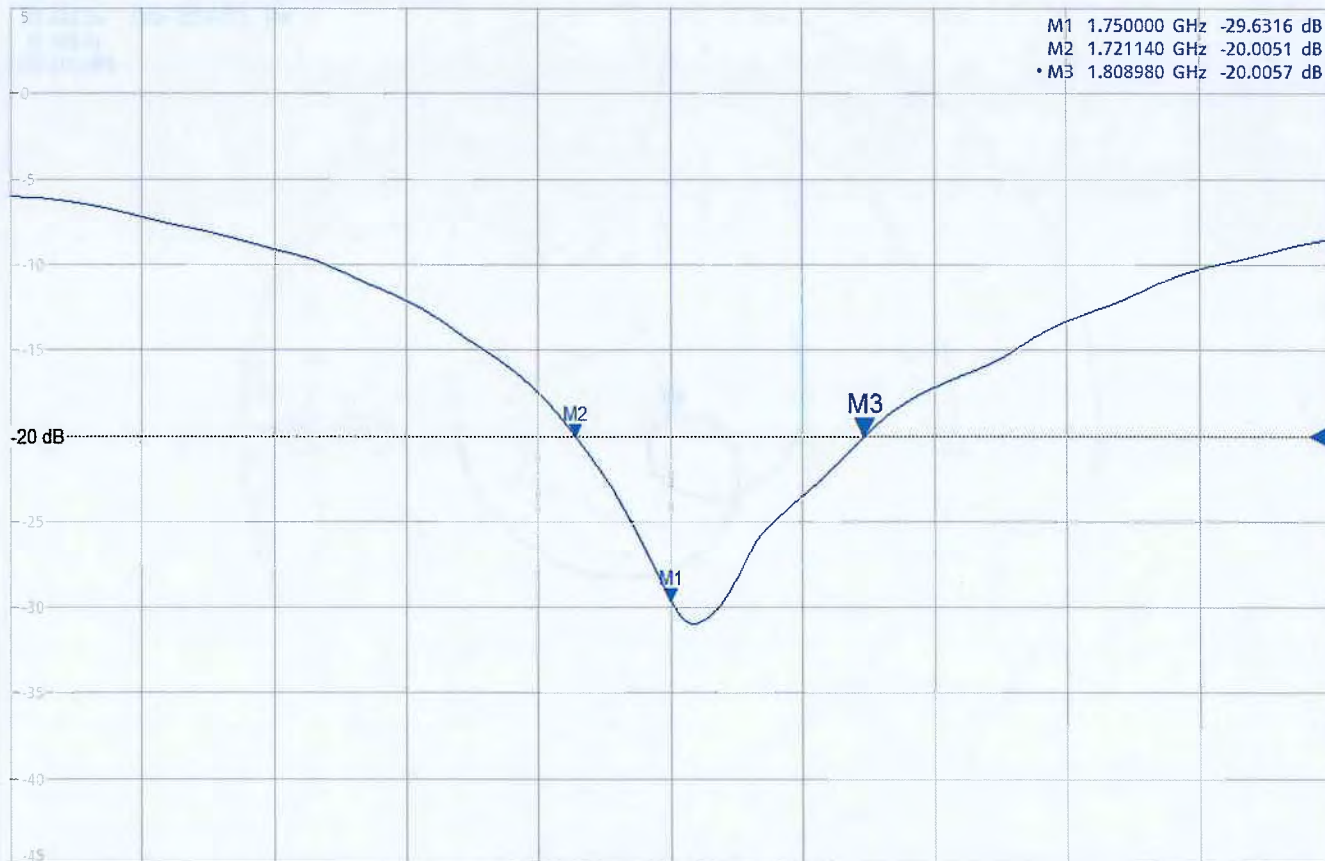


10/9/2017 2:15:13 PM
1328.5170K92-100151-MV

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

1

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



Ch1 Start 1.55 GHz

Pwr -10 dBm Bw 10 kHz

Stop 1.95 GHz

Calibration Certificate Label:

	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903941JD01B Instrument ID: 1077 Calibration Date: 05/Oct/2017 Calibration Due Date:
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CERTIFICATE NUMBER : 12134278JD01C



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RG23 8BG, UK

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FAX: +44 (0) 1256 312001

Email: LST.UK.Calibration@ul.com



Page 1 of 10

APPROVED SIGNATORY

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

.....
Naseer Mirza

Customer :

UL VS Inc

47173 Benicia Street

Fremont, CA 94538, USA

Equipment Details:

Description: Dipole Validation Kit Date of Receipt: 10/Apr/2018

Manufacturer: Speag

Type/Model Number: D1900V2

Serial Number: 5d140

Calibration Date: 11/Apr/2018

Calibrated By: Chanthu Thevarajah
Senior Engineer

Signature:

A handwritten signature in black ink, appearing to be a stylized 'C' followed by 'T'.

.....

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

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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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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. **SPEAG DASY4/ DASY5 System Handbook**

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2110	Data Acquisition Electronics	SPEAG	DAE4	431	08 Nov 2017	12
A2077	Probe	SPEAG	EX3DV4	3814	28 Sep 2017	12
A1237	Dipole	SPEAG	D1900V2	540	20 Sep 2018	12
PRE0151451	Power Monitoring Kit	Art-Fi SAS	ART 100850-01	0001	Cal as part of System	12
PRE0151441	Power Sensor	Rhode & Schwarz	NRP8S	102481	05 Feb 2018	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	12 Oct 2017	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2017	12
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	09 May 2017	12
M1838	Signal Generator	Rhode & Schwarz	SME06	831377/005	22 Mar 2018	12

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Page 3 of 10

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	22.0 °C	22.0 °C	24.0°C	22.0°C	ϵ_r	40.00	39.15	± 5%
						σ	1.40	1.39	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	9.78 W/Kg	38.93 W/Kg	± 17.57%
	SAR averaged over 10g	5.06 W/Kg	20.14 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	49.954 Ω -4.22 $j\Omega$	± 0.28 Ω ± 0.044 $j\Omega$
	Return Loss	27.13	± 2.03 dB

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Page 4 of 10

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	21.5°C	21.5°C	ϵ_r	53.30	51.78	± 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	10.30 W/Kg	41.00 W/Kg	± 18.06%
	SAR averaged over 10g	5.29 W/Kg	21.05 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	52.40 Ω -5.72 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	23.22	± 2.03 dB

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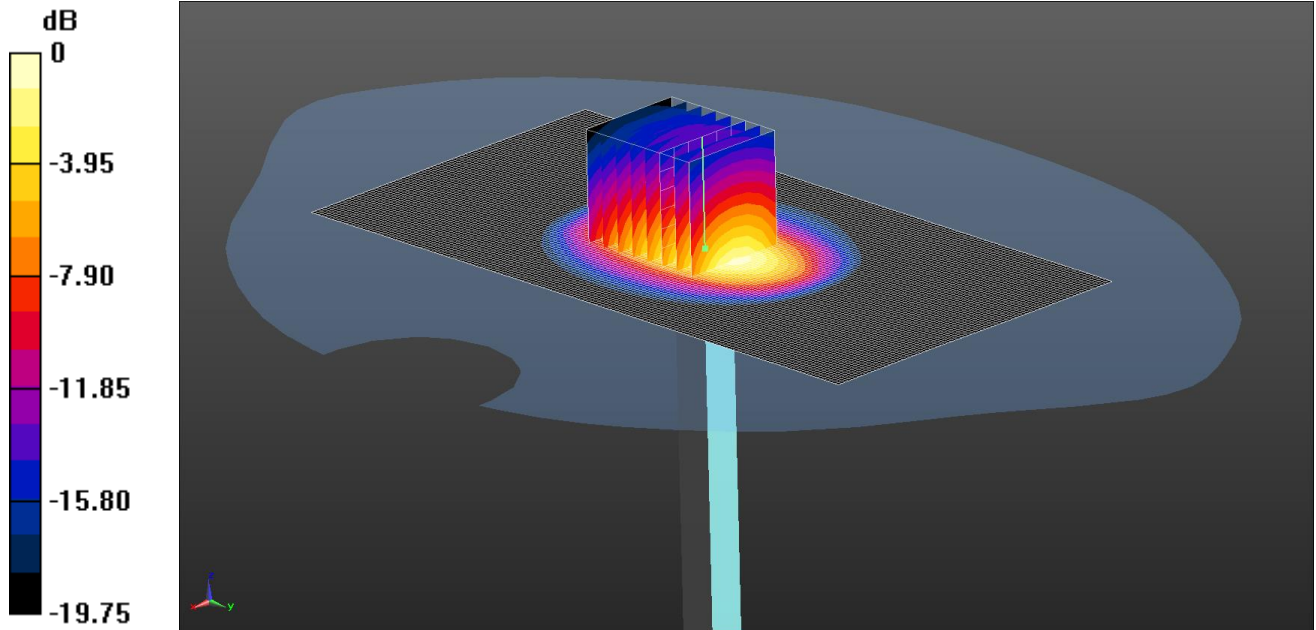
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Page 5 of 10

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1900V2 - SN5d140; Type: D1900V2; Serial: SN5d140



0 dB = 12.4 W/kg = 10.93 dBW/kg

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

Medium: 1900 MHz MSL Medium parameters used: $f = 1900$ MHz; $\sigma = 1.392$ S/m; $\epsilon_r = 39.154$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3814; ConvF(7.84, 7.84, 7.84); Calibrated: 28/09/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn431; Calibrated: 08/11/2017
- Phantom: SAM (20deg probe tilt) with CRP v5.0; Type: QD000P40CC; Serial: TP:1832
- ; SEMCAD X Version 14.6.10 (7372)

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

Maximum value of SAR (interpolated) = 12.9 W/kg

SAR/d=10mm, Pin=250mW/Zoom Scan (5x5x7) (7x8x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 95.54 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 18.3 W/kg

