CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 12/Apr/2018 CERTIFICATE NUMBER : 12134278JD01C

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

APPROVED SIGNATORY

.....

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:	.....		

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}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.

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

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 ℃	22.0 ℃	24.0℃	22.0℃	**εr**	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 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	27.13	± 2.03 dB

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 ℃	22.0 ℃	21.5℃	21.5℃	**εr**	53.30	51.78	± 5%
						σ	1.52	1.57	± 5%

SAR Results – Body Simulating Liquid (MSL)

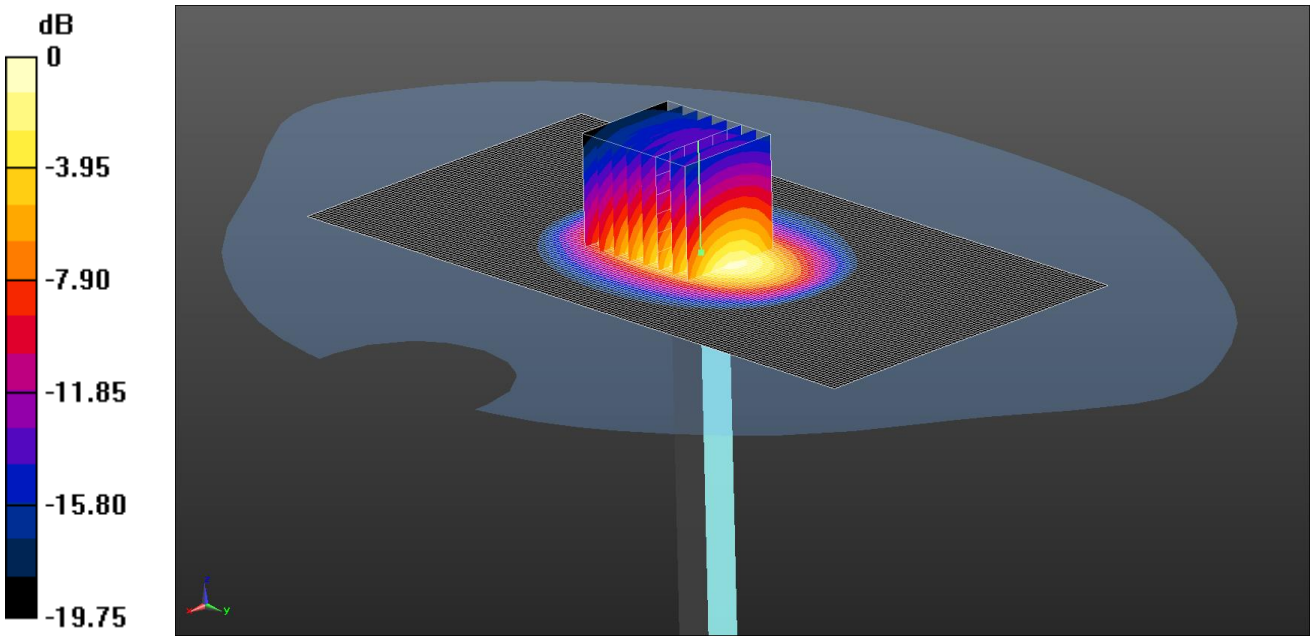
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	10.30 W/Kg	**41.00 W/Kg**	± 18.06%
	SAR averaged over 10g	5.29 W/Kg	**21.05 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

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

DASY Validation Scan for Head Stimulating Liquid (HSL)

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

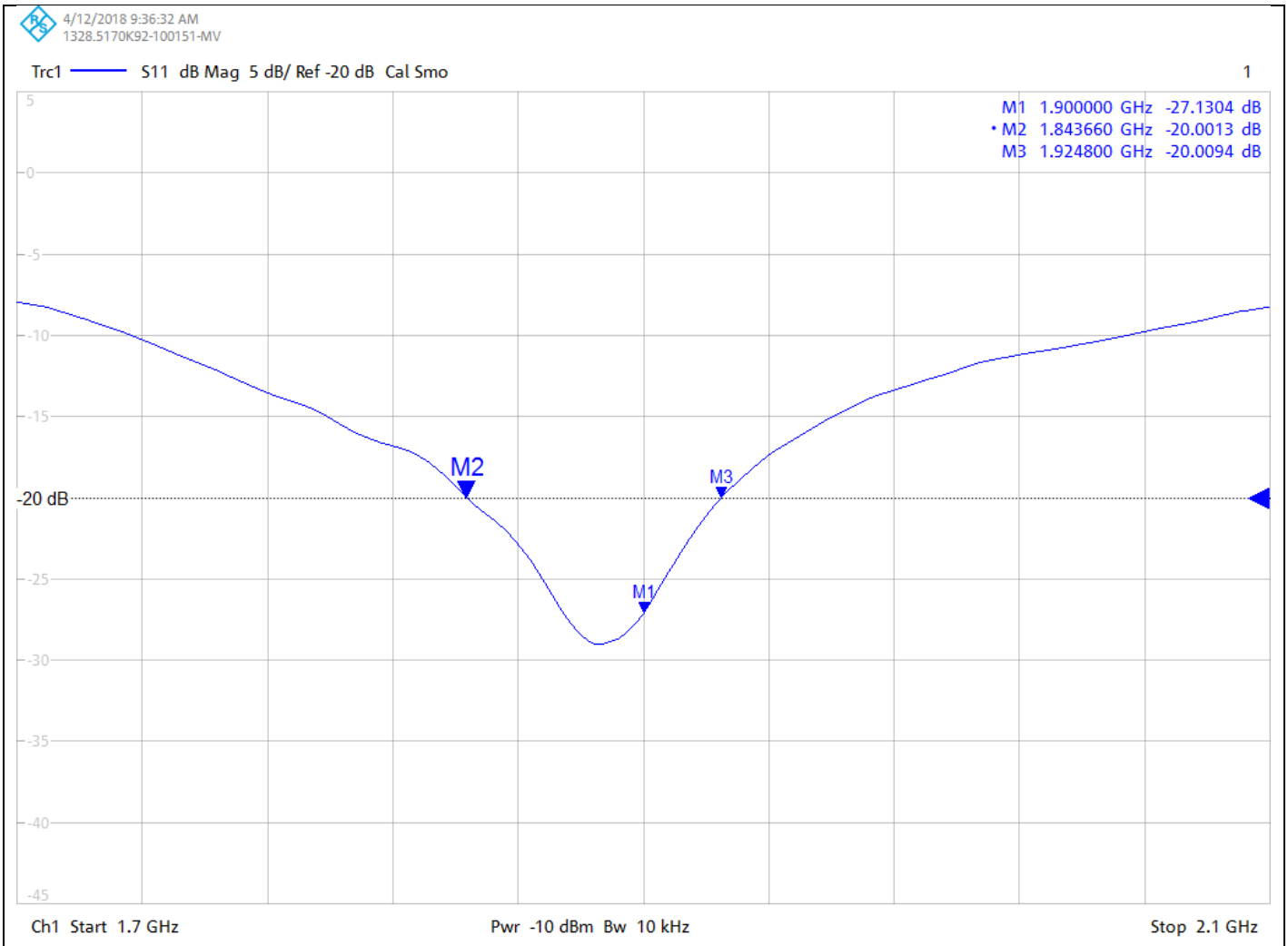


0 dB = 12.4 W/kg = 10.93 dBW/kg

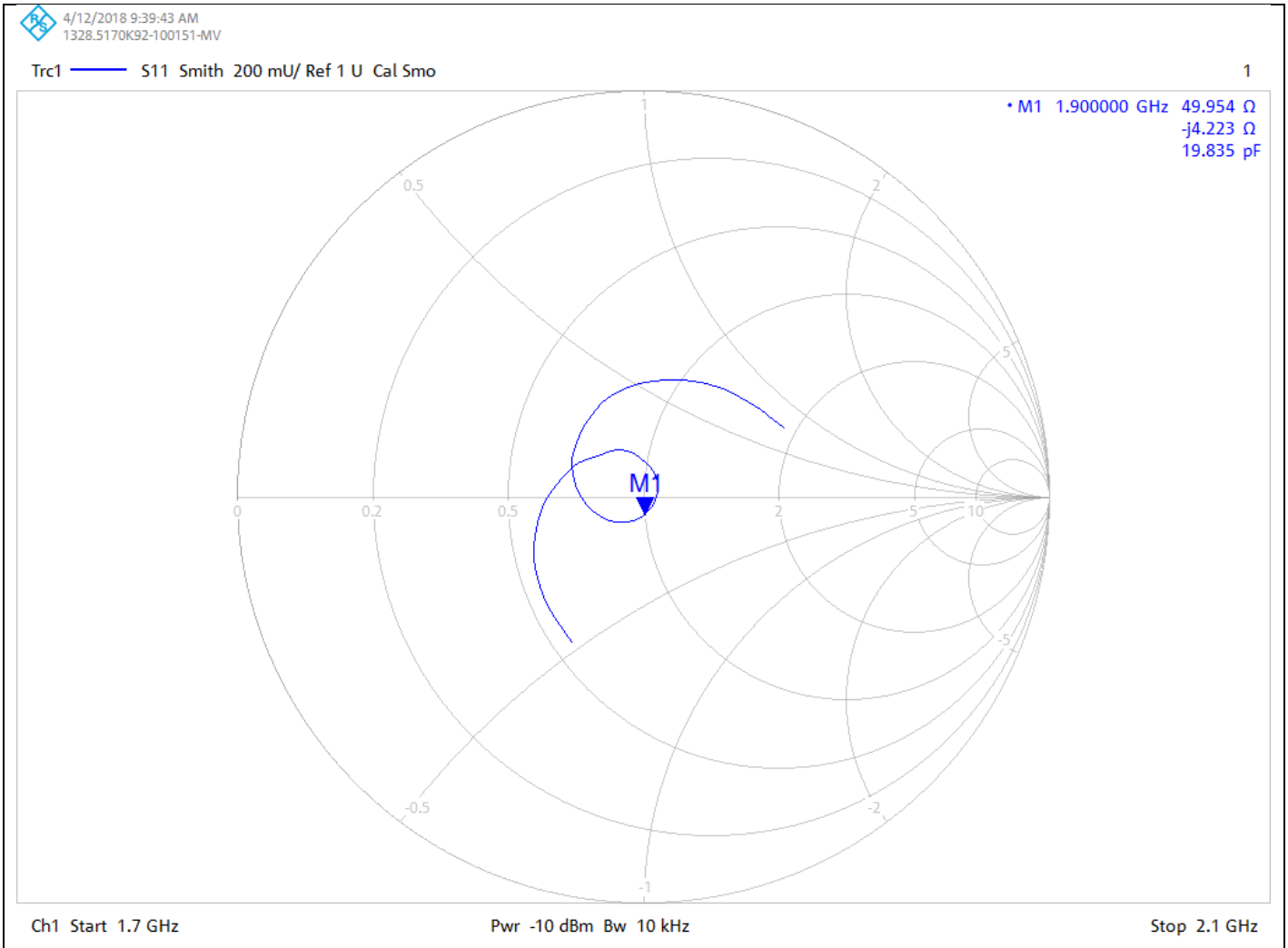
Communication System: UID 0, CW (0); Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 MHz MSL Medium parameters used: f = 1900 MHz; σ = 1.392 S/m; ε_r = 39.154; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.84, 7.84, 7.84); Calibrated: 28/09/2017;
- 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

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

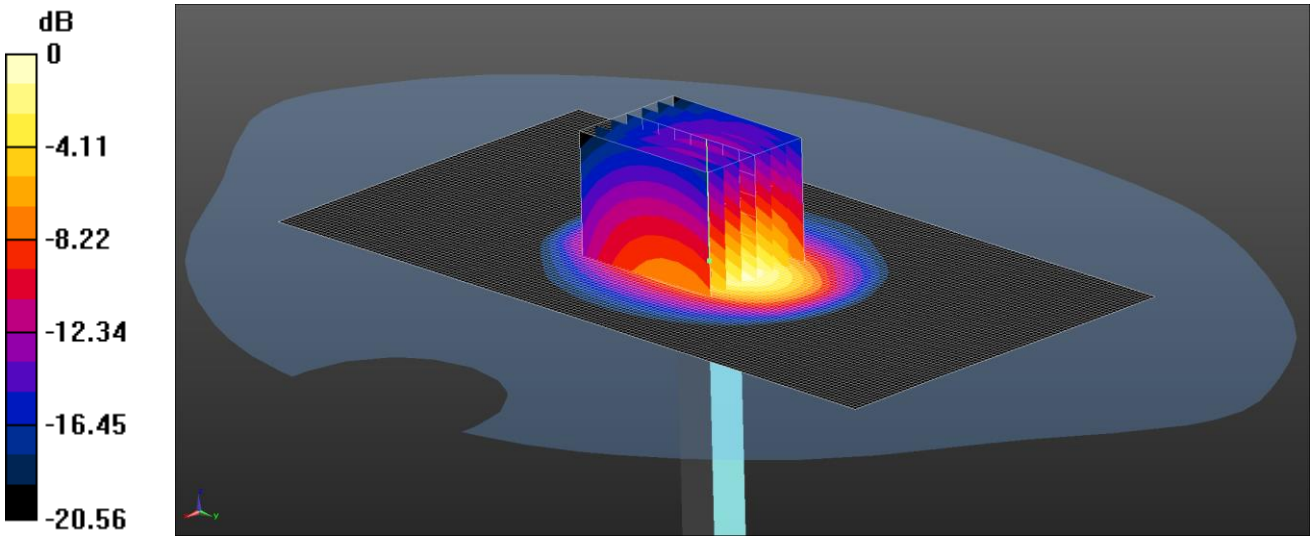


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

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



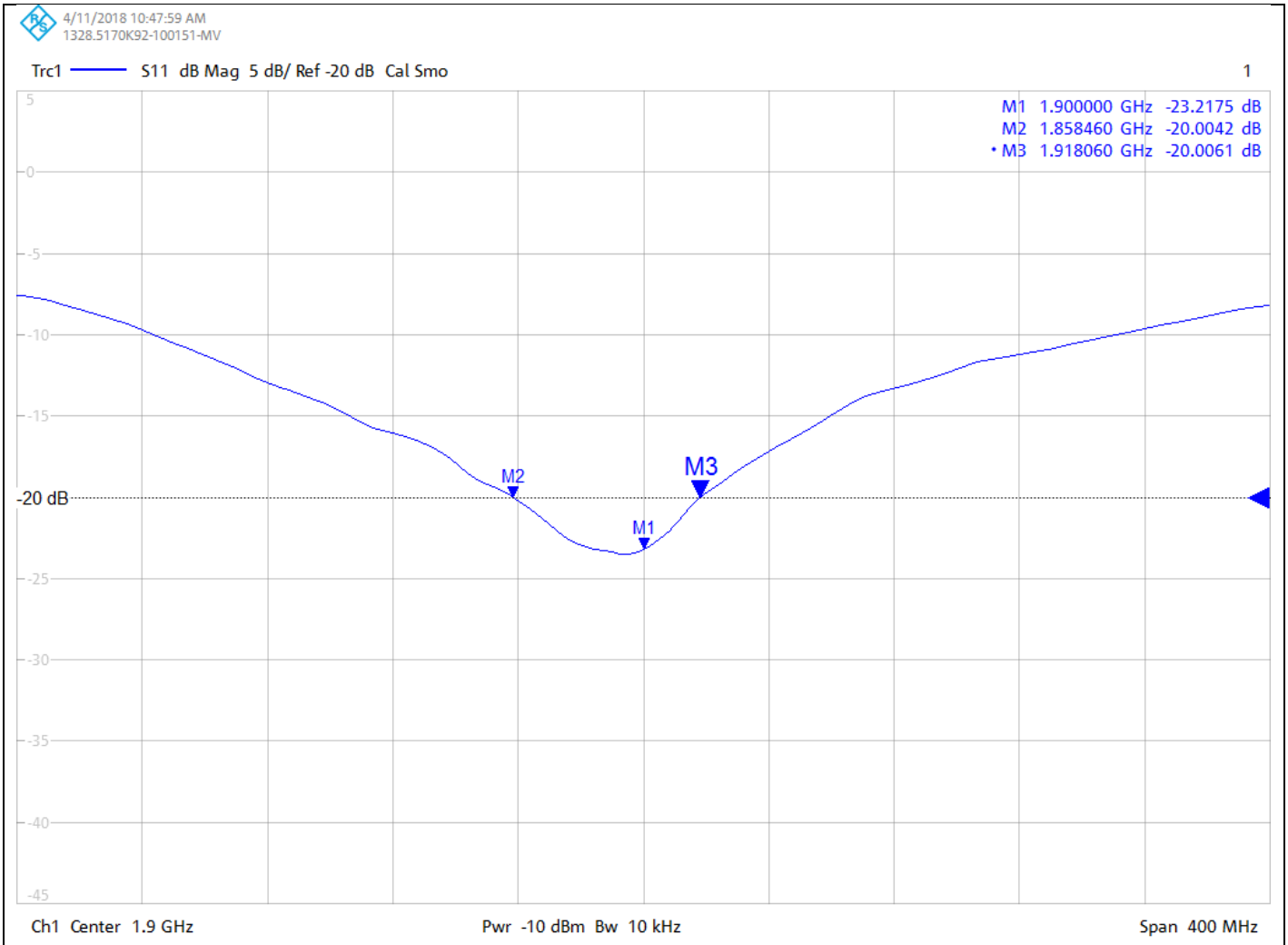
0 dB = 13.1 W/kg = 11.17 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 MHz MSL Medium parameters used: f = 1900 MHz; σ = 1.568 S/m; ε_r = 51.783; ρ = 1000 kg/m^3
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)

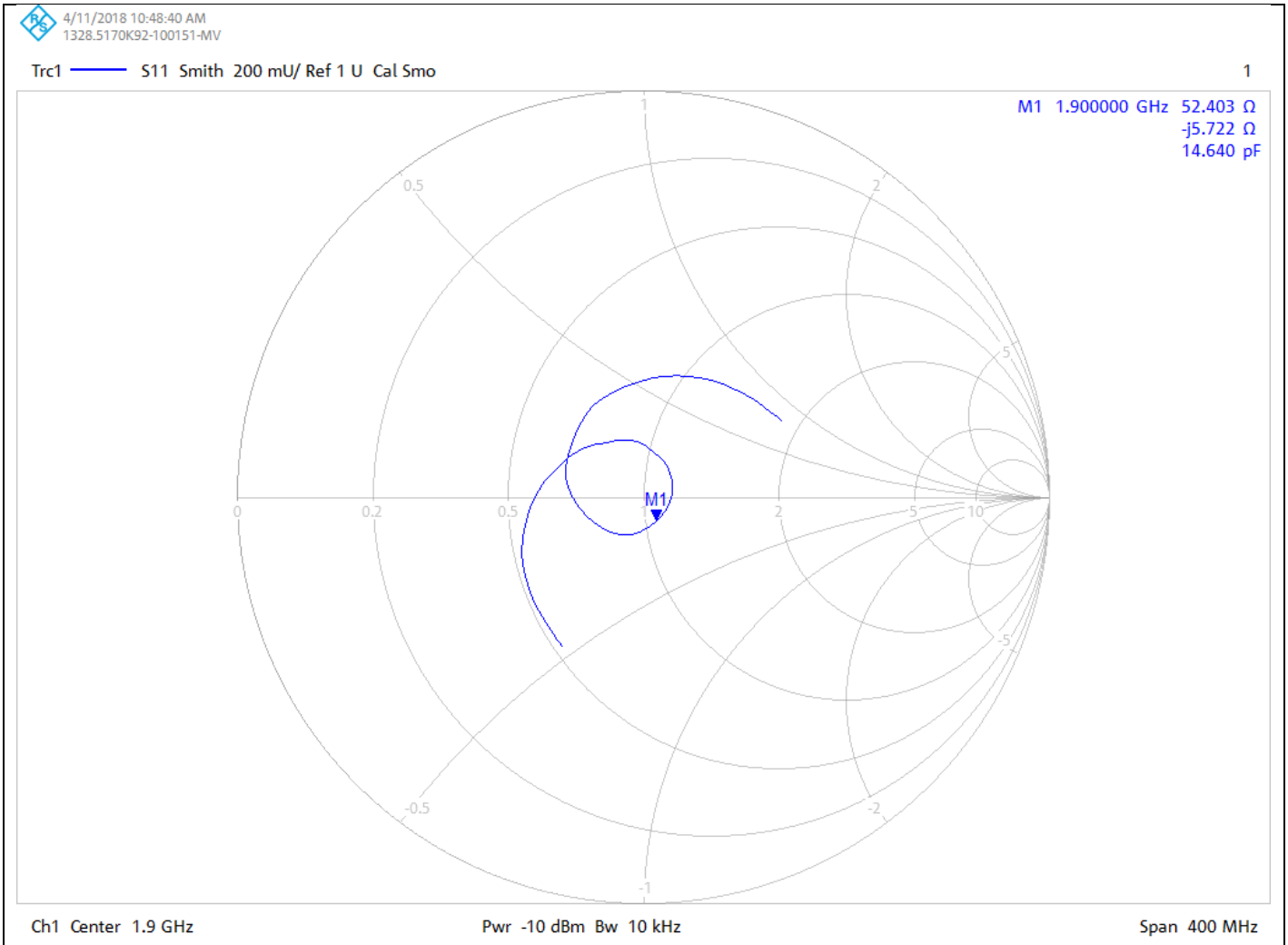
SAR/d=10mm, Pin=250mW/Area Scan (81x151x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 13.6 W/kg

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

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134278JD01C Instrument ID: 5d140 Calibration Date: 11/Apr/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134278JD01C Instrument ID: 5d140 Calibration Date: 11/Apr/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134278JD01C Instrument ID: 5d140 Calibration Date: 11/Apr/2018 Calibration Due Date:

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 29/Nov/2017 CERTIFICATE NUMBER : 11903932JD01E

5248

UL VS LTD
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Email: LST.UK.Calibration@ul.com

APPROVED SIGNATORY

.....

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:	D1900V2		
Serial Number:	5d043		
Calibration Date:	22/Nov/2017		
Calibrated By:	Chanthu Thevarajah Laboratory Engineer		
Signature:			

.....

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}C and humidity < 70%

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The calibration methods and procedures used were as detailed in:

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

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2546	Data Acquisition Electronics	SPEAG	DAE4	1435	10 Feb 2017	12
A2545	Probe	SPEAG	ES3DV4	3395	04 May 2017	12
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
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

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	21.0 °C	21.0 °C	20.5°C	21.0°C	εr	40.00	39.91	± 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	10.80 W/Kg	**42.99 W/Kg**	± 17.57%
	SAR averaged over 10g	5.57 W/Kg	**22.17 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	52.432 Ω -3.49 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	27.60	± 2.03 dB

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	21.0 °C	21.0 °C	21.0°C	21.0°C	εr	53.30	52.87	± 5%
						σ	1.52	1.56	± 5%

SAR Results – Body Simulating Liquid (MSL)

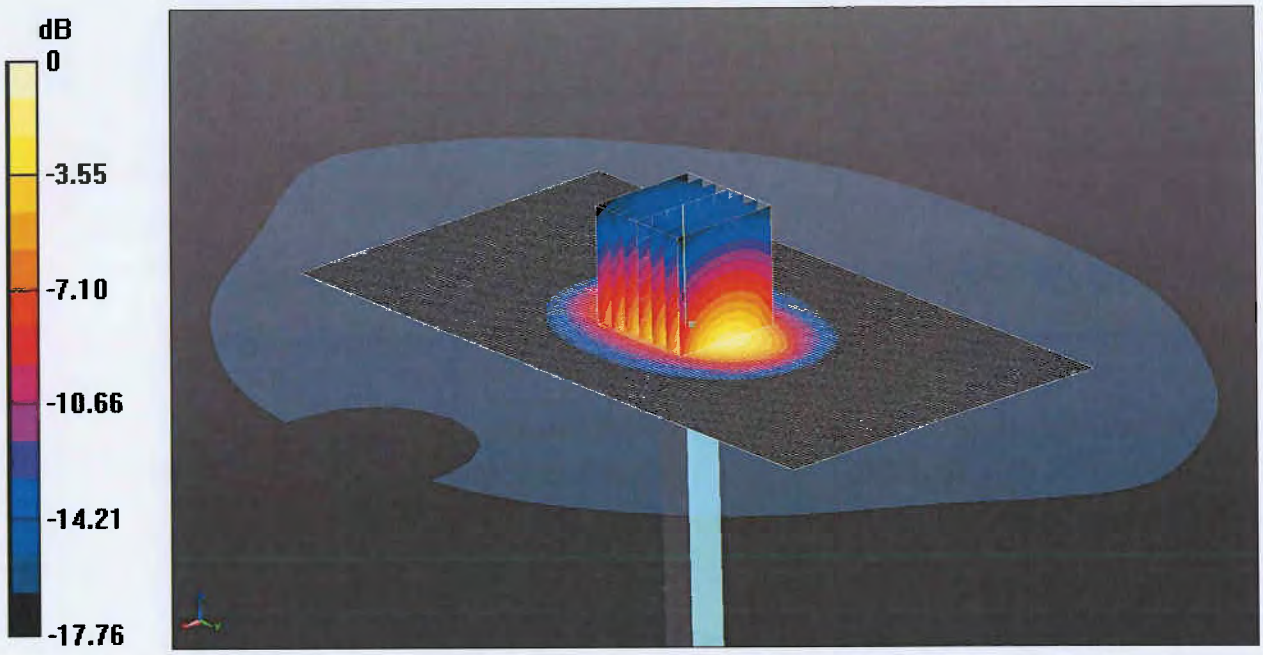
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	10.30 W/Kg	**41.00 W/Kg**	± 18.06%
	SAR averaged over 10g	5.25 W/Kg	**20.90 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	55.43 Ω -4.69 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	23.18	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1900V2 - SN: 5D043; Type: D1900V2; Serial: SN: 5D043