SAR(1 g) = 9.78 W/kg; SAR(10 g) = 5.06 W/kg

Maximum value of SAR (measured) = 12.4 W/kg

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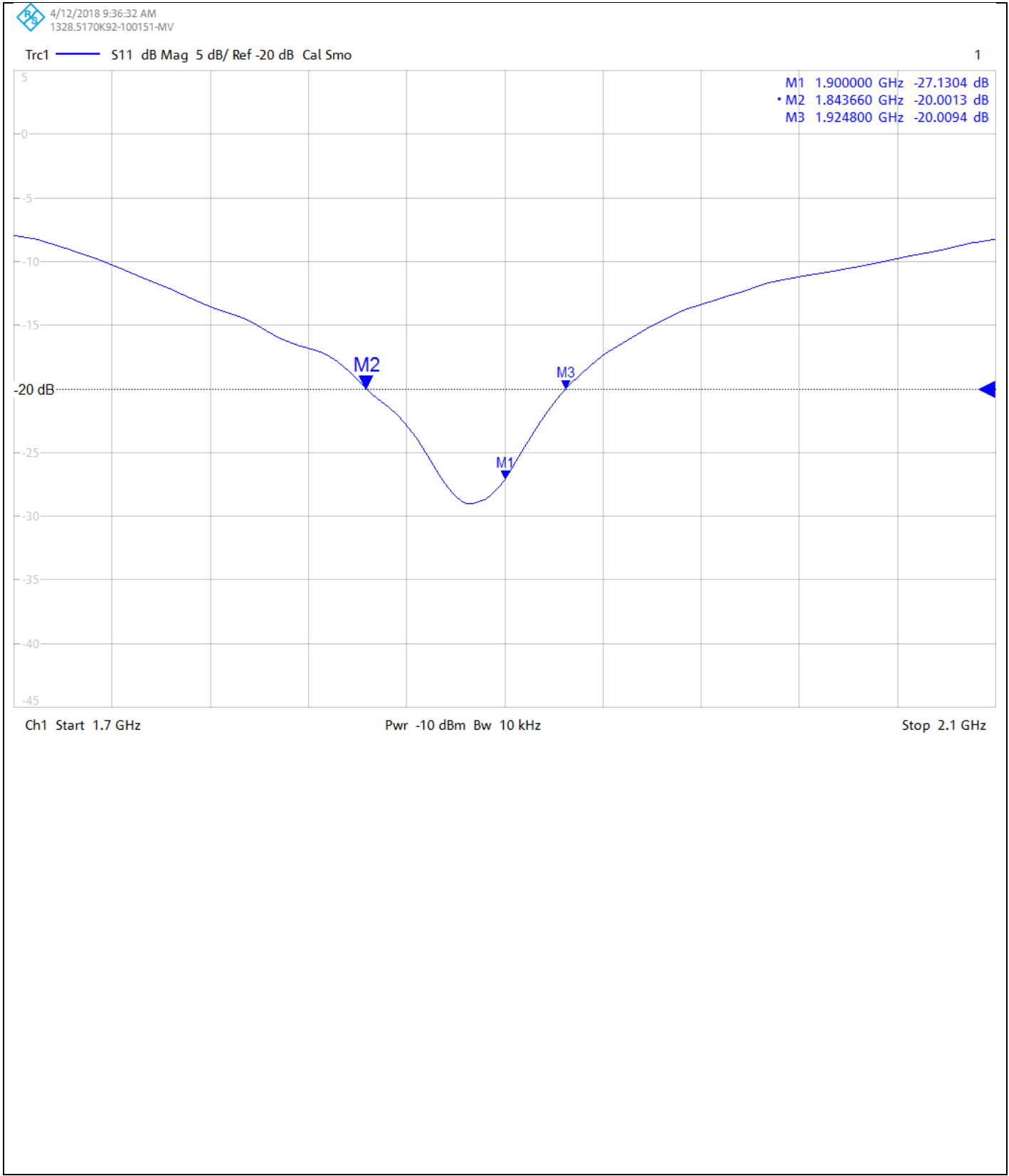
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Page 6 of 10

Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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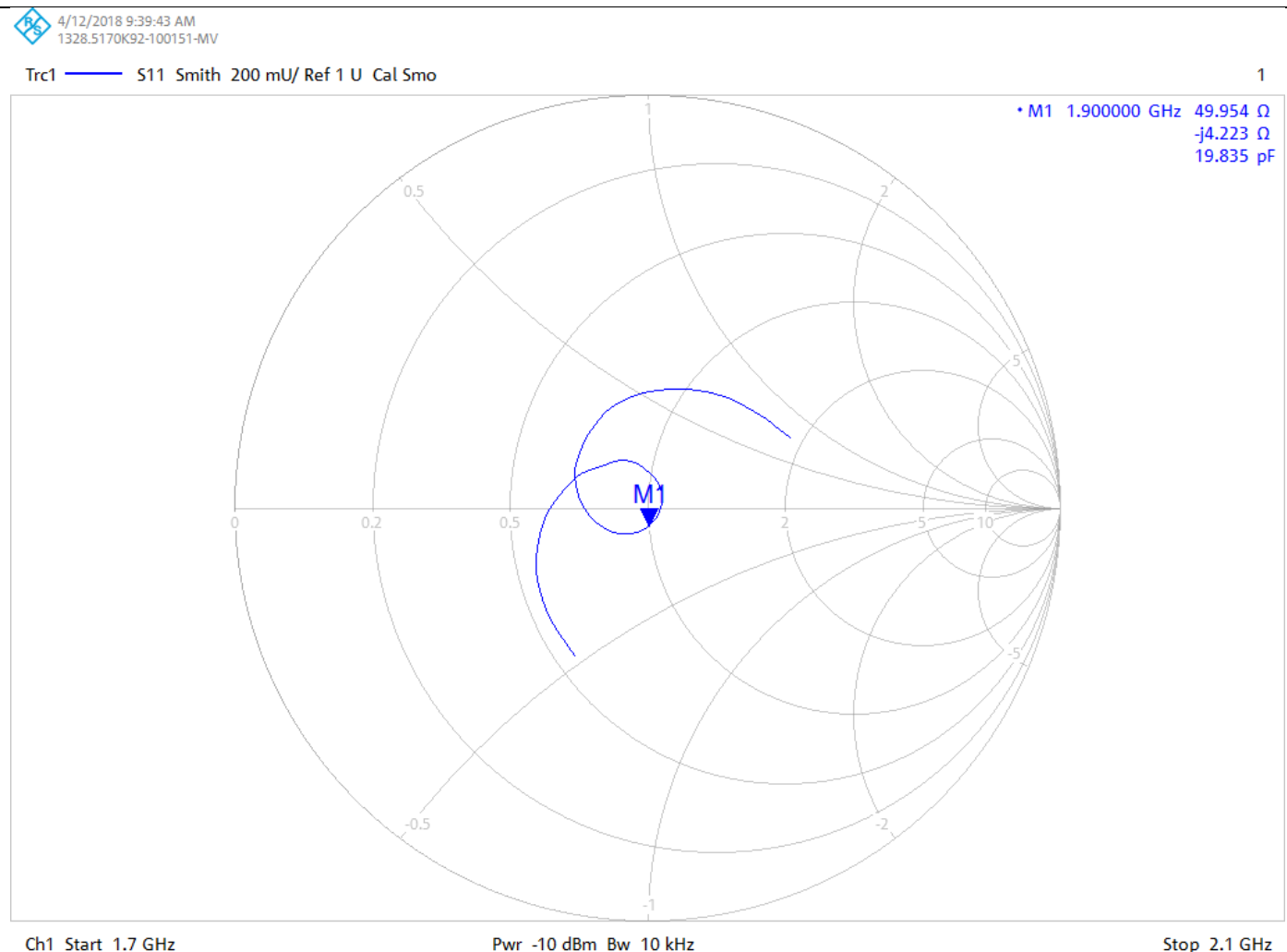
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Page 7 of 10

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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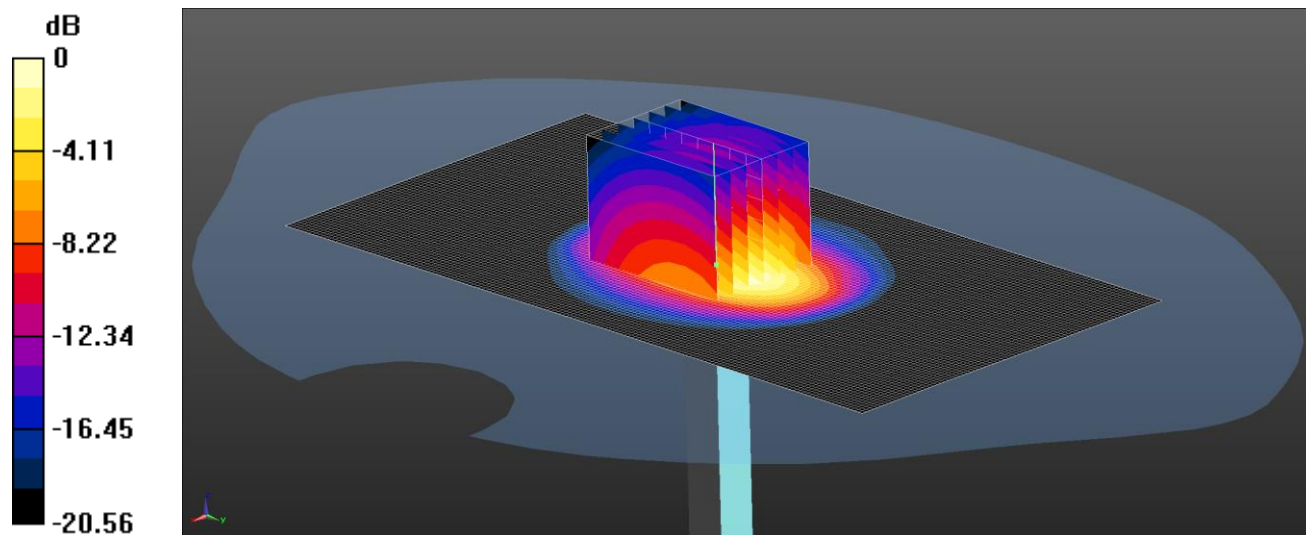
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Page 8 of 10

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D1900V2 - SN5d140; Type: D1900V2; Serial: SN5d140



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

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

Medium: 1900 MHz MSL Medium parameters used: $f = 1900$ MHz; $\sigma = 1.568$ S/m; $\epsilon_r = 51.783$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3814; ConvF(7.57, 7.57, 7.57); Calibrated: 28/09/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn431; Calibrated: 08/11/2017
- Phantom: SAM (20deg probe tilt) with CRP v5.0; Type: QD000P40CC; Serial: TP:1832
- ; SEMCAD X Version 14.6.10 (7372)

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

Maximum value of SAR (interpolated) = 13.6 W/kg

SAR/d=10mm, Pin=250mW/Zoom Scan (5x5x7) (7x9x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 91.82 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 19.1 W/kg

SAR(1 g) = 10.3 W/kg; SAR(10 g) = 5.29 W/kg

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

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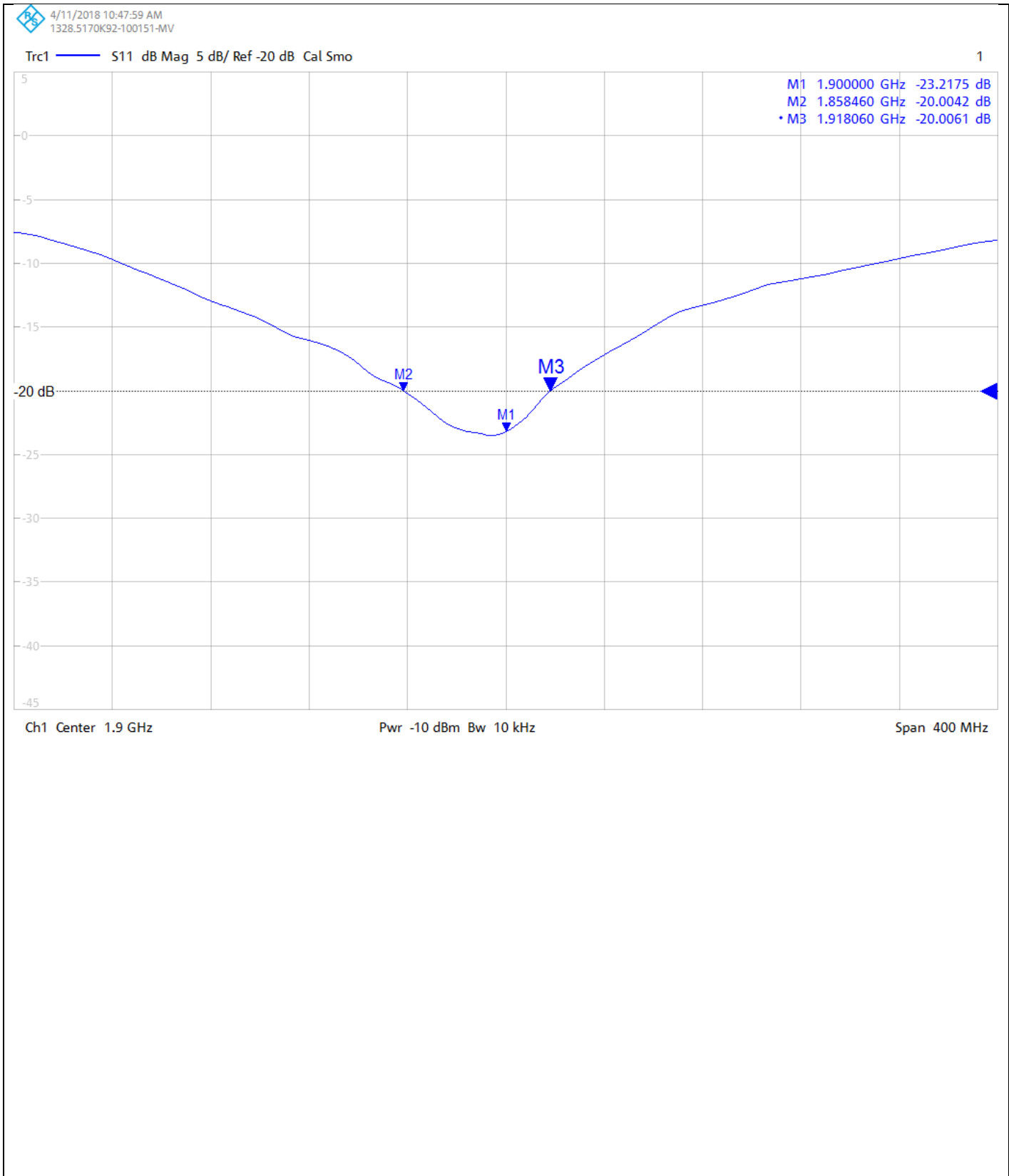
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Page 9 of 10

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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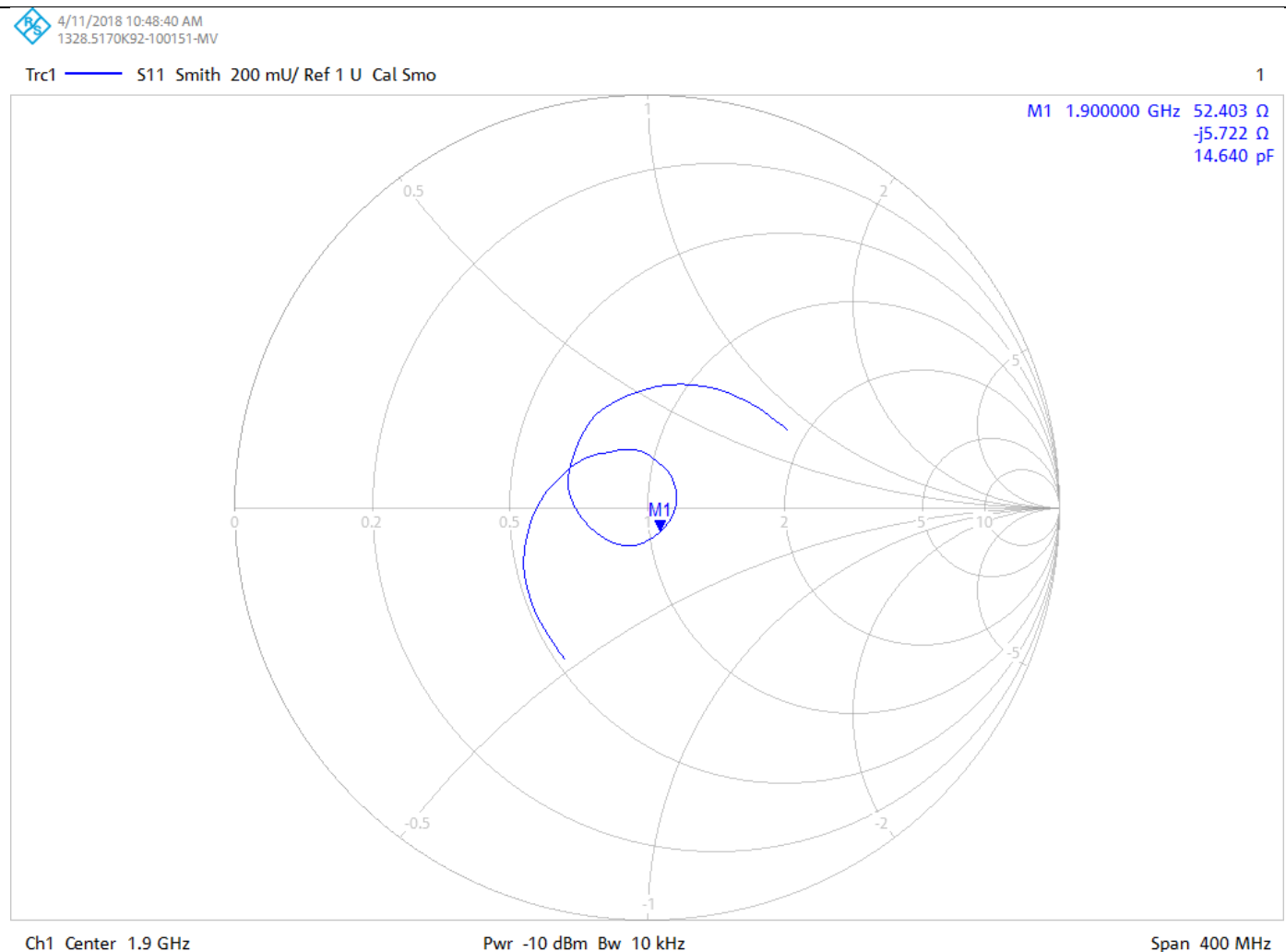
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Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 12134278JD01C Instrument ID: 5d140 Calibration Date: 11/Apr/2018 Calibration Due Date:
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ISSUED BY **UL VS LTD**

DATE OF ISSUE: 19/Feb/2018

CERTIFICATE NUMBER : 12129912JD01A



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BASINGSTOKE, HAMPSHIRE
RG23 8BG, UK
TEL: +44 (0) 1256 312000
FAX: +44 (0) 1256 312001
Email: LST.UK.Calibration@ul.com



Page 1 of 10

APPROVED SIGNATORY

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

.....
Naseer Mirza

Customer :

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	09/Feb/2018
Manufacturer:	Speag		
Type/Model Number:	D2450V2		
Serial Number:	748		
Calibration Date:	14/Feb/2018		
Calibrated By:	Chanthu Thevarajah Laboratory Engineer		
Signature:	A handwritten signature in blue ink, appearing to read 'C. Thevarajah'.		