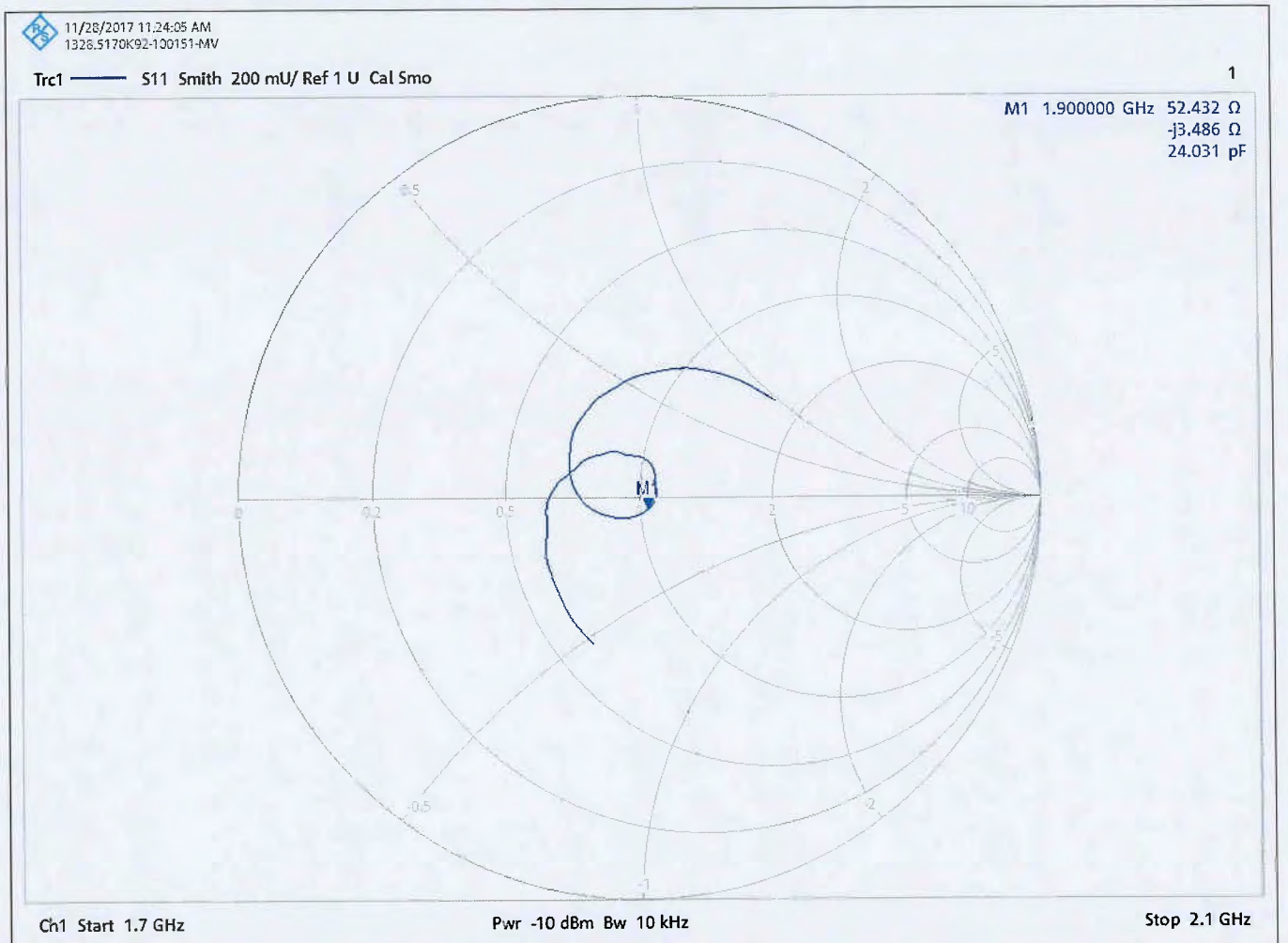


0 dB = 13.6 W/kg = 11.34 dBW/kg

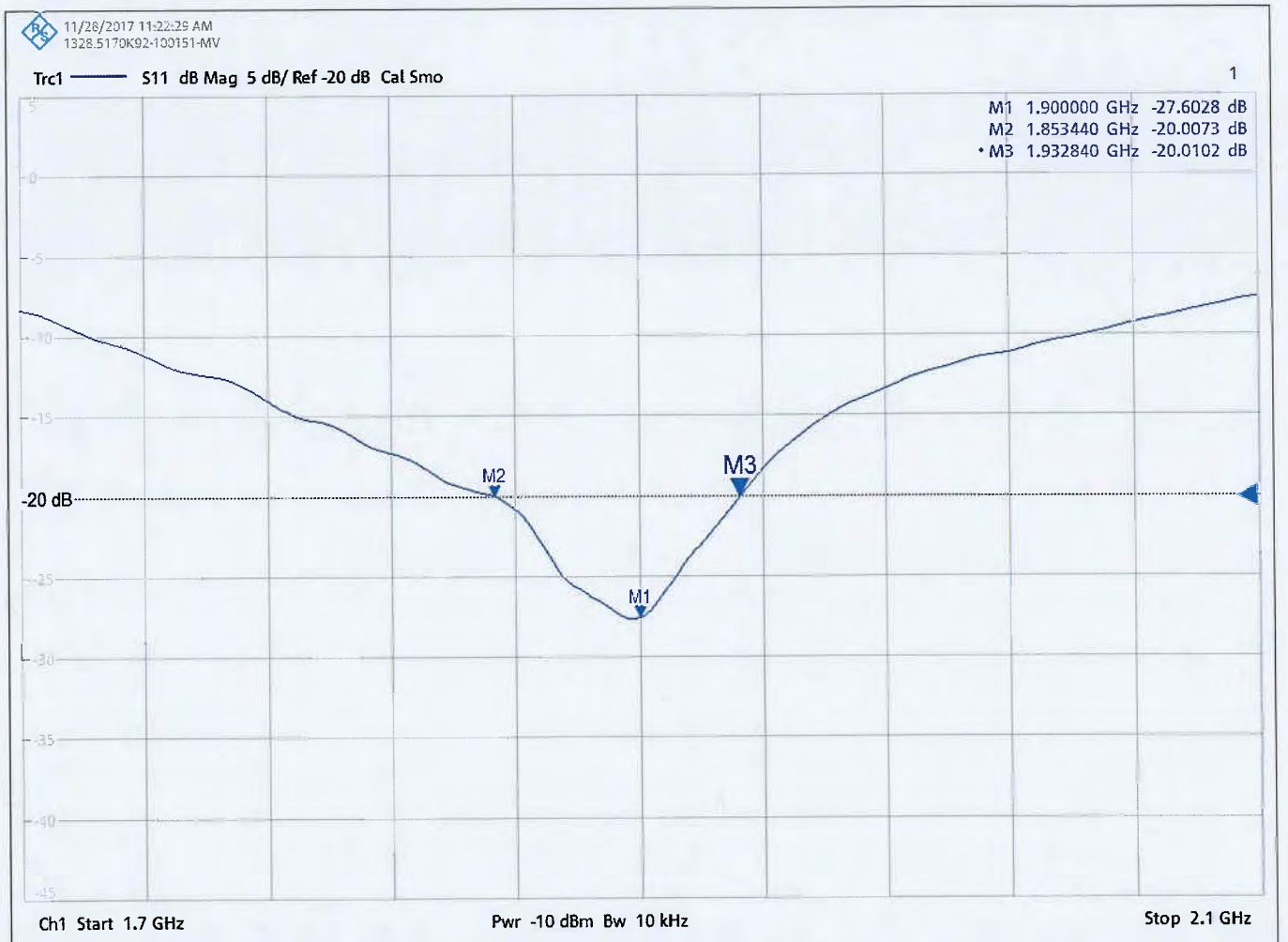
Communication System: UID 0, CW (0); Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 750,835,900,1800,1900 MHz HSL Medium parameters used: f = 1900 MHz; σ = 1.438 S/m; ε_r = 39.91; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(8.37, 8.37, 8.37); Calibrated: 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=10mm, Pin=250mW/Area Scan (81x151x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 14.1 W/kg
Configuration/d=10mm, Pin=250mW/Zoom Scan (5x5x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 97.92 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 20.2 W/kg
SAR(1 g) = 10.8 W/kg; SAR(10 g) = 5.57 W/kg
Maximum value of SAR (measured) = 13.6 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

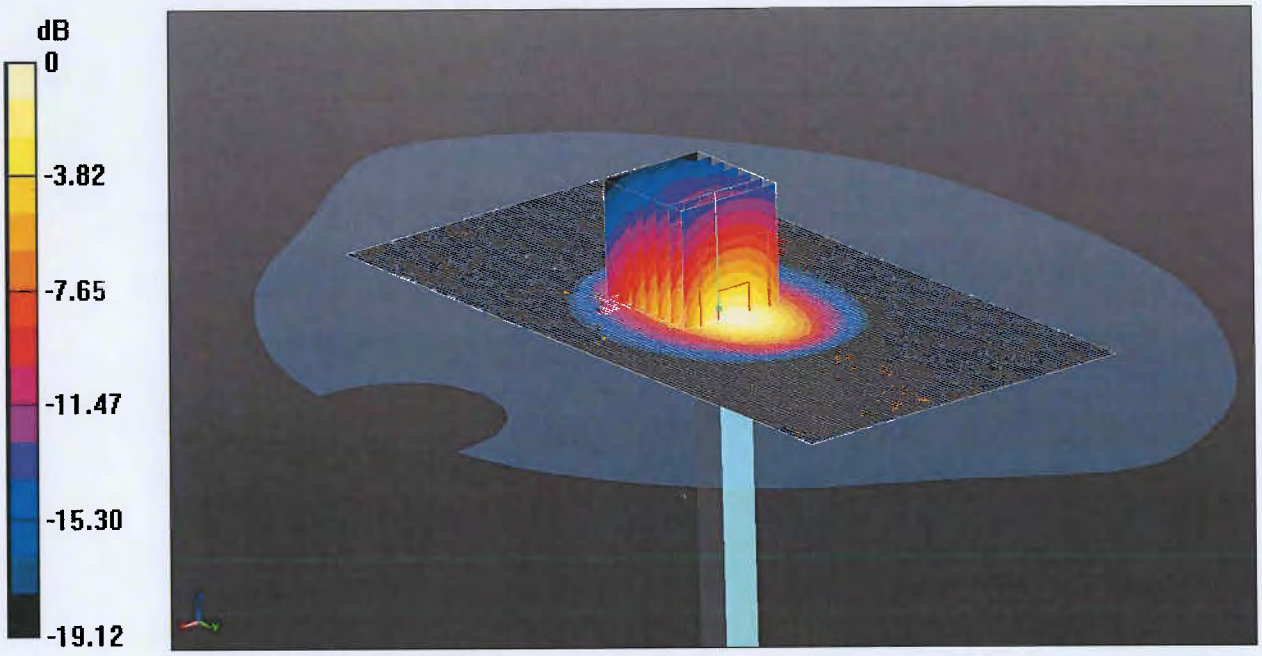


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 1900 MHz; Type: D1900V2; Serial: SN5d043



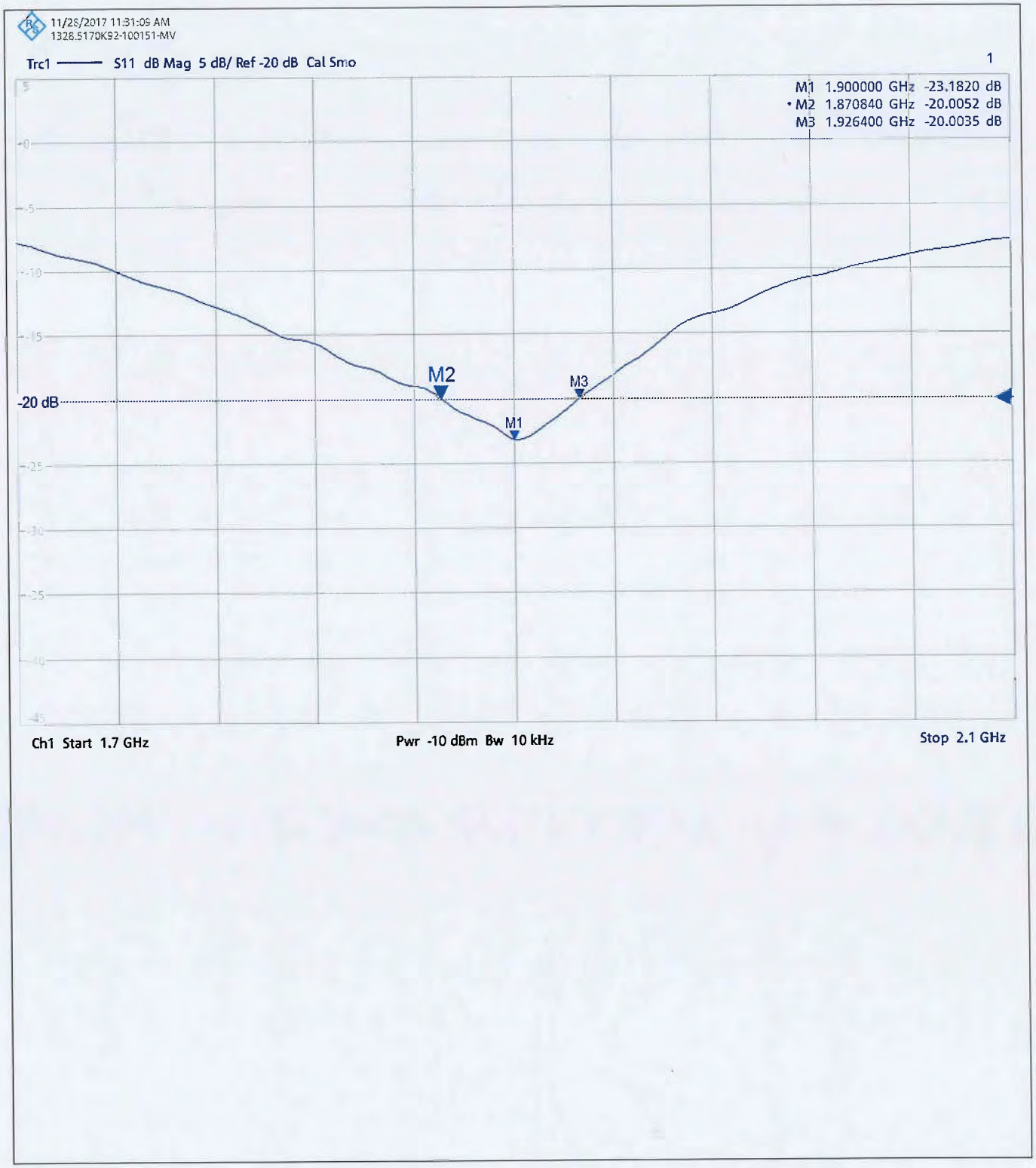
0 dB = 13.0 W/kg = 11.14 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: MSL(750,835,900,1800,1900,5G) Medium parameters used: f = 1900 MHz; σ = 1.564 S/m; ε_r = 52.87; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY 5 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(8.04, 8.04, 8.04); 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)

SAR/d=10mm, Pin=250mW/Area Scan (81x151x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 13.4 W/kg
SAR/d=10mm, Pin=250mW/Zoom Scan (5x5x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 91.38 V/m; Power Drift = -0.07 dB
Peak SAR (extrapolated) = 18.4 W/kg
SAR(1 g) = 10.3 W/kg; SAR(10 g) = 5.25 W/kg
Maximum value of SAR (measured) = 13.0 W/kg

Impedance Measurement Plot for Body Stimulating Liquid (MSL)

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903932JD01E Instrument ID: 5d043 Calibration Date: 22/Nov/2017 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903932JD01E Instrument ID: 5d043 Calibration Date: 22/Nov/2017 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903932JD01E Instrument ID: 5d043 Calibration Date: 22/Nov/2017 Calibration Due Date:

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 26/Mar/2018 CERTIFICATE NUMBER : 12134276JD01B

5248

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FAX: +44 (0) 1256 312001
Email: LST.UK.Calibration@ul.com

APPROVED SIGNATORY

.....

Naseer Mirza

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	15/Mar/2018
Manufacturer:	Speag		
Type/Model Number:	D2300V2		
Serial Number:	1002		
Calibration Date:	16/Mar/2018		
Calibrated By:	Masood Khan Laboratory Engineer		
Signature:	.....		

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}C and humidity < 70%

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A2110	Data Acquisition Electronics	SPEAG	DAE4	431	08 Nov 2017	12
A2077	Probe	SPEAG	EX3DV4	3814	28 Sep 2017	12
A2489	Dipole	SPEAG	D2300V2	1036	05 Feb 2018	12
PRE0151451	Power Monitoring Kit	Art-Fi	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	10 Oct 2017	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2017	24
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947	09 May 2017	12
M1838	Signal Generator	Rhode & Schwarz	SME06	831377/005	30 Mar 2017	12

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:	2300 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	2300	23.5 ℃	23.5 ℃	22.5℃	22.5℃	**εr**	39.50	39.58	± 5%
						σ	1.67	1.73	± 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	13.00 W/Kg	**51.75 W/Kg**	± 17.57%
	SAR averaged over 10g	6.20 W/Kg	**24.68 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	51.913 Ω 3.85 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-27.76	± 2.03 dB

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	2300	23.0 ℃	23.0 ℃	22.0℃	22.0℃	**εr**	52.90	51.91	± 5%
						σ	1.81	1.86	± 5%

SAR Results – Body Simulating Liquid (MSL)

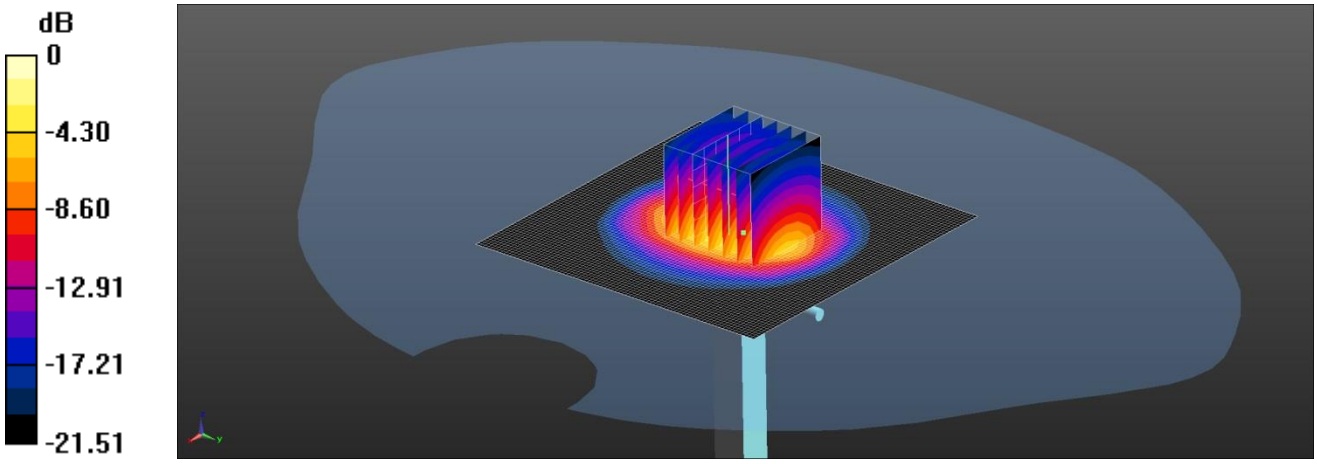
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	12.60 W/Kg	**50.16 W/Kg**	± 18.06%
	SAR averaged over 10g	5.96 W/Kg	**23.72 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	53.78 Ω 7.09 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-22.73	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D2300V3 - SN1002; Type: D2300V3; Serial: SN1002

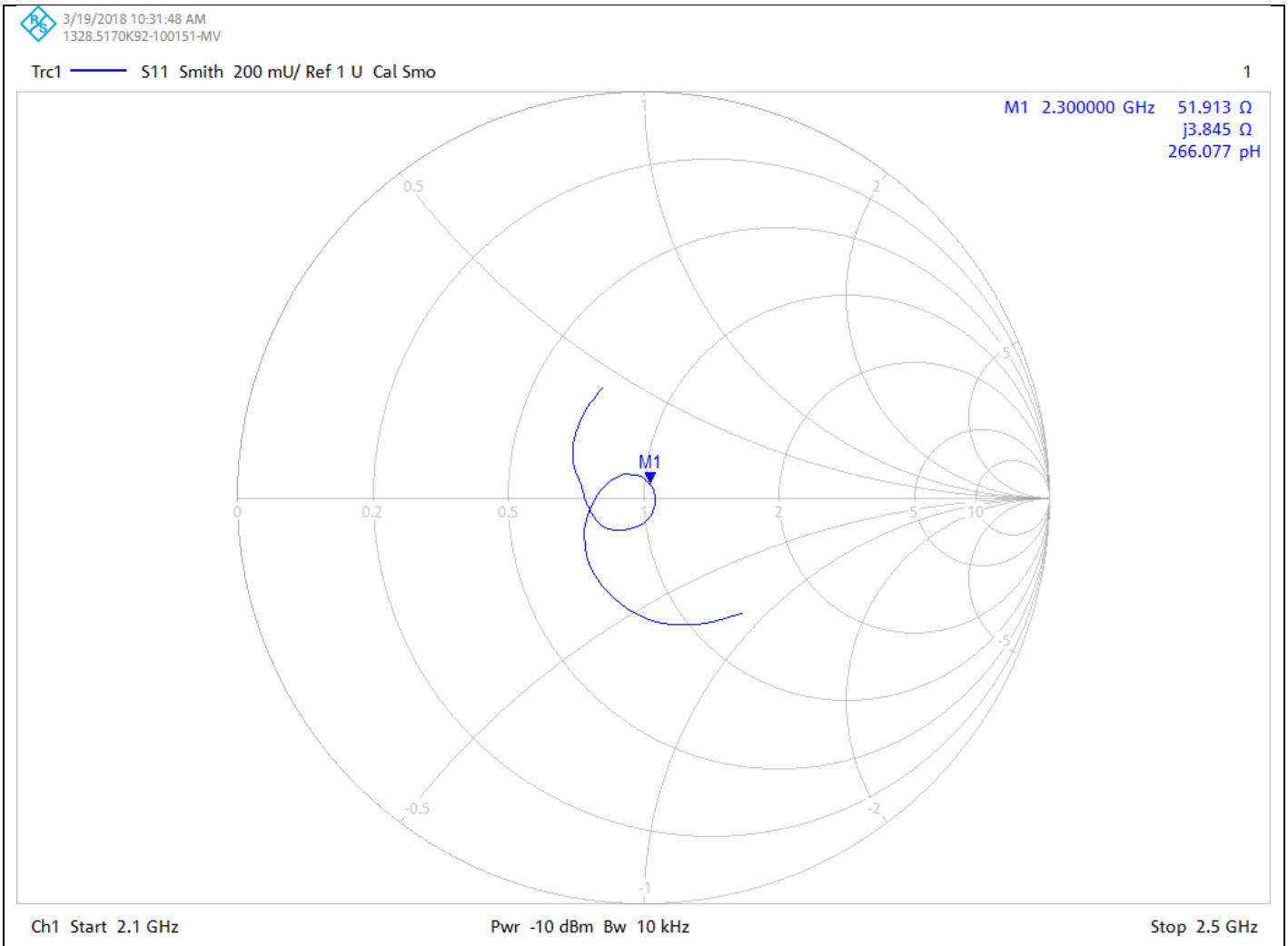


0 dB = 19.3 W/kg = 12.86 dBW/kg

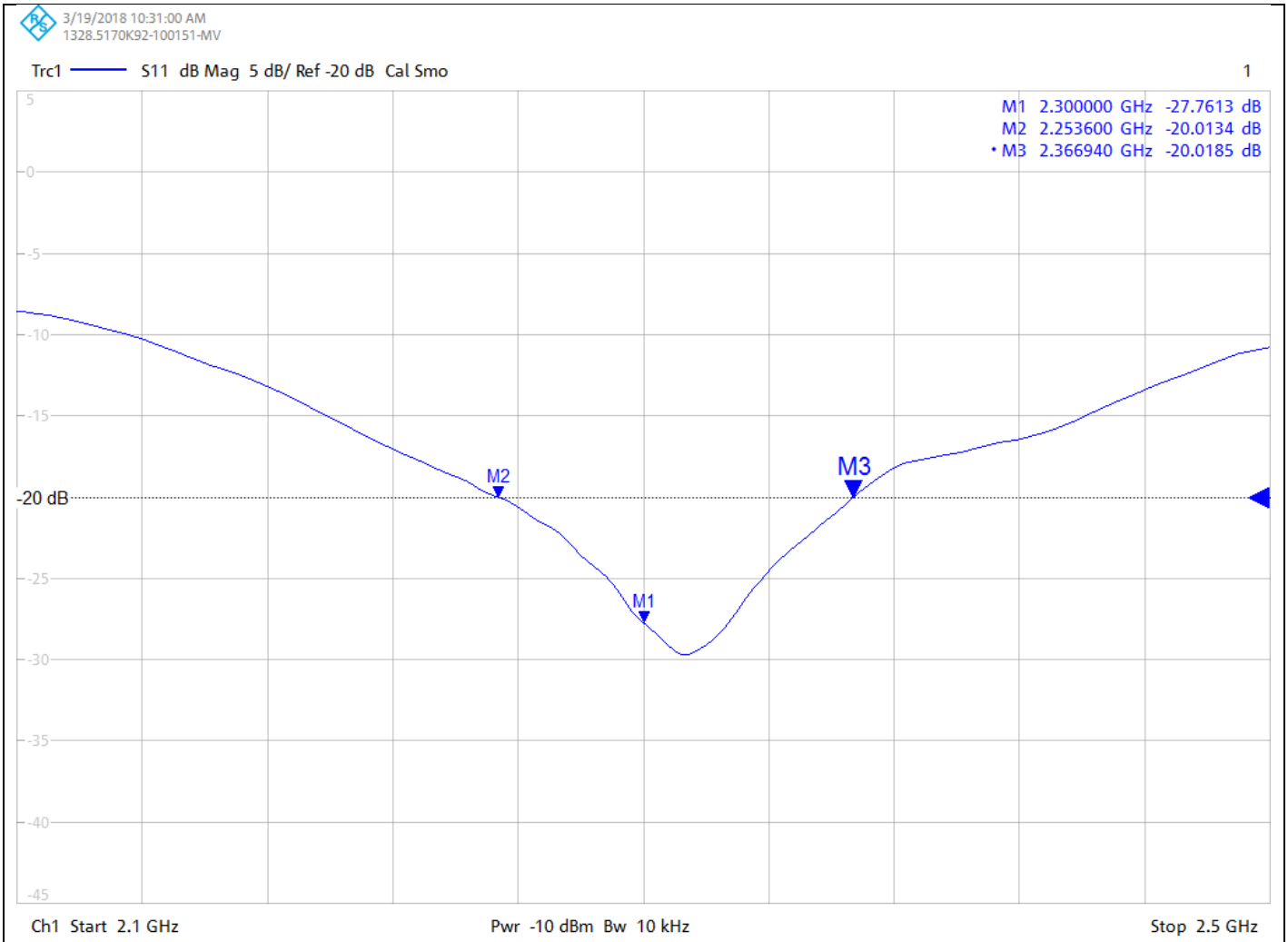
Communication System: UID 0, CW (0); Frequency: 2300 MHz;Duty Cycle: 1:1
Medium: 2300 2450 2600 MHz HSL Medium parameters used: f = 2300 MHz; σ = 1.728 S/m; ε_r = 39.576; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.45, 7.45, 7.45); Calibrated: 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:1817
- ; 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) = 15.0 W/kg
Configuration/d=10mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 92.16 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 25.8 W/kg
SAR(1 g) = 13 W/kg; SAR(10 g) = 6.2 W/kg
Maximum value of SAR (measured) = 19.3 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

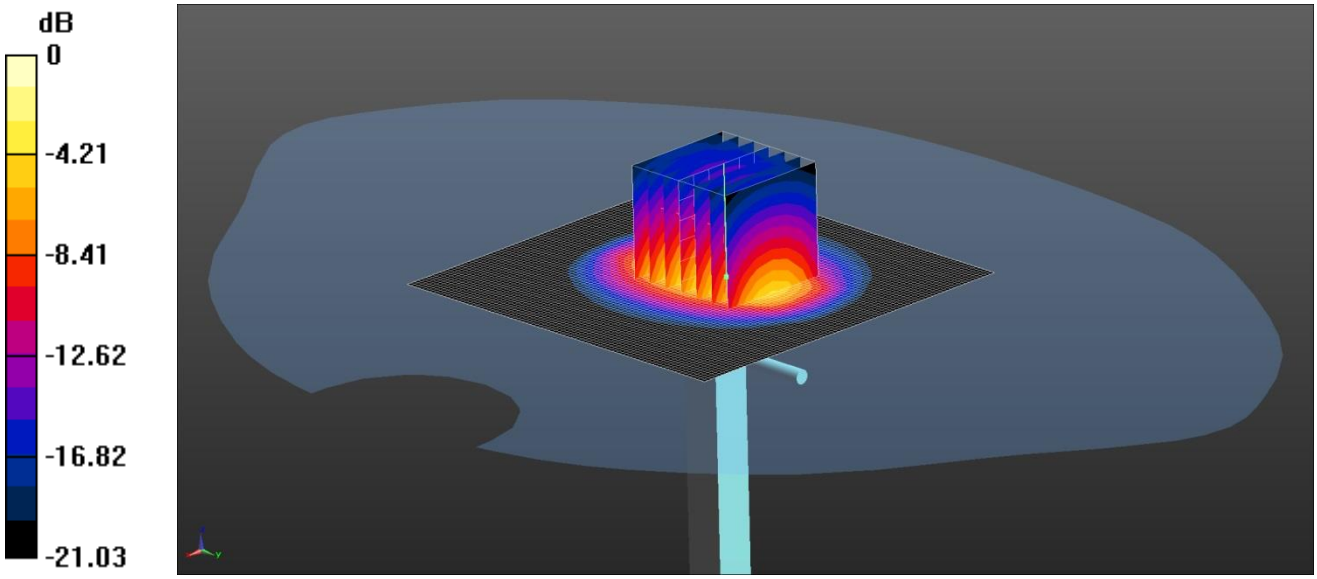


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D2300V2 - SN1002; Type: D2300V2; Serial: SN1002