.....

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

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

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

CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

UKAS Accredited Calibration Laboratory No. 5248

CERTIFICATE
NUMBER :
12129912JD01A

Page 2 of 10

The calibration methods and procedures used were as detailed in:

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

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2110	Data Acquisition Electronics	SPEAG	DAE4	431	08 Nov 2017	12
A2077	Probe	SPEAG	EX3DV4	3814	28 Sep 2017	12
A1322	Dipole	SPEAG	D2450V2	725	19 Sep 2017	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	12
PRE0176448	Power Sensor	Rhode & Schwarz	NRP-Z51	103459	20 June 2017	12
M1015	Network Analyser	Agilent Technologies	8753ES	US39172406	10 Oct 2017	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2016	24
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947-Bt	09 May 2016	12
M1838	Signal Generator	Rhode & Schwarz	SME06	831377/005	30 March 2017	12

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Page 3 of 10

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:	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	22.0 °C	22.0 °C	21.6°C	22.0°C	ϵ_r	39.20	38.11	± 5%
						σ	1.80	1.78	± 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	13.30 W/Kg	52.94 W/Kg	± 17.57%
	SAR averaged over 10g	6.18 W/Kg	24.60 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	52.358 Ω 3.89 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	27.52	± 2.03 dB

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Page 4 of 10

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	2450	22.0 °C	22.0 °C	21.6°C	22.0°C	ϵ_r	52.70	50.63	± 5%
						σ	1.95	2.02	± 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	12.80 W/Kg	50.95 W/Kg	± 18.06%
	SAR averaged over 10g	5.98 W/Kg	23.80 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	52.47 Ω -1.10 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	30.00	± 2.03 dB

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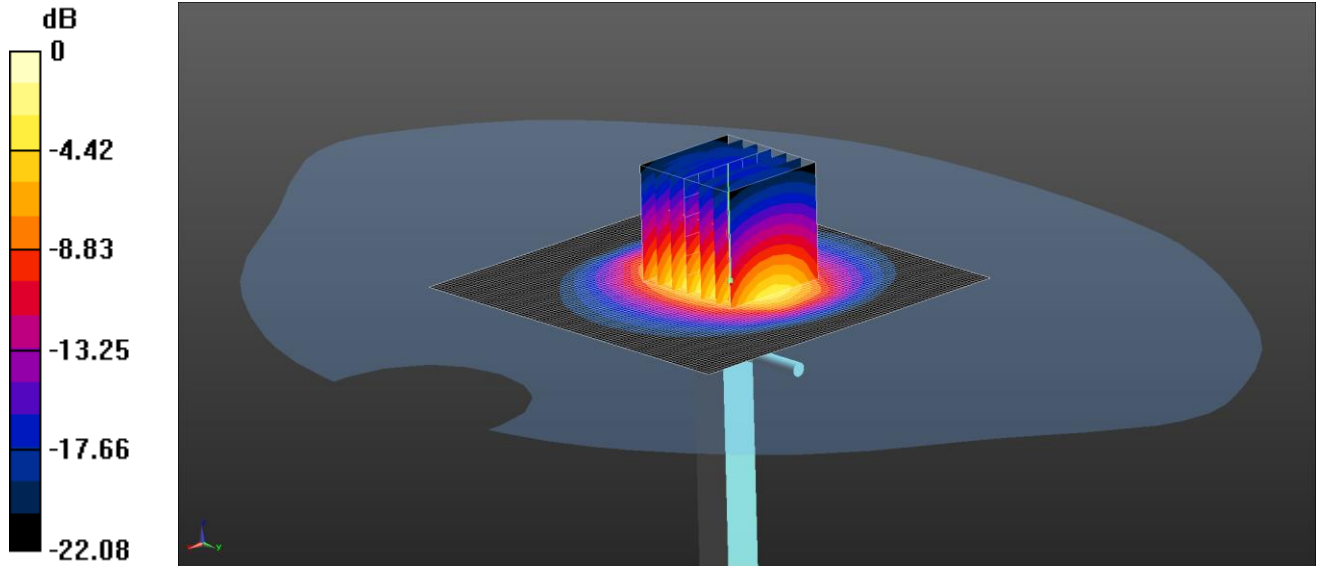
UKAS Accredited Calibration Laboratory No. 5248

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NUMBER :
12129912JD01A

Page 5 of 10

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D2450V2 - SN748; Type: D2450V2; Serial: SN748



0 dB = 17.6 W/kg = 12.46 dBW/kg

Communication System: UID 0, CW (0); Frequency: 2450 MHz; Duty Cycle: 1:1

Medium: 2450 MHz HSL Medium parameters used: $f = 2450$ MHz; $\sigma = 1.779$ S/m; $\epsilon_r = 38.111$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3814; ConvF(7.04, 7.04, 7.04); Calibrated: 28/09/2017;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn431; Calibrated: 08/11/2017
- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:1818
- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW /Area Scan (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

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

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

Reference Value = 97.54 V/m; Power Drift = 0.14 dB

Peak SAR (extrapolated) = 27.6 W/kg

SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.18 W/kg

Maximum value of SAR (measured) = 17.6 W/kg

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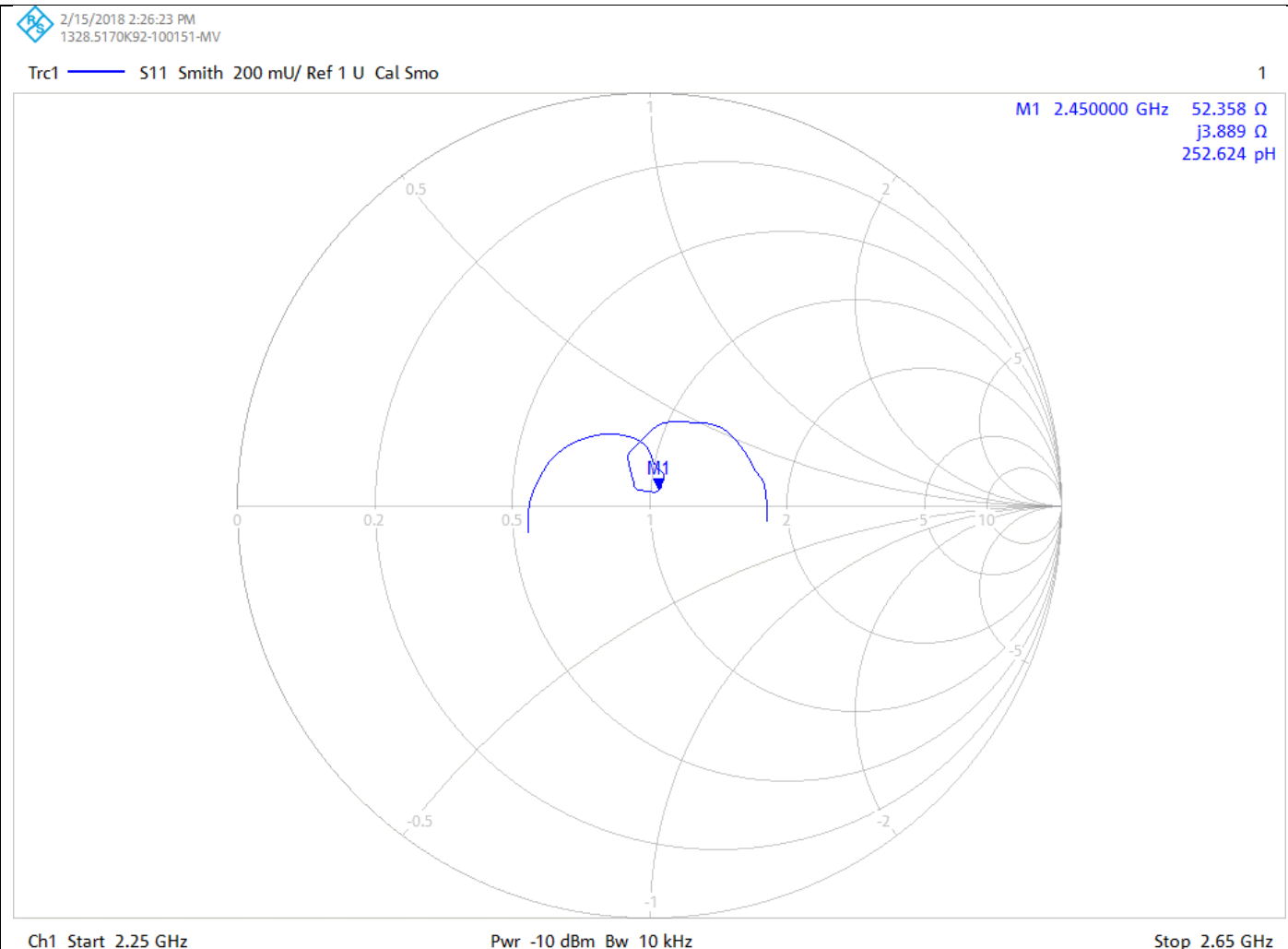
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Page 6 of 10

Impedance Measurement Plot for Head Stimulating Liquid (HSL)