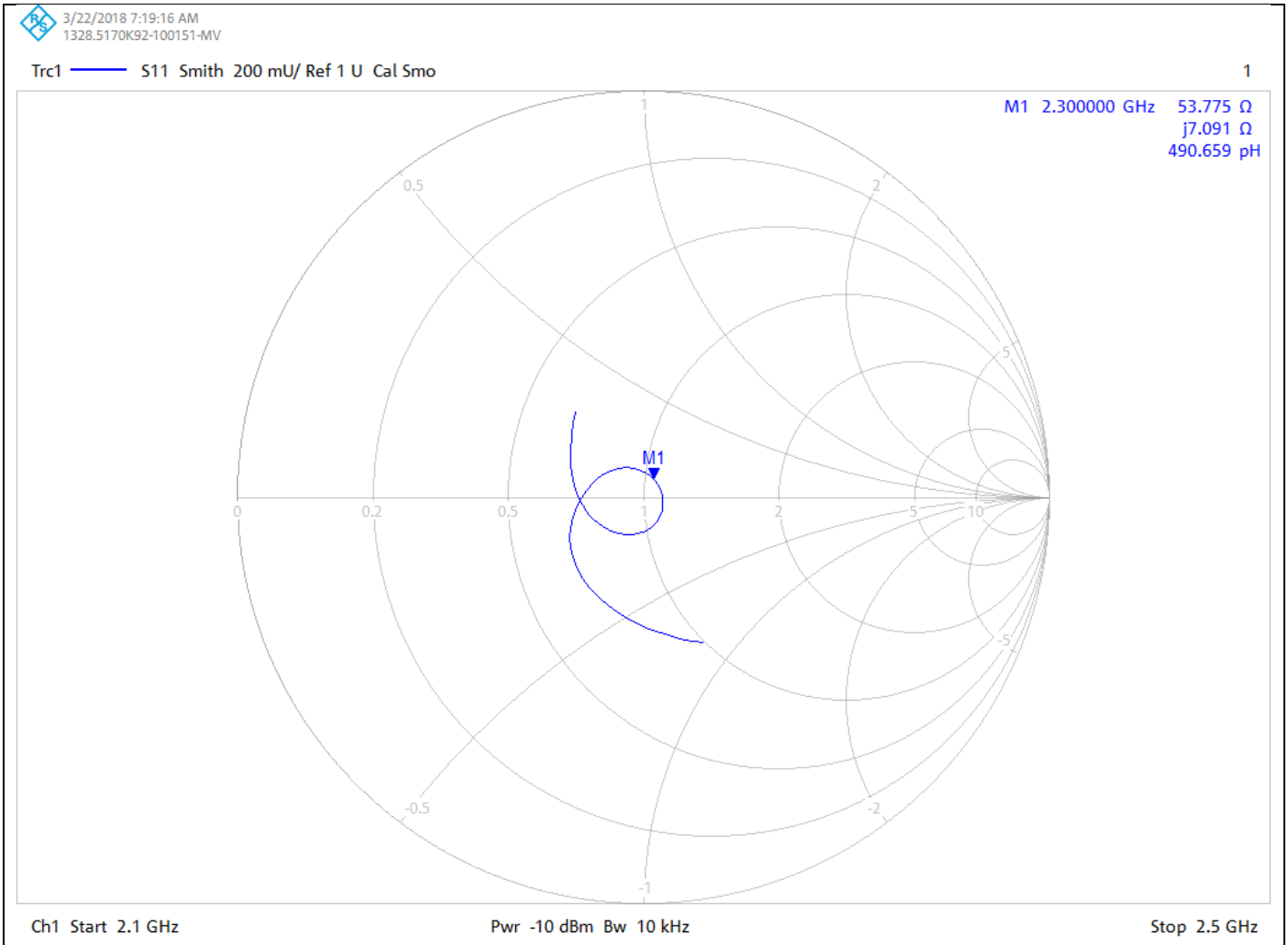


0 dB = 18.9 W/kg = 12.76 dBW/kg

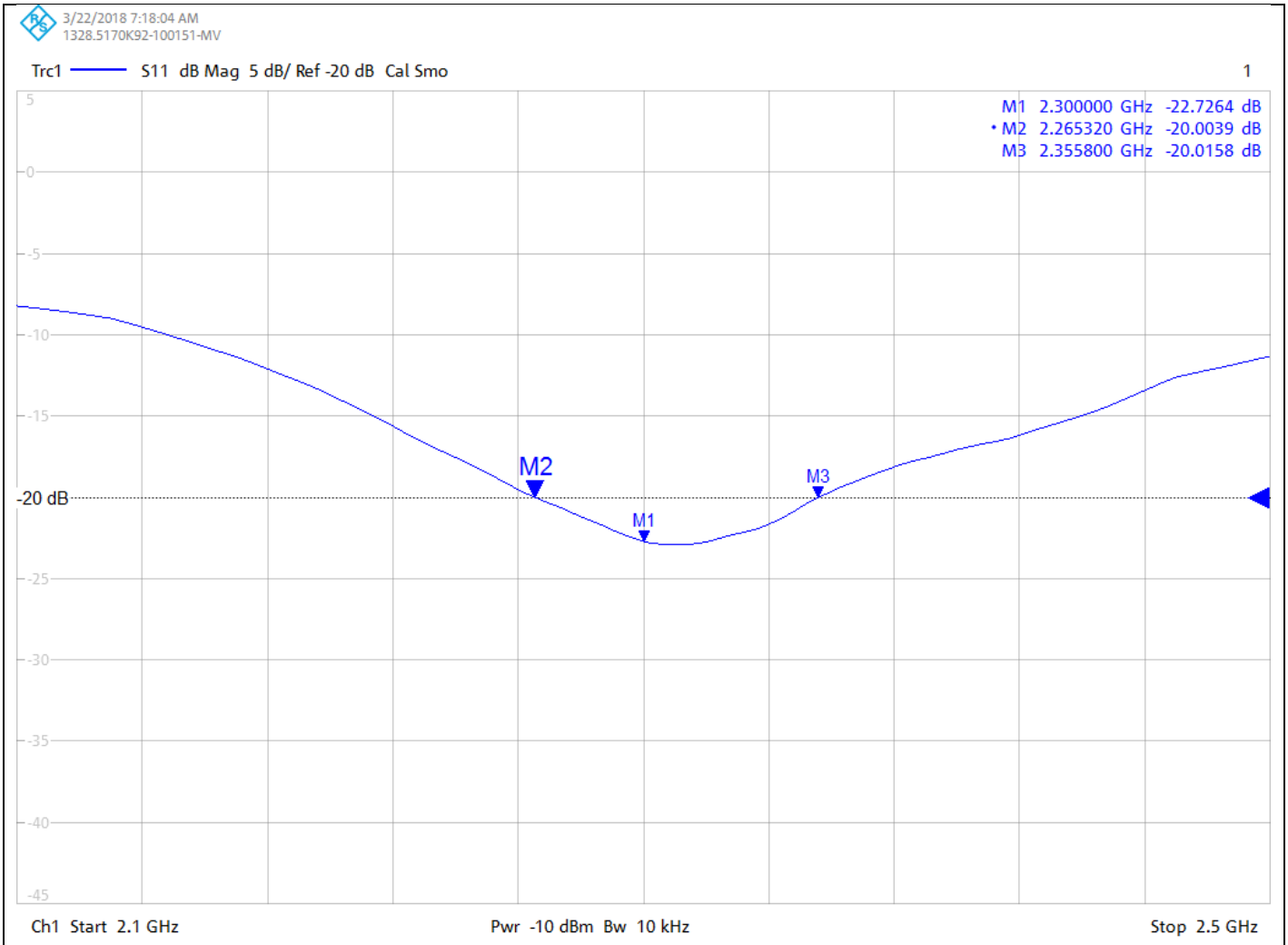
Communication System: UID 0, CW (0); Frequency: 2300 MHz;Duty Cycle: 1:1
Medium: 2300 MHz MSL Medium parameters used: f = 2300 MHz; σ = 1.864 S/m; ε_r = 51.912; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.41, 7.41, 7.41); Calibrated: 28/09/2017;
- 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:1817
- ; 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) = 14.9 W/kg
Configuration/d=10mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 86.76 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 25.1 W/kg
SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.96 W/kg
Maximum value of SAR (measured) = 18.9 W/kg

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134276JD01B Instrument ID: 1002 Calibration Date: 16/Mar/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134276JD01B Instrument ID: 1002 Calibration Date: 16/Mar/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134276JD01B Instrument ID: 1002 Calibration Date: 16/Mar/2018 Calibration Due Date:

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 18/Sep/2017 CERTIFICATE NUMBER : 11903949JD01D

5248

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FAX: +44 (0) 1256 312001
Email: LST.UK.Calibration@ul.com

APPROVED SIGNATORY

……

Naseer Mirza

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	24/Aug/2017
Manufacturer:	Speag		
Type/Model Number:	D2300V2		
Serial Number:	1058		
Calibration Date:	31/Aug/2017		
Calibrated By:	Chanthu Thevarajah Laboratory Engineer		
Signature:	……		

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}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.

The calibration methods and procedures used were as detailed in:

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

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

UL No.	Instrument	Manufacturer	Type No.	Serial No.	Date Last Calibrated	Cal. Interval (Months)
A2110	Data Acquisition Electronics	SPEAG	DAE4	431	18 Nov 2016	12
A2436	Probe	SPEAG	ES3DV3	3335	28 July 2017	12
A2077	Probe	SPEAG	EX3DV4	3814	30 Sep 2016	12
A2489	Dipole	SPEAG	D2300V2	1036	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
M1768	Signal Generator	Rhode & Schwarz	SME06	837633/001	08 Nov 2016	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: RX90L
Robot Serial Number:	F00/SD89A1/A/01
DASY Version:	DASY 4 (v4.7.80)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	10 mm (with spacer)
Frequency:	2300 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	2300	22.6 ℃	22.5 ℃	22.5℃	22.5℃	**εr**	39.50	38.3	± 5%
						σ	1.67	1.69	± 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	13.50 W/Kg	**53.74 W/Kg**	± 17.57%
	SAR averaged over 10g	6.36 W/Kg	**25.31 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	49.554 Ω 2.25 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	32.74	± 2.03 dB

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	2300	22.6 ℃	22.0 ℃	22.5℃	22.0℃	**εr**	52.90	51.9	± 5%
						σ	1.81	1.86	± 5%

SAR Results – Body Simulating Liquid (MSL)

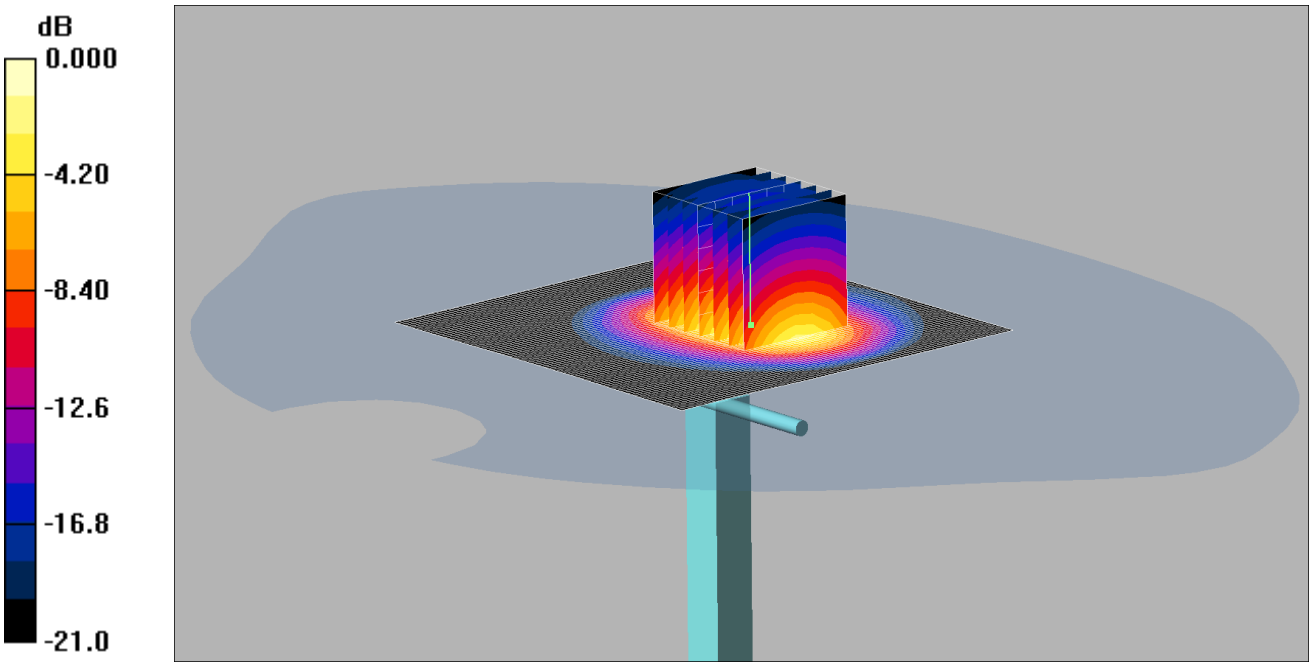
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	13.60 W/Kg	**54.14 W/Kg**	± 18.06%
	SAR averaged over 10g	6.25 W/Kg	**24.88 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	52.48 Ω 4.25 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	26.81	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: Dipole 2300 MHz D2300V2; Type: D2300V2; Serial: SN:1058



0 dB = 15.4mW/g

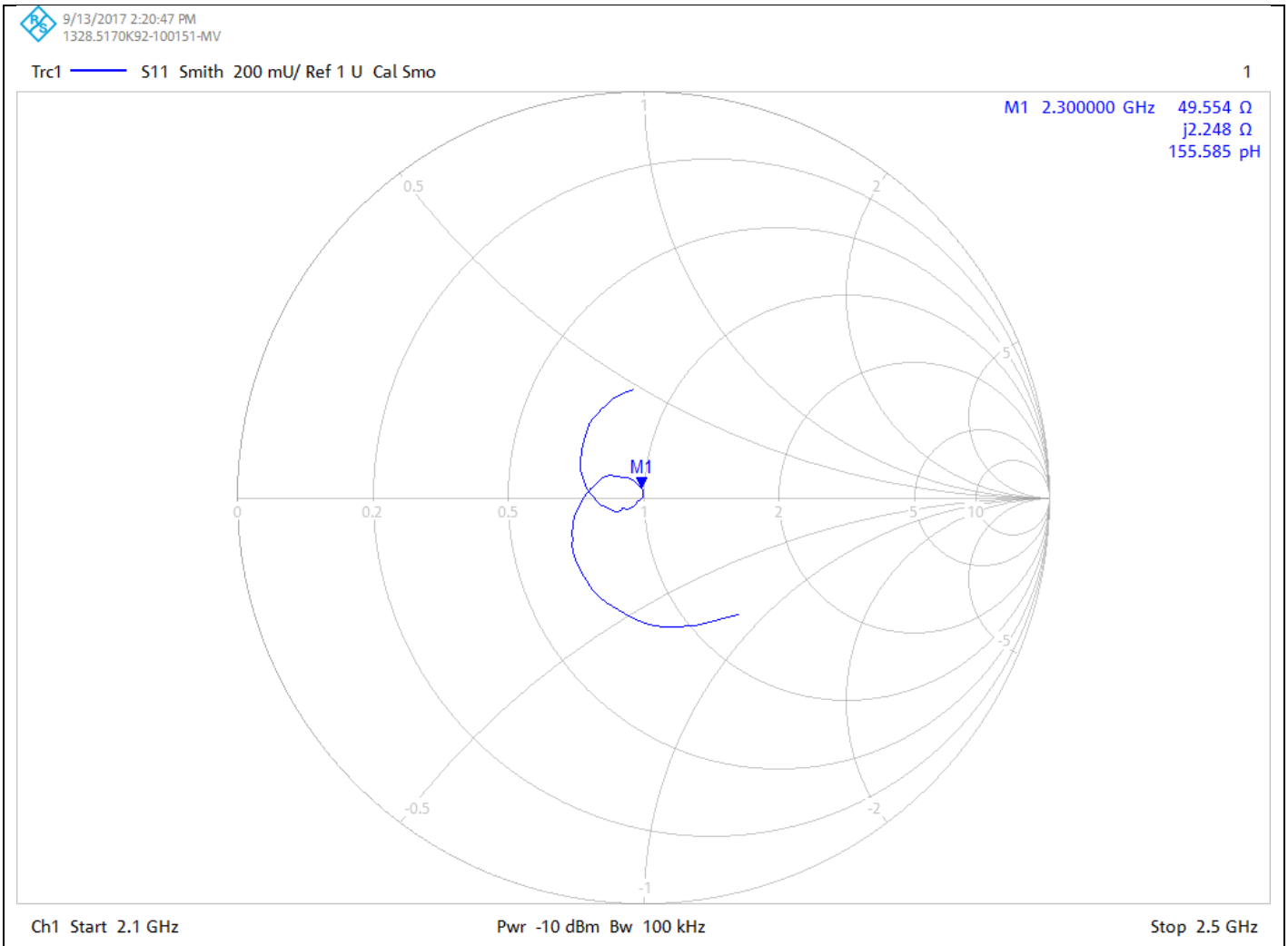
Communication System: CW; Frequency: 2300 MHz;Duty Cycle: 1:1
Medium: 2300MHz HSL Medium parameters used: f = 2300 MHz; σ = 1.69 mho/m; ε_r = 38.3; ρ = 1000 kg/m^3
Phantom section: Flat Section

DASY4 Configuration:
- Probe: ES3DV3 - SN3335; ConvF(5.08, 5.08, 5.08);