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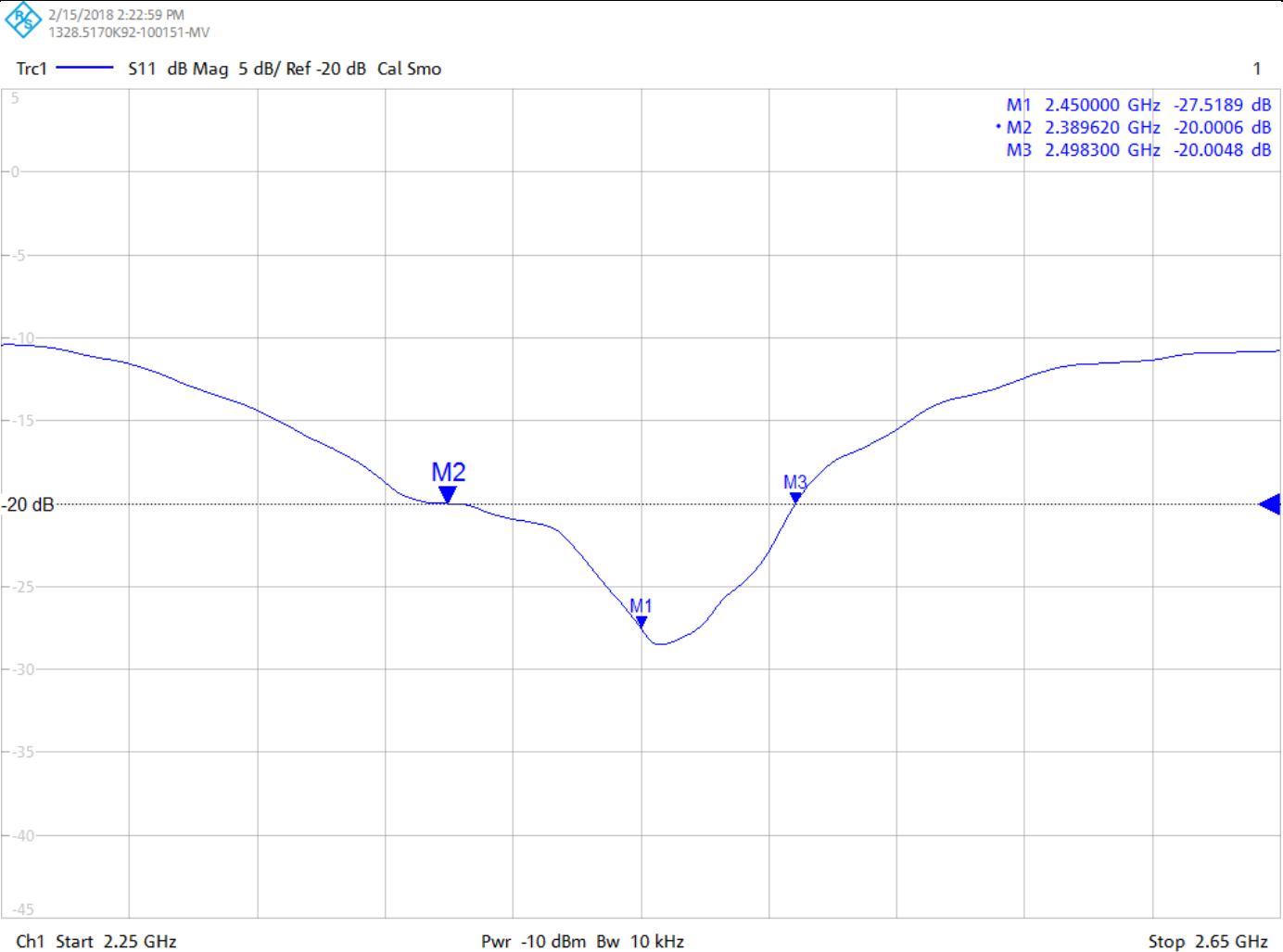
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Page 7 of 10

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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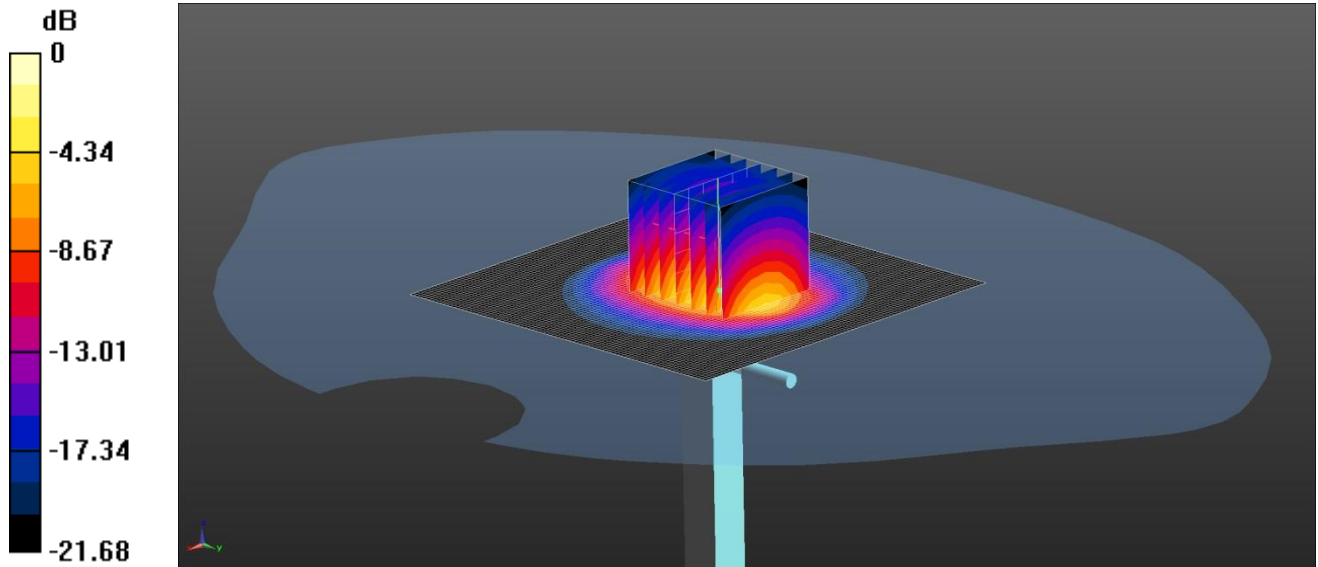
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NUMBER :
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Page 8 of 10

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D2450V2 - SN748; Type: D2450V2; Serial: SN748



0 dB = 19.4 W/kg = 12.88 dBW/kg

Communication System: UID 0, CW (0); Frequency: 2450 MHz; Duty Cycle: 1:1

Medium: 2450 MSL Medium parameters used: $f = 2450$ MHz; $\sigma = 2.02$ S/m; $\epsilon_r = 50.632$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: EX3DV4 - SN3814; ConvF(7.2, 7.2, 7.2); Calibrated: 28/09/2017;

- Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 2mm (Mechanical Surface Detection)

- Electronics: DAE4 Sn431; Calibrated: 08/11/2017

- Phantom: SAM (20deg probe tilt) with CRP v4.0; Type: QD000P40CC; Serial: TP:1818

- ; SEMCAD X Version 14.6.10 (7372)

Configuration/d=10mm, Pin=250mW /Area Scan (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 15.4 W/kg

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

Reference Value = 85.33 V/m; Power Drift = -0.00 dB

Peak SAR (extrapolated) = 25.8 W/kg

SAR(1 g) = 12.8 W/kg; SAR(10 g) = 5.98 W/kg

Maximum value of SAR (measured) = 19.4 W/kg

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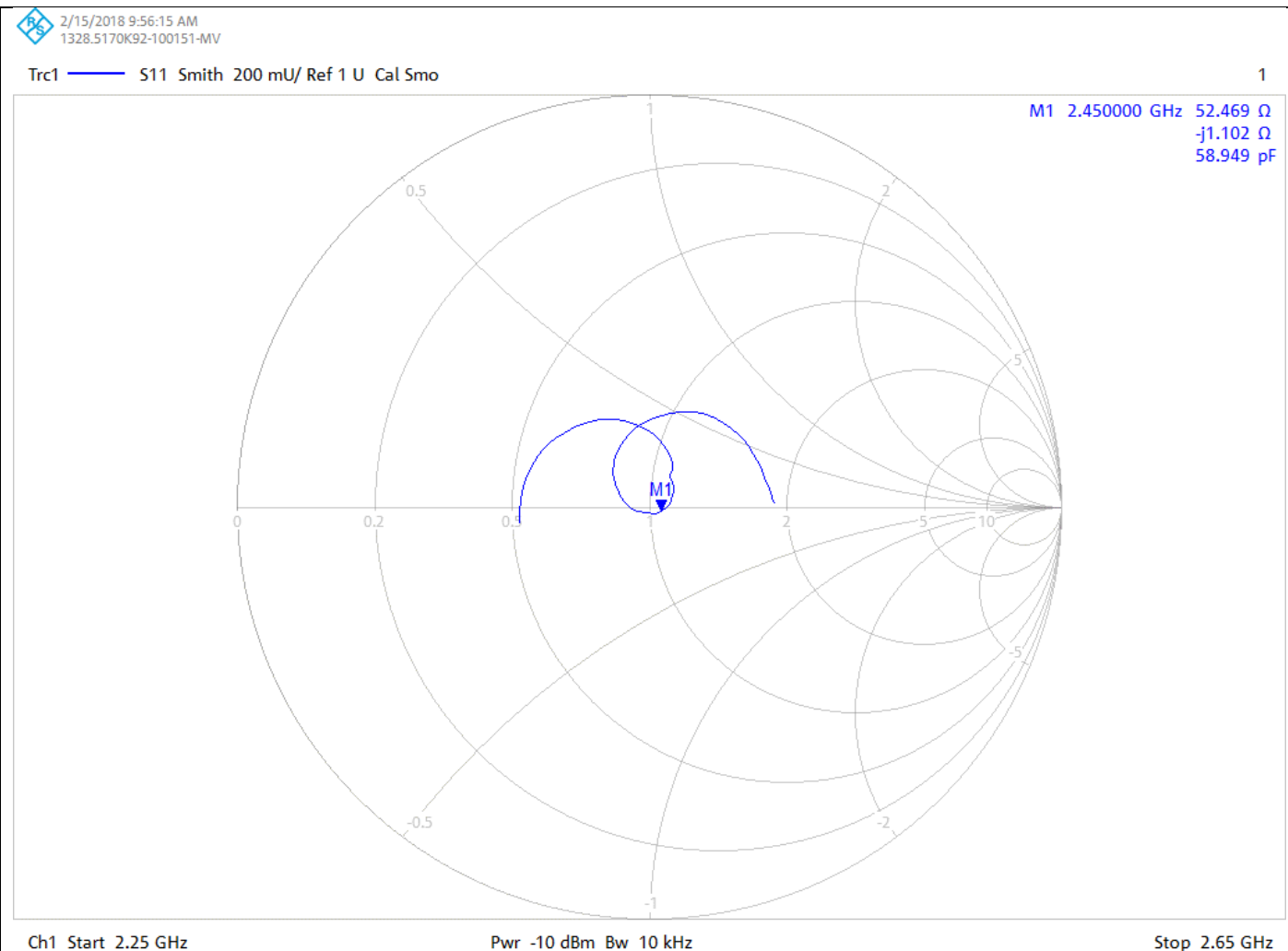
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Page 9 of 10