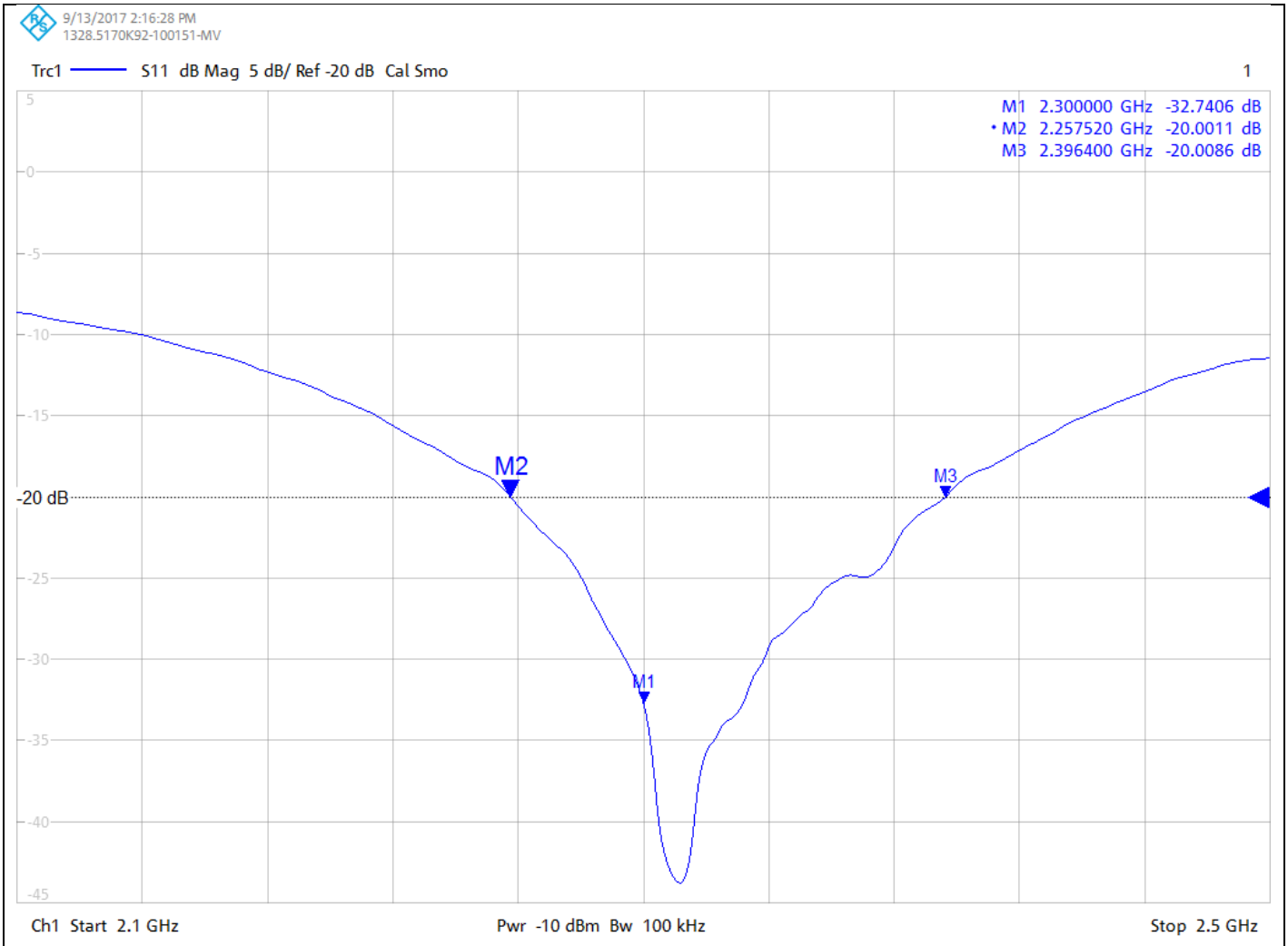
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn431; Calibrated: 18/11/2016
- Phantom: SAM 12a (Site 57); Type: SAM 4.0; Serial: TP:1020
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

d=10mm, Pin=250mW -9 2 2 2 2/Area Scan (81x81x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (interpolated) = 15.9 mW/g
d=10mm, Pin=250mW -9 2 2 2 2/Zoom Scan (7x7x7) 2 (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 81.3 V/m; Power Drift = 0.100 dB
Peak SAR (extrapolated) = 28.0 W/kg
SAR(1 g) = 13.5 mW/g; SAR(10 g) = 6.36 mW/g
Maximum value of SAR (measured) = 15.4 mW/g

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

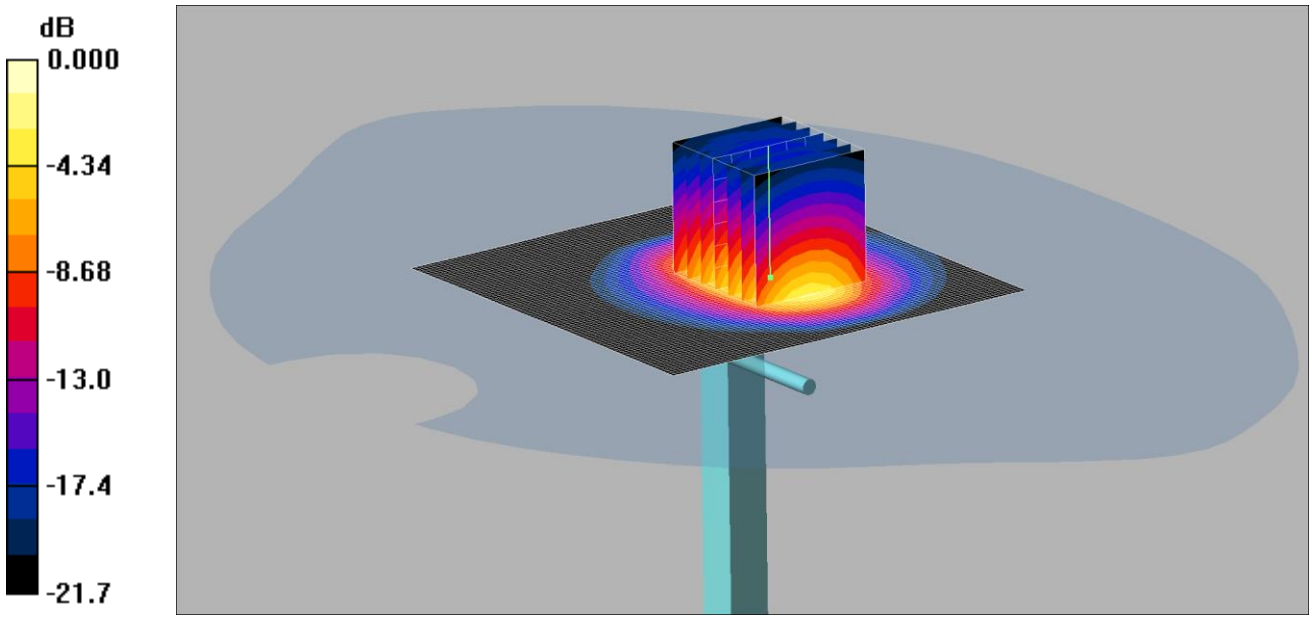


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: Dipole 2300 MHz D2300V2; Type: D2300V2; Serial: SN:1058



0 dB = 15.5mW/g

Communication System: CW; Frequency: 2300 MHz;Duty Cycle: 1:1
Medium: 2300 Medium parameters used: f = 2300 MHz; σ = 1.86 mho/m; ε_r = 51.9; ρ = 1000 kg/m^3
Phantom section: Flat Section

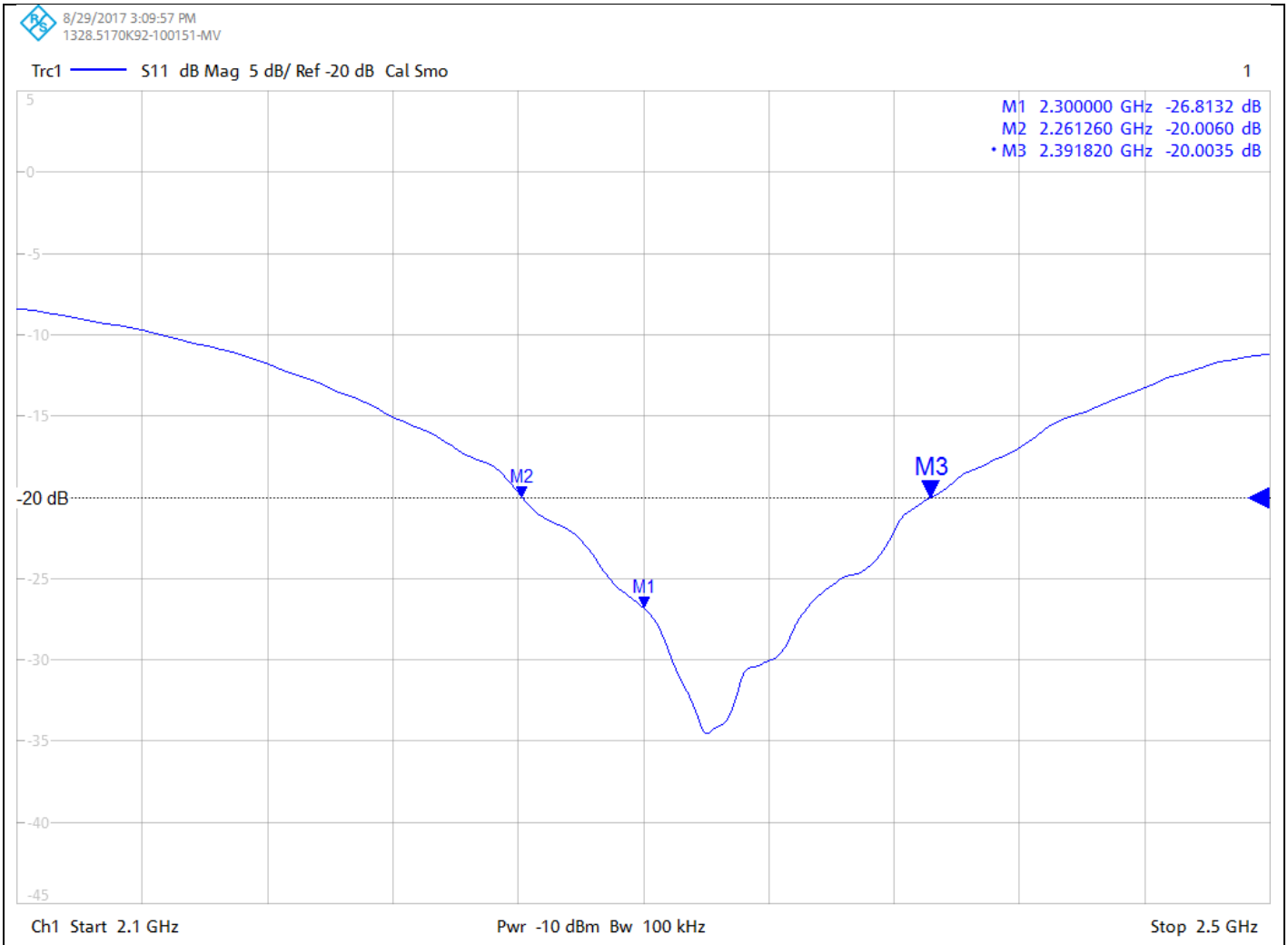
DASY4 Configuration:
- Probe: ES3DV3 - SN3335; ConvF(4.88, 4.88, 4.88);

- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn431; Calibrated: 18/11/2016
- Phantom: SAM 12a (Site 57); Type: SAM 4.0; Serial: TP:1020
- Measurement SW: DASY4, V4.7 Build 80; Postprocessing SW: SEMCAD, V1.8 Build 186

d=10mm, Pin=250mW 2 2 2/Area Scan (81x81x1): Measurement grid: dx=12mm, dy=12mm
Maximum value of SAR (interpolated) = 16.1 mW/g
d=10mm, Pin=250mW 2 2 2/Zoom Scan (7x7x7) 2 (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 71.9 V/m; Power Drift = 0.091 dB
Peak SAR (extrapolated) = 28.9 W/kg
SAR(1 g) = 13.6 mW/g; SAR(10 g) = 6.25 mW/g
Maximum value of SAR (measured) = 15.5 mW/g

Impedance Measurement Plot for Body Stimulating Liquid (MSL)

Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903949JD01D Instrument ID: 1058 Calibration Date: 31/Aug/2017 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903949JD01D Instrument ID: 1058 Calibration Date: 31/Aug/2017 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903949JD01D Instrument ID: 1058 Calibration Date: 31/Aug/2017 Calibration Due Date:

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 19/Feb/2018 CERTIFICATE NUMBER : 12129912JD01A

5248

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FAX: +44 (0) 1256 312001
Email: LST.UK.Calibration@ul.com

APPROVED SIGNATORY

M. Naseer

.....

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:	.....		

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}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.