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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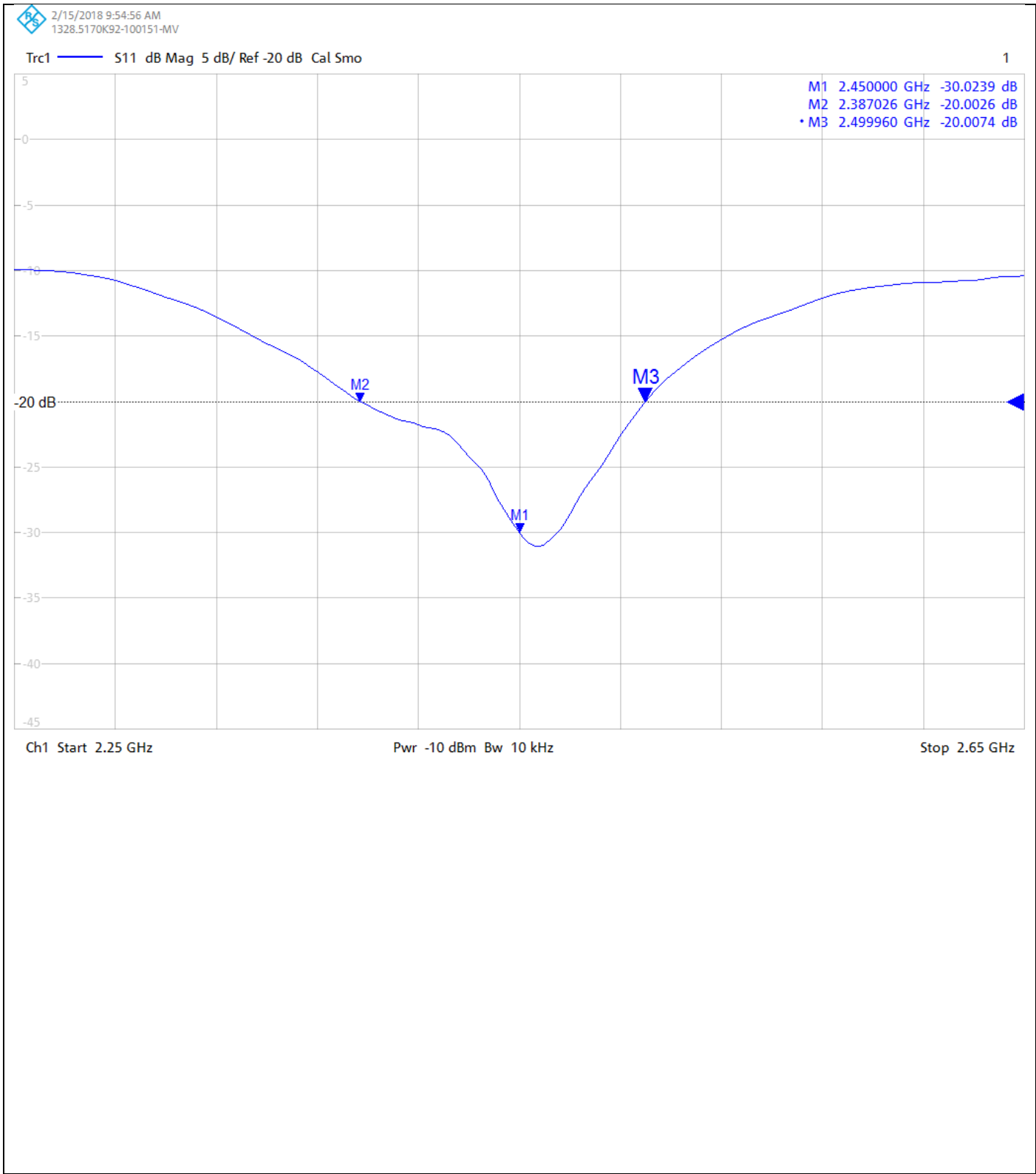
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NUMBER :
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Page 10 of 10

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

 5248	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 12129912JD01A Instrument ID: 748 Calibration Date: 14/Feb/2018 Calibration Due Date:
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 5248	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 12129912JD01A Instrument ID: 748 Calibration Date: 14/Feb/2018 Calibration Due Date:
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CERTIFICATE OF CALIBRATION

ISSUED BY UL VS LTD

DATE OF ISSUE: 10/Oct/2017

CERTIFICATE NUMBER : 11903941JD01E



5248

UL VS LTD
PAVILION A
ASHWOOD PARK, ASHWOOD WAY
BASINGSTOKE, HAMPSHIRE
RG23 8BG, UK
TEL: +44 (0) 1256 312000
FAX: +44 (0) 1256 312001
Email: LST.UK.Calibration@ul.com



Page 1 of 10

APPROVED SIGNATORY

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:	D2600V2		
Serial Number:	1006		
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%

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Page 2 of 10

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
A2767	Dipole	SPEAG	D2600V2	1109	13 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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Page 3 of 10

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:	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	23.0 °C	22.0 °C	20.0°C	22.0°C	ϵ_r	39.00	37.06	± 5%
						σ	1.96	1.97	± 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	14.00 W/Kg	55.73 W/Kg	± 17.57%
	SAR averaged over 10g	6.30 W/Kg	25.08 W/Kg	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	50.38 Ω 6.70 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	23.52	± 1.27 dB

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Page 4 of 10

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	22.0 °C	22.0 °C	22.0°C	22.0°C	ϵ_r	52.50	51.39	± 5%
						σ	2.16	2.19	± 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	14.10 W/Kg	56.13 W/Kg	± 18.06%
	SAR averaged over 10g	6.28 W/Kg	25.00 W/Kg	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	48.51 Ω -2.73 j Ω	± 0.28 Ω ± 0.044 j Ω
	Return Loss	30.37	± 1.27 dB

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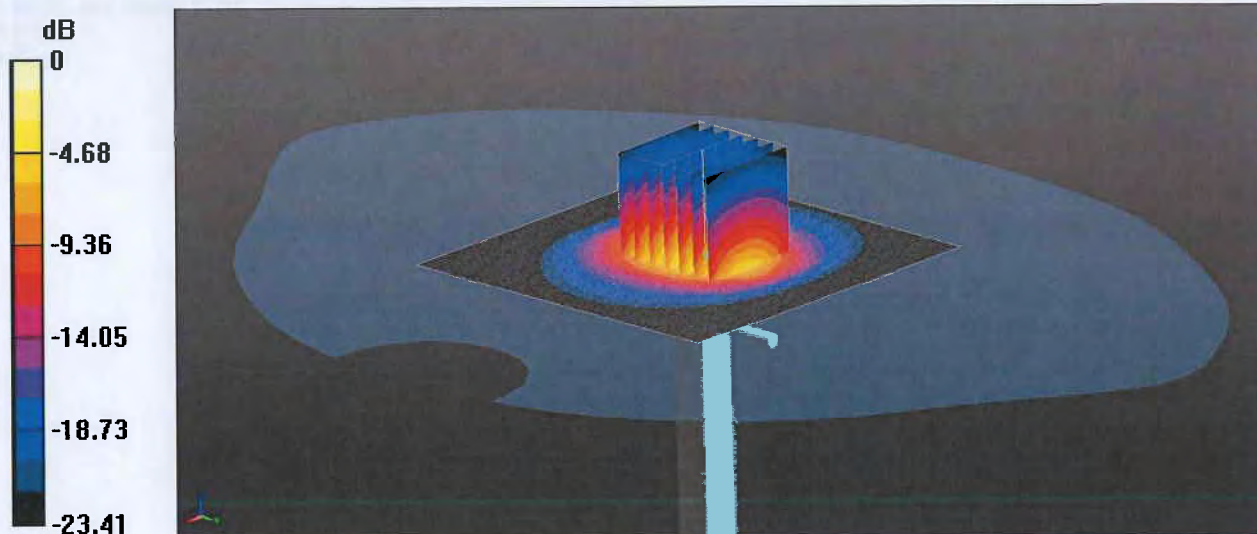
UKAS Accredited Calibration Laboratory No. 5248

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NUMBER :
11903941JD01E

Page 5 of 10

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1006



0 dB = 21.7 W/kg = 13.36 dBW/kg

Communication System: UID 0, CW (0); Frequency: 2600 MHz; Duty Cycle: 1:1

Medium: 2600 MHz HSL Medium parameters used: $f = 2600$ MHz; $\sigma = 1.971$ S/m; $\epsilon_r = 37.058$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(4.5, 4.5, 4.5); Calibrated: 14/08/2017;

- Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 2mm (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 (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 15.9 W/kg

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

Reference Value = 91.28 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 29.9 W/kg

SAR(1 g) = 14 W/kg; SAR(10 g) = 6.3 W/kg

Maximum value of SAR (measured) = 21.7 W/kg

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Page 6 of 10

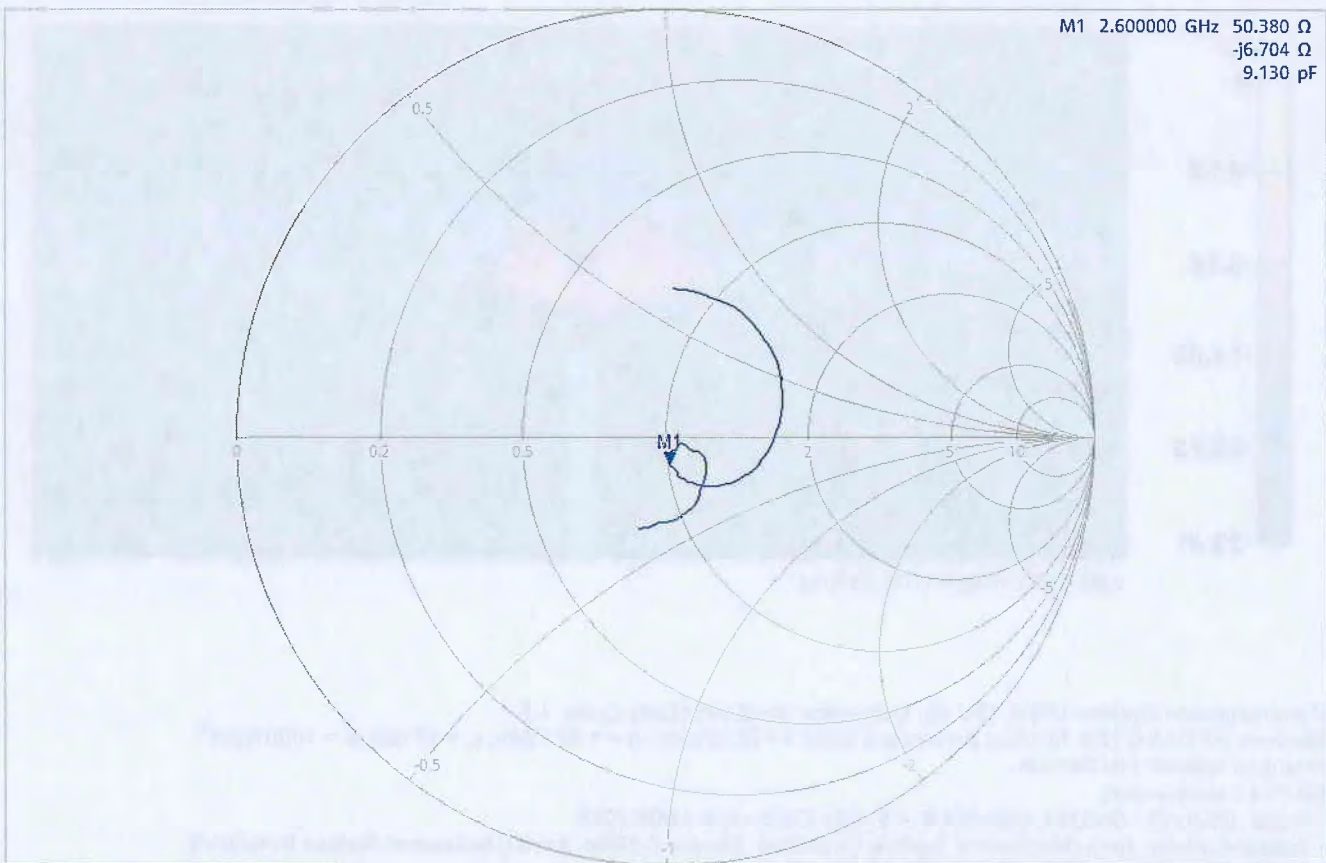
Impedance Measurement Plot for Head Stimulating Liquid (HSL)

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1328.5170K62-100151-MV

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

1

M1 2.600000 GHz 50.380 Ω
-j6.704 Ω
9.130 pF



Ch1 Start 2.4 GHz

Pwr -10 dBm Bw 10 kHz

Stop 2.8 GHz

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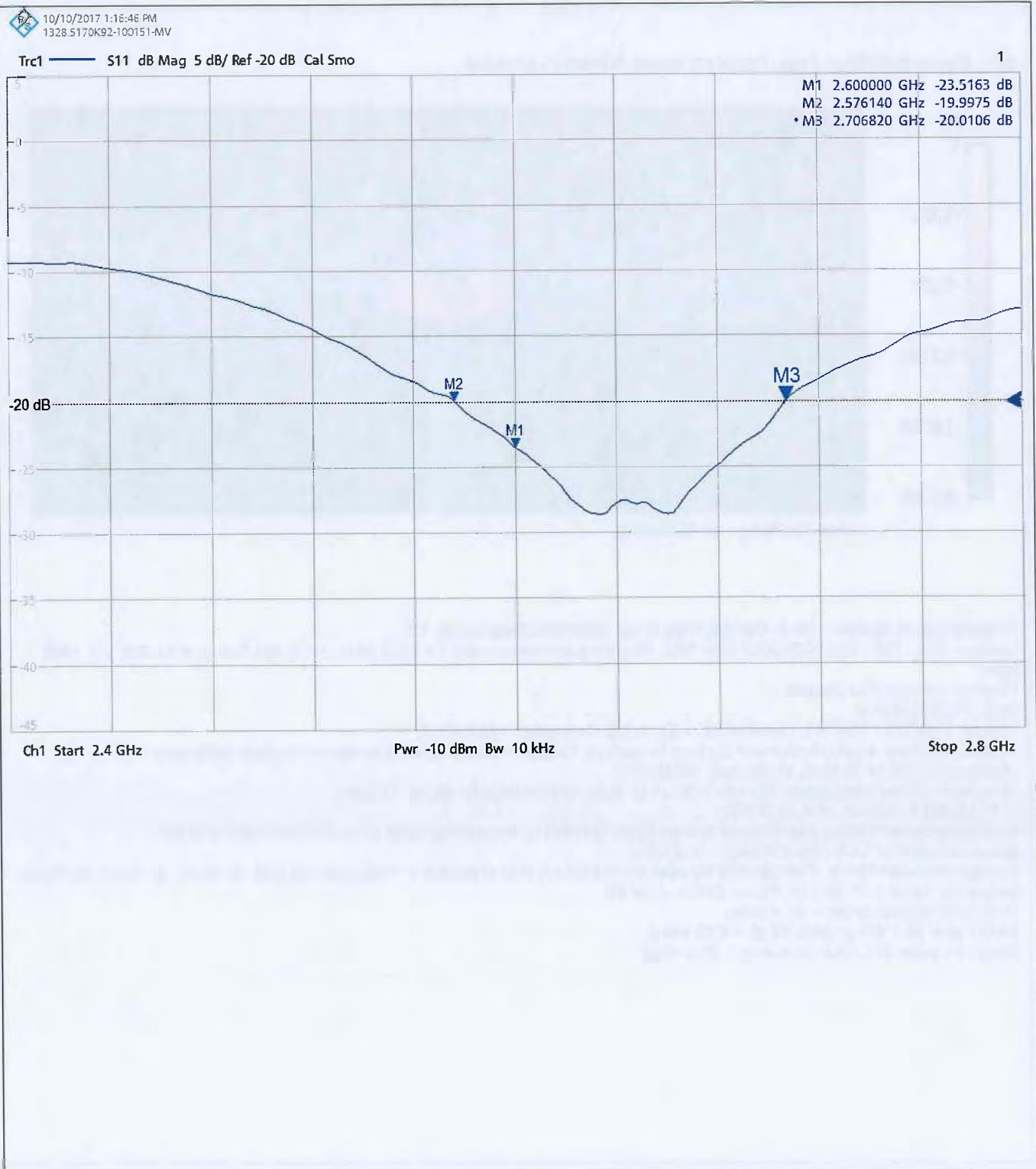
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11903941JD01E

Page 7 of 10

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



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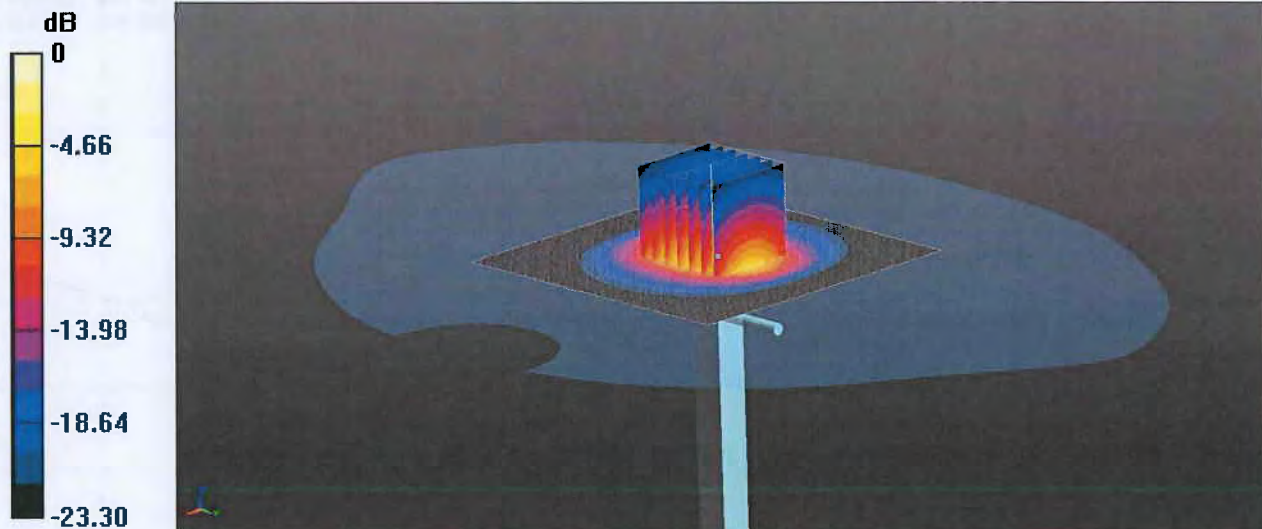
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Page 8 of 10