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

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 ℃	22.0 ℃	21.6℃	22.0℃	**εr**	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 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	27.52	± 2.03 dB

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 ℃	22.0 ℃	21.6℃	22.0℃	**εr**	52.70	50.63	± 5%
						σ	1.95	2.02	± 5%

SAR Results – Body Simulating Liquid (MSL)

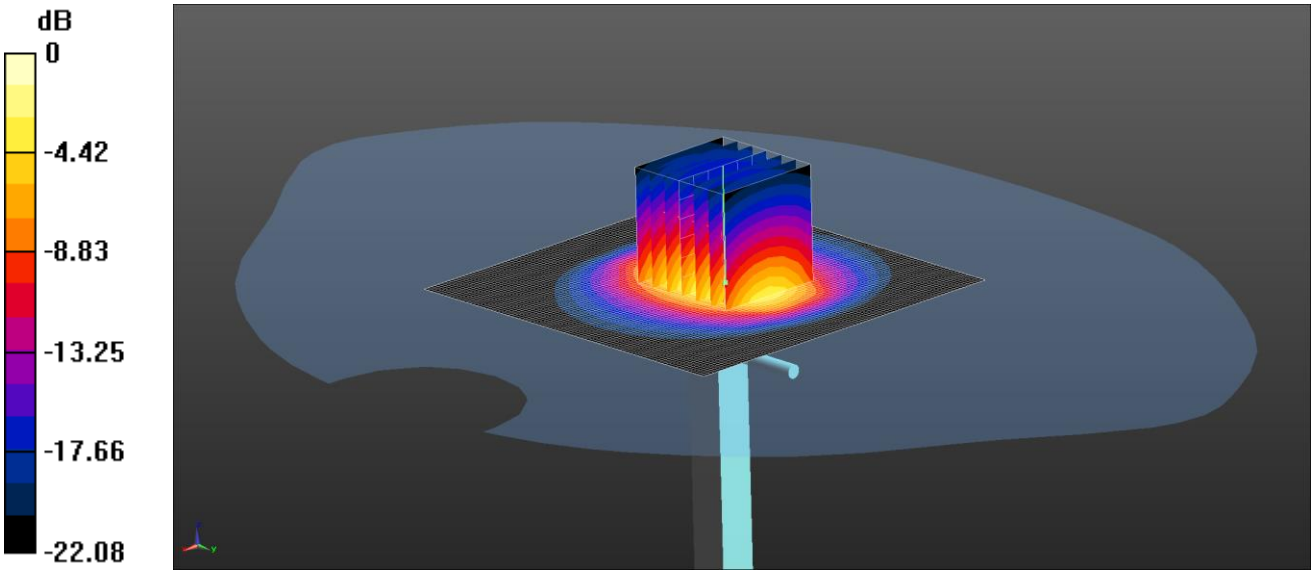
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	12.80 W/Kg	**50.95 W/Kg**	± 18.06%
	SAR averaged over 10g	5.98 W/Kg	**23.80 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

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

DASY Validation Scan for Head Stimulating Liquid (HSL)

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

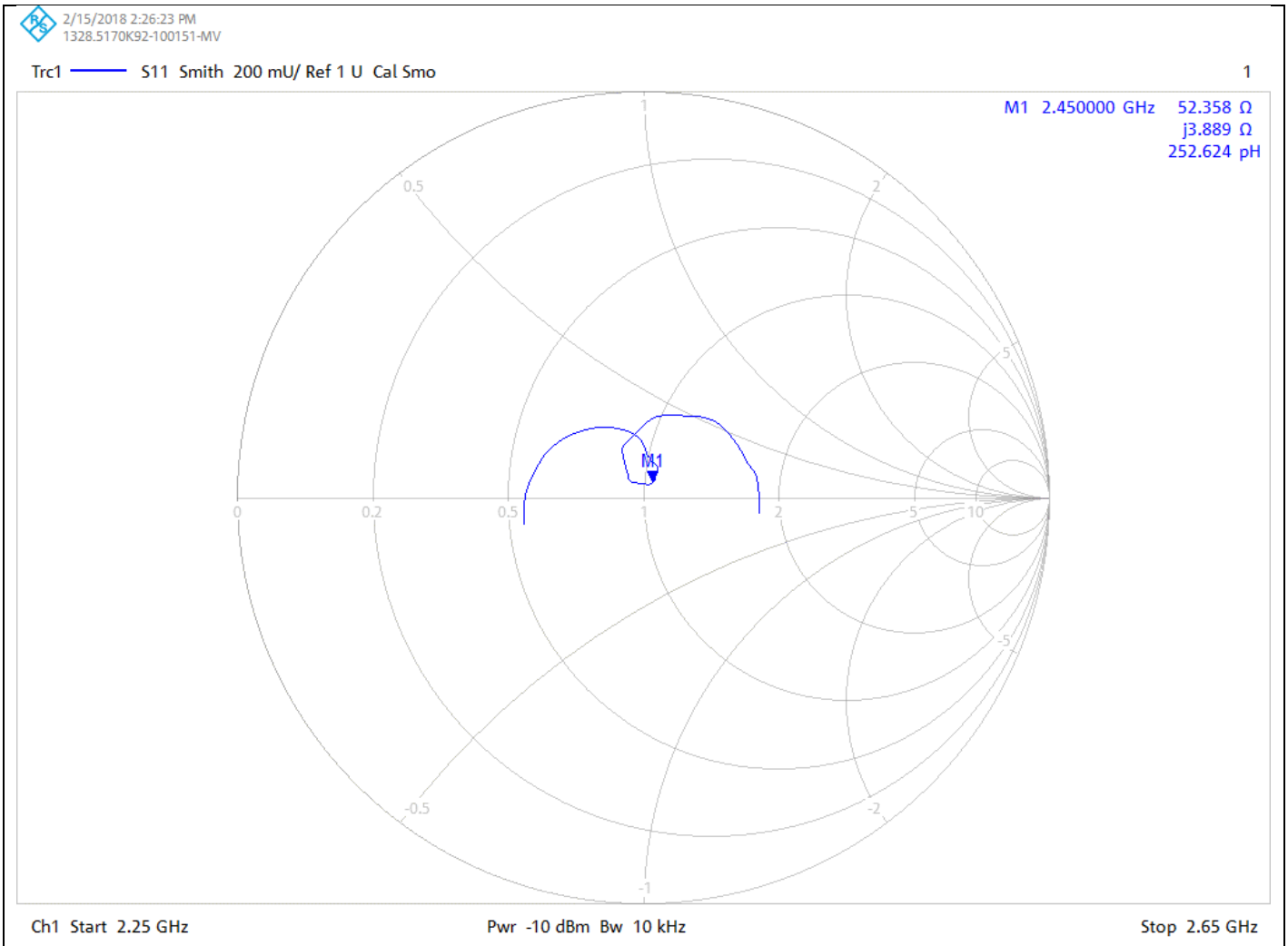


0 dB = 17.6 W/kg = 12.46 dBW/kg

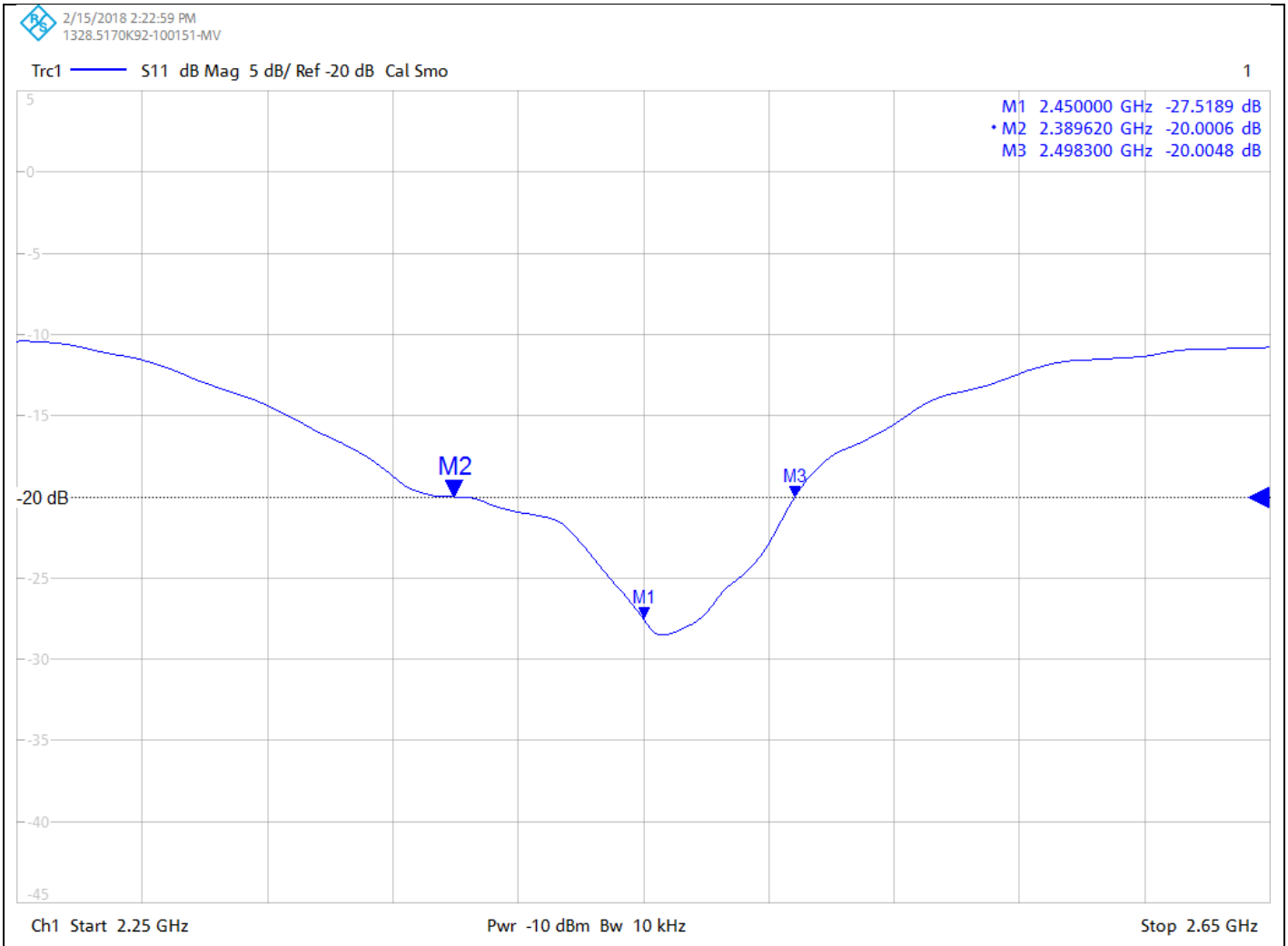
Communication System: UID 0, CW (0); Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: 2450 MHz HSL Medium parameters used: f = 2450 MHz; σ = 1.779 S/m; ε_r = 38.111; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.04, 7.04, 7.04); Calibrated: 28/09/2017;
- 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