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 2600 MHz; Type: D2600V2; Serial: D2600V2 - SN:1006



0 dB = 22.3 W/kg = 13.48 dBW/kg

Communication System: UID 0, CW (0); Frequency: 2600 MHz; Duty Cycle: 1:1

Medium: 900,1750,1800,1900,2600 MHz MSL Medium parameters used: $f = 2600$ MHz; $\sigma = 2.189$ S/m; $\epsilon_r = 51.388$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY4 Configuration:

- Probe: ES3DV3 - SN3341; ConvF(4.32, 4.32, 4.32); Calibrated: 14/08/2017;
- Sensor-Surface: 4mm (Mechanical Surface Detection), Sensor-Surface: 2mm (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 (81x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm

Maximum value of SAR (interpolated) = 16.2 W/kg

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

Reference Value = 87.50 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 31.4 W/kg

SAR(1 g) = 14.1 W/kg; SAR(10 g) = 6.28 W/kg

Maximum value of SAR (measured) = 22.3 W/kg

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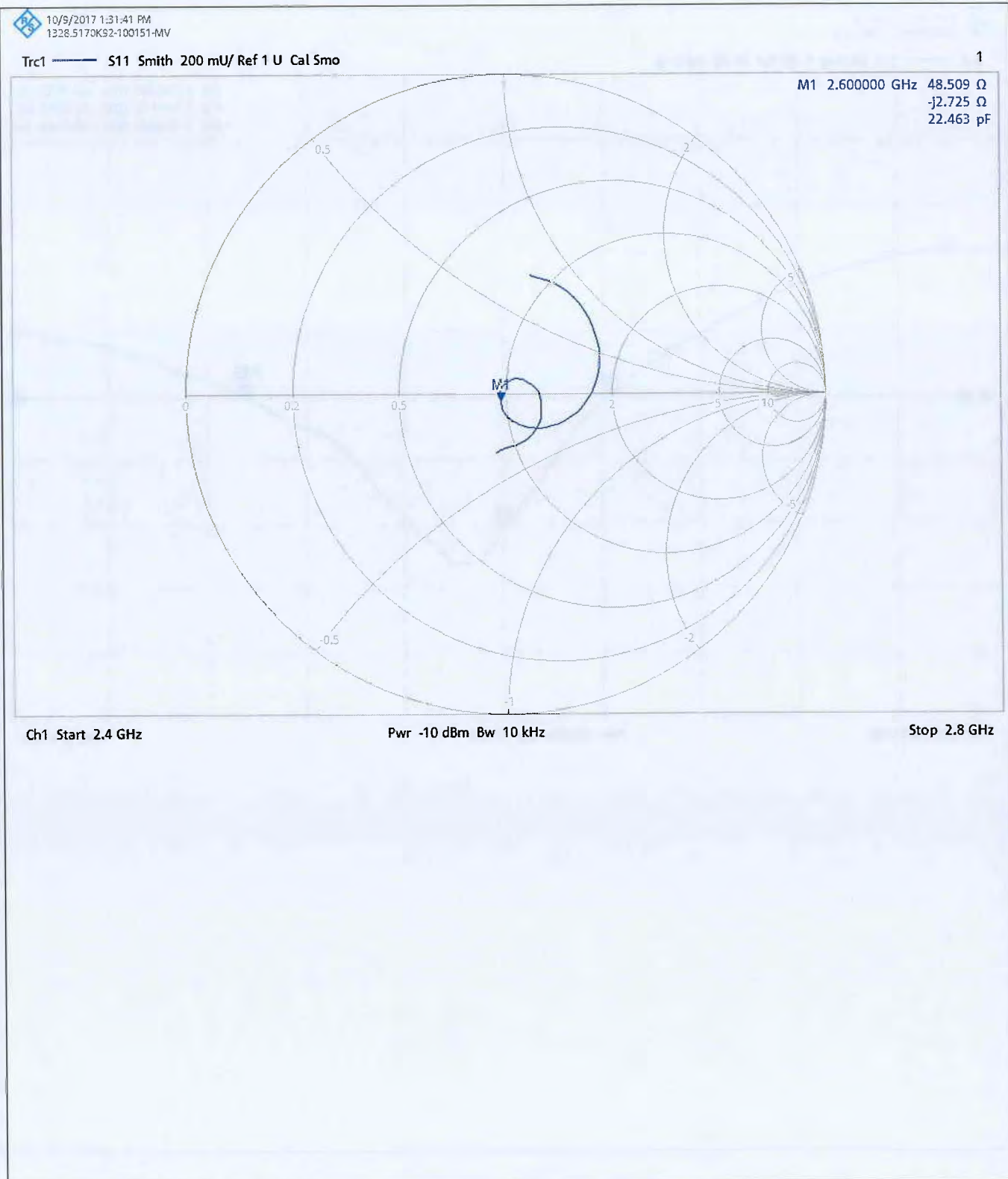
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Page 9 of 10

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



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Page 10 of 10

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)

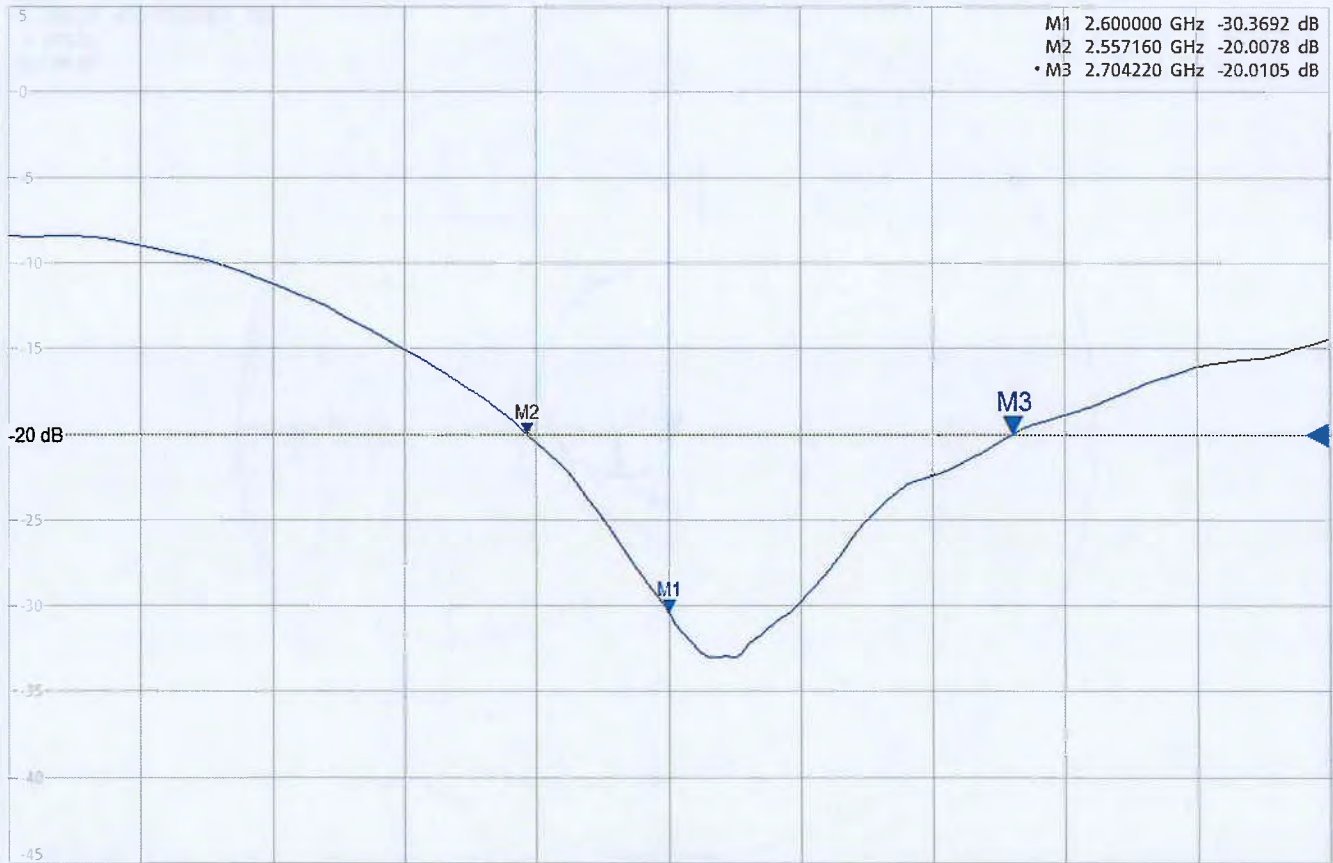


10/9/2017 1:30:54 PM
1328.5170K92-100151-MV

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

1

M1 2.600000 GHz -30.3692 dB
M2 2.557160 GHz -20.0078 dB
• M3 2.704220 GHz -20.0105 dB



Ch1 Start 2.4 GHz

Pwr -10 dBm Bw 10 kHz

Stop 2.8 GHz

Calibration Certificate Label:

	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date:
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	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date:
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	UL VS LTD - Tel: +44 (0) 1256312000 Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date:
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