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

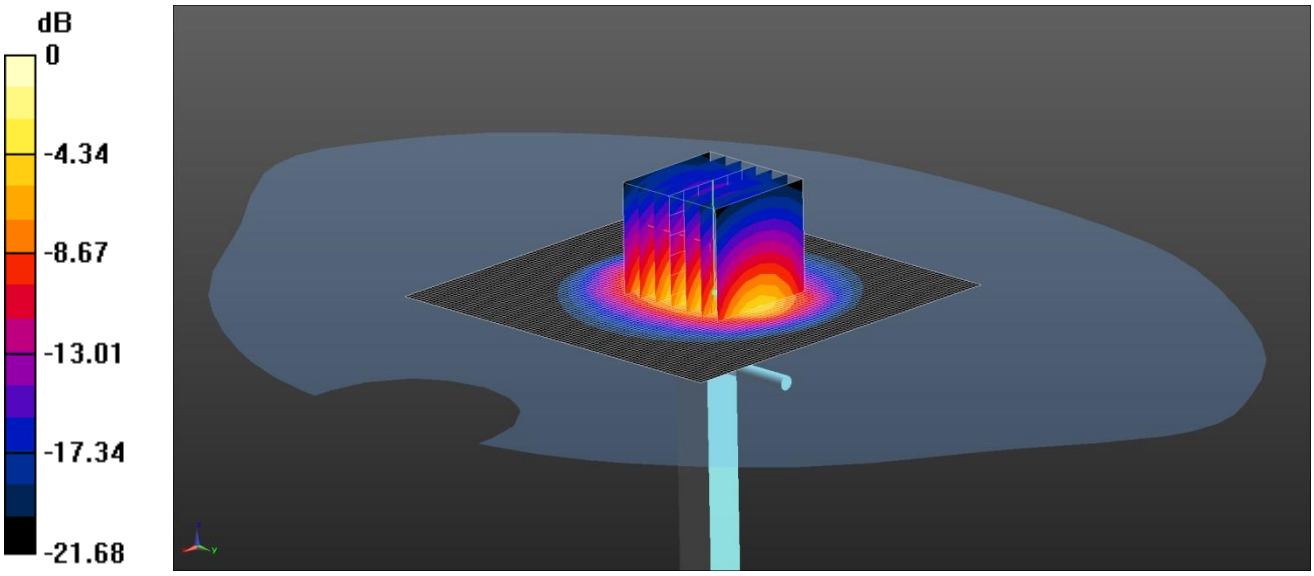


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

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

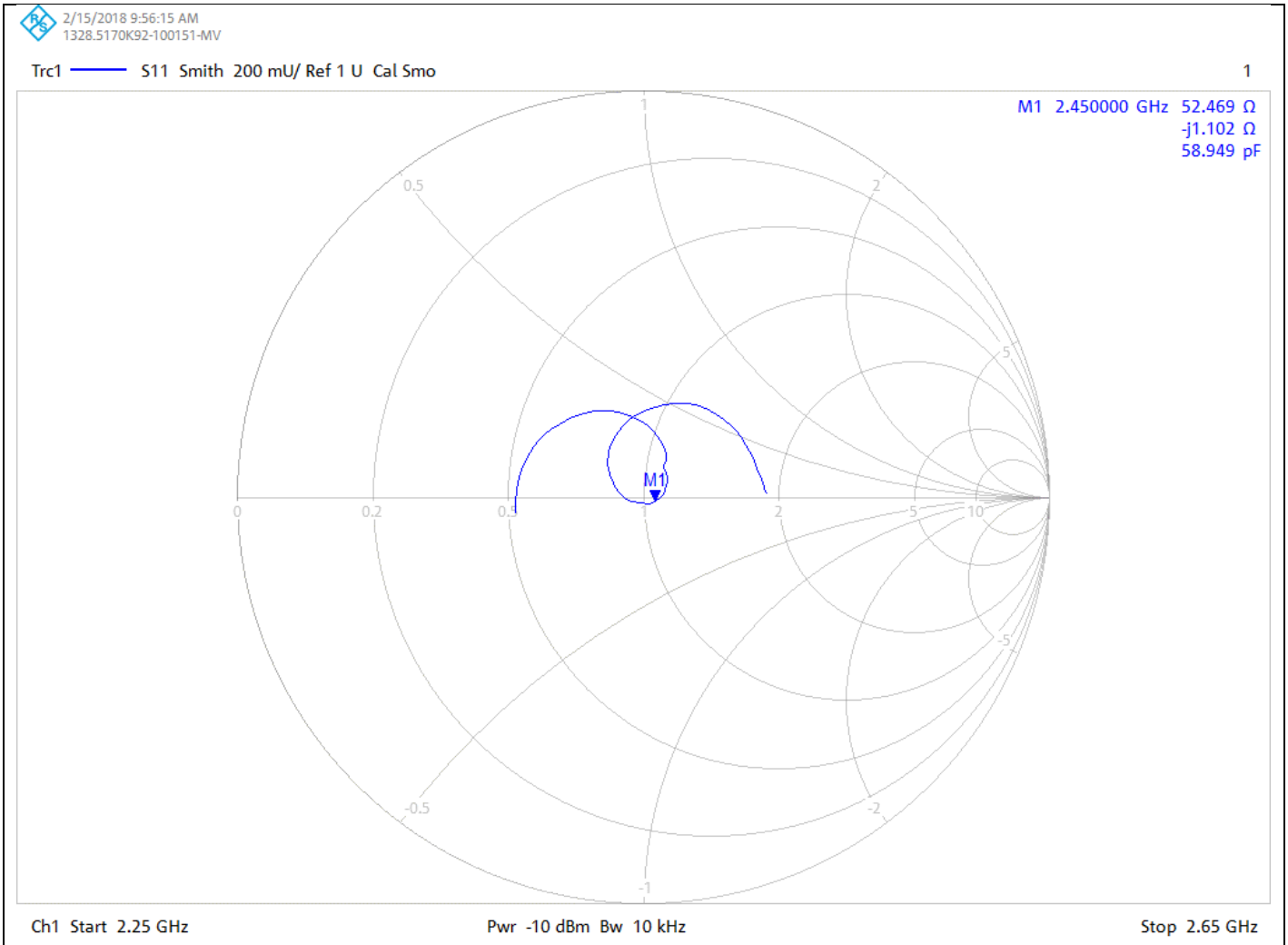


0 dB = 19.4 W/kg = 12.88 dBW/kg

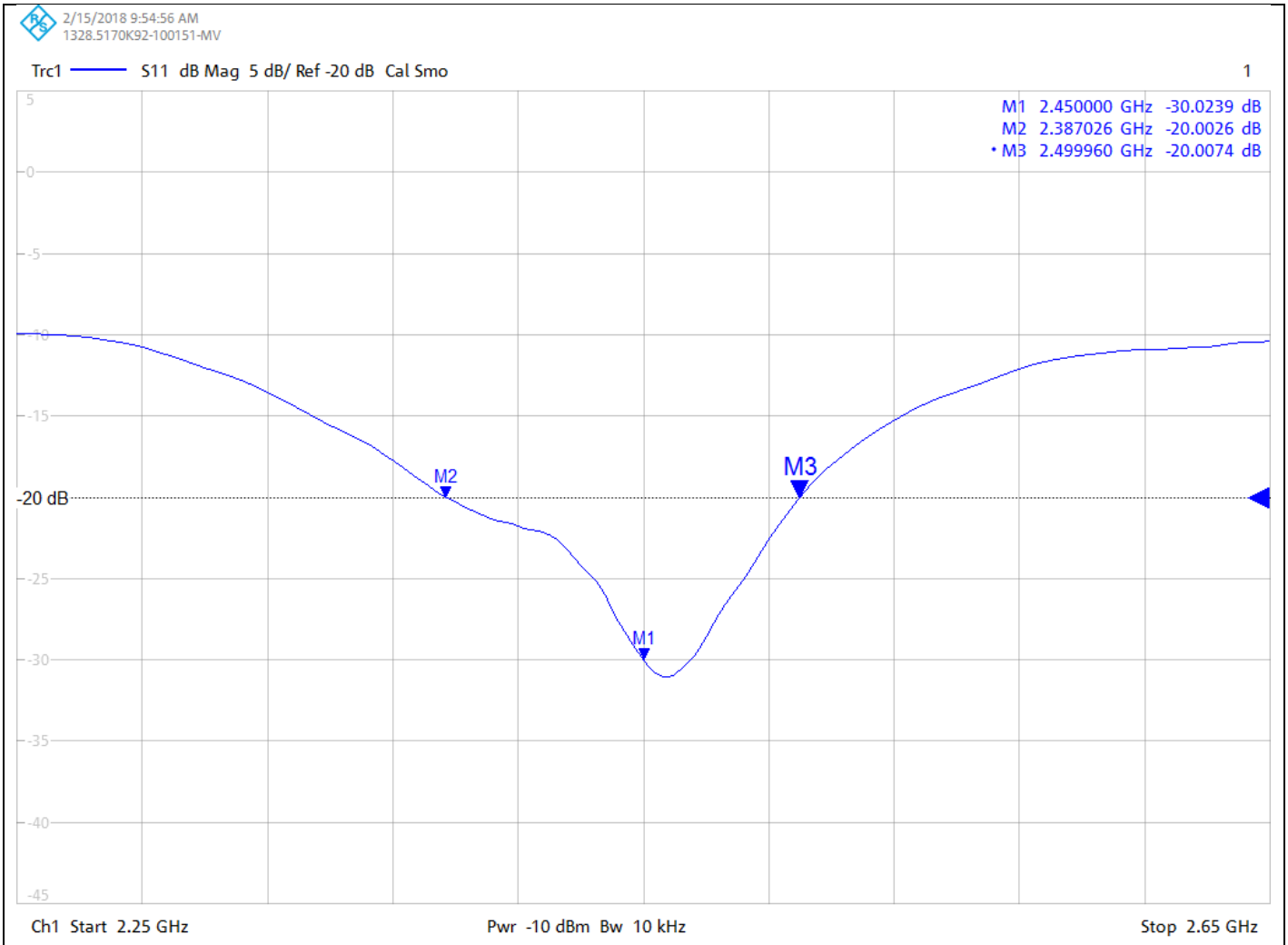
Communication System: UID 0, CW (0); Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: 2450 MSL Medium parameters used: f = 2450 MHz; σ = 2.02 S/m; ε_r = 50.632; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.2, 7.2, 7.2); Calibrated: 28/09/2017;
- Sensor-Surface: 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

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

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

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

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

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 26/Mar/2018 CERTIFICATE NUMBER : 12134276JD01C

5248

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

APPROVED SIGNATORY

.....

Naseer Mirza

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	15/Mar/2018
Manufacturer:	Speag		
Type/Model Number:	D2450V2		
Serial Number:	899		
Calibration Date:	16/Mar/2018		
Calibrated By:	Masood Khan Laboratory Engineer		
Signature:	.....		

All Calibration have been conducted in the closed laboratory facility: Lab Temperature (22±3) ^{0}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.

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
A2022	Dipole	SPEAG	D2440V2	701	05 Feb 2018	12
PRE0151451	Power Monitoring Kit	Art-Fi	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	10 Oct 2017	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2017	24
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947	09 May 2017	12
M1838	Signal Generator	Rhode & Schwarz	SME06	831377/005	30 Mar 2017	12

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	23.5 ℃	23.5 ℃	22.5℃	22.5℃	**εr**	39.20	39.42	± 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	13.00 W/Kg	**51.75 W/Kg**	± 17.57%
	SAR averaged over 10g	6.08 W/Kg	**24.20 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	46.548 Ω 1.86 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-27.26	± 2.03 dB

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 ℃	22.0 ℃	23.0℃	23.0℃	**εr**	52.70	51.71	± 5%
						σ	1.95	2.00	± 5%

SAR Results – Body Simulating Liquid (MSL)

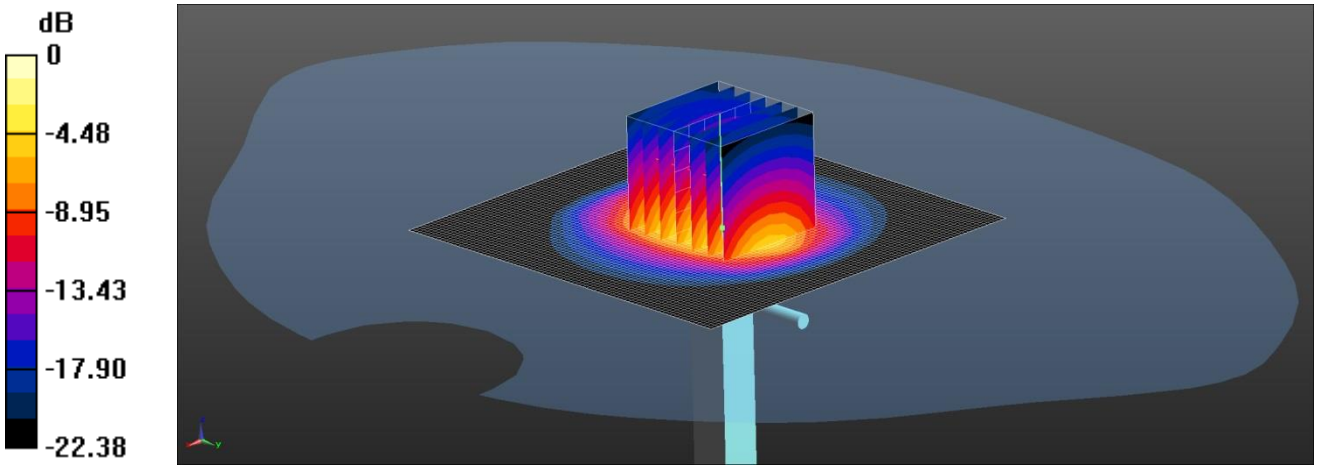
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	12.70 W/Kg	**50.55 W/Kg**	± 18.06%
	SAR averaged over 10g	5.83 W/Kg	**23.20 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	44.85 Ω -2.77 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-25.93	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D2450V2 - SN899; Type: D2450V2; Serial: SN899



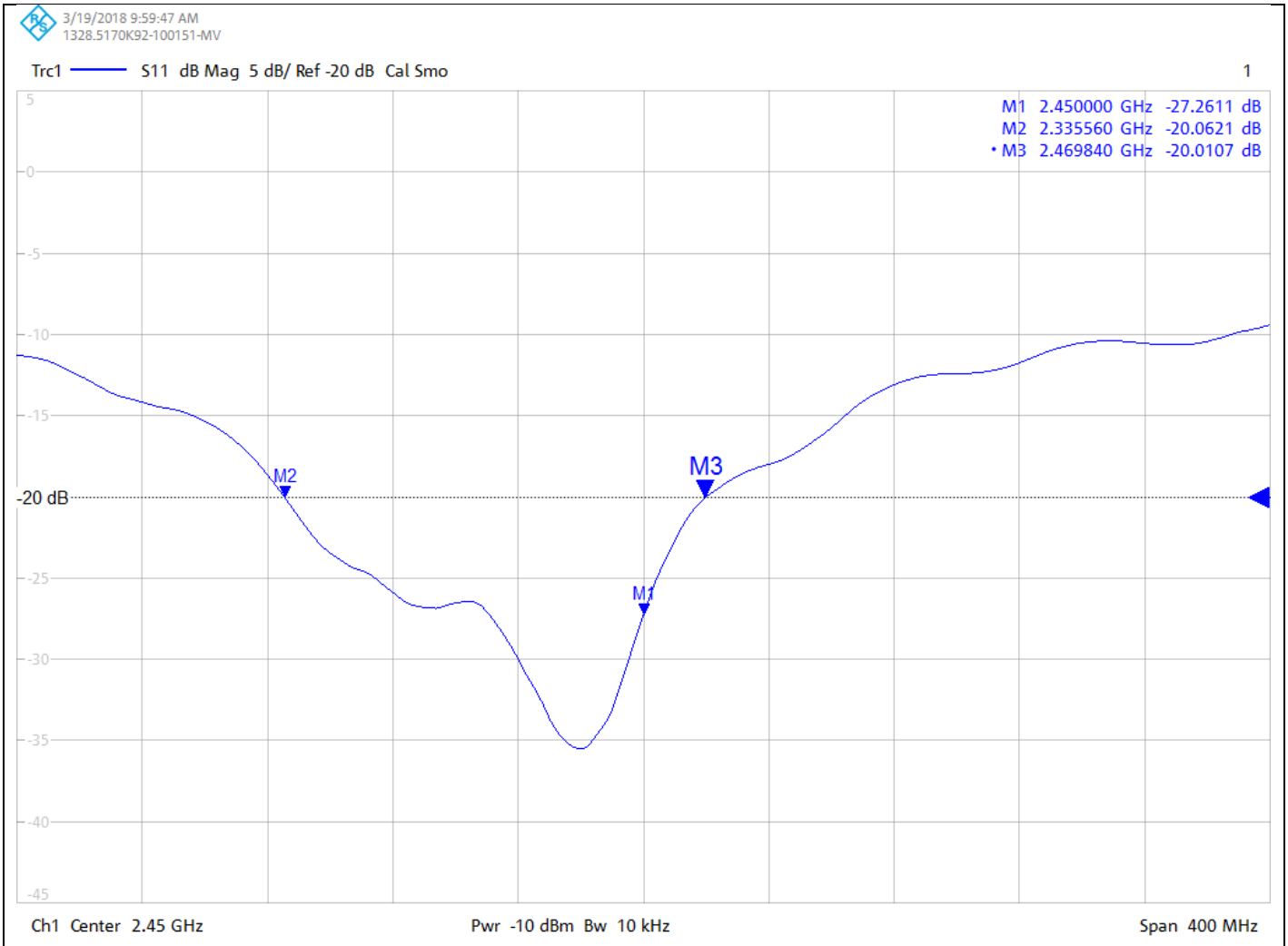
0 dB = 19.6 W/kg = 12.92 dBW/kg

Communication System: UID 0, CW (0); Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: 2300 2450 2600 MHz HSL Medium parameters used: f = 2450 MHz; σ = 1.831 S/m; ε_r = 39.418; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.04, 7.04, 7.04); 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:1817
- ; 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 = 89.36 V/m; Power Drift = -0.12 dB
Peak SAR (extrapolated) = 26.7 W/kg
SAR(1 g) = 13 W/kg; SAR(10 g) = 6.08 W/kg
Maximum value of SAR (measured) = 19.6 W/kg

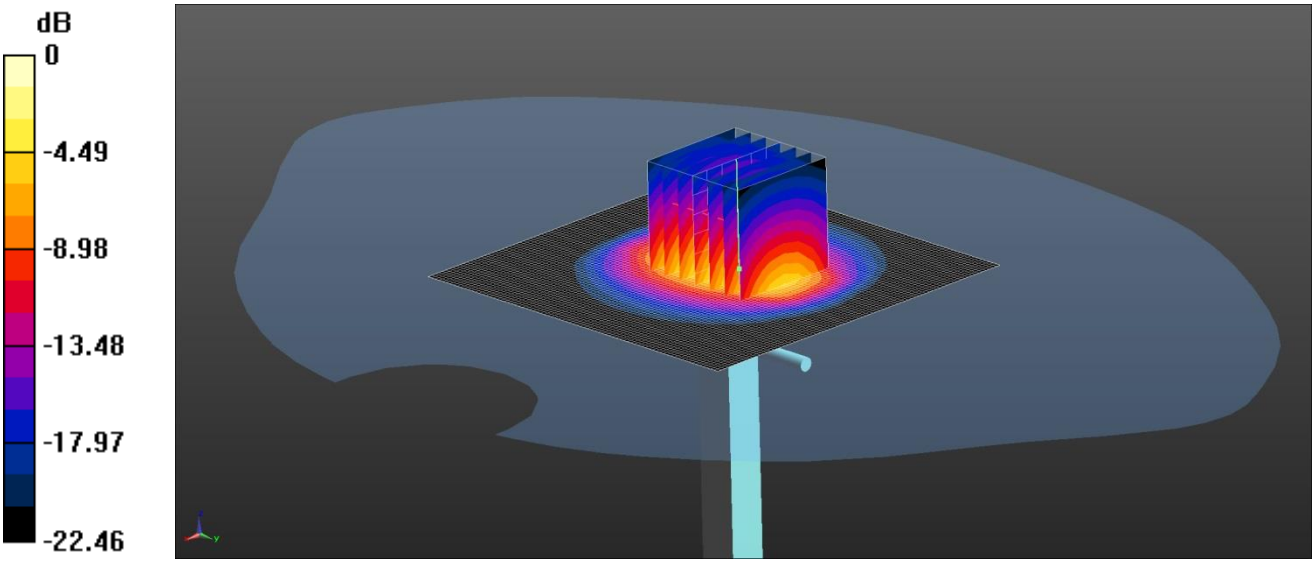
Impedance Measurement Plot for Head Stimulating Liquid (HSL)

Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D2450V2 - SN899; Type: D2450V2; Serial: SN899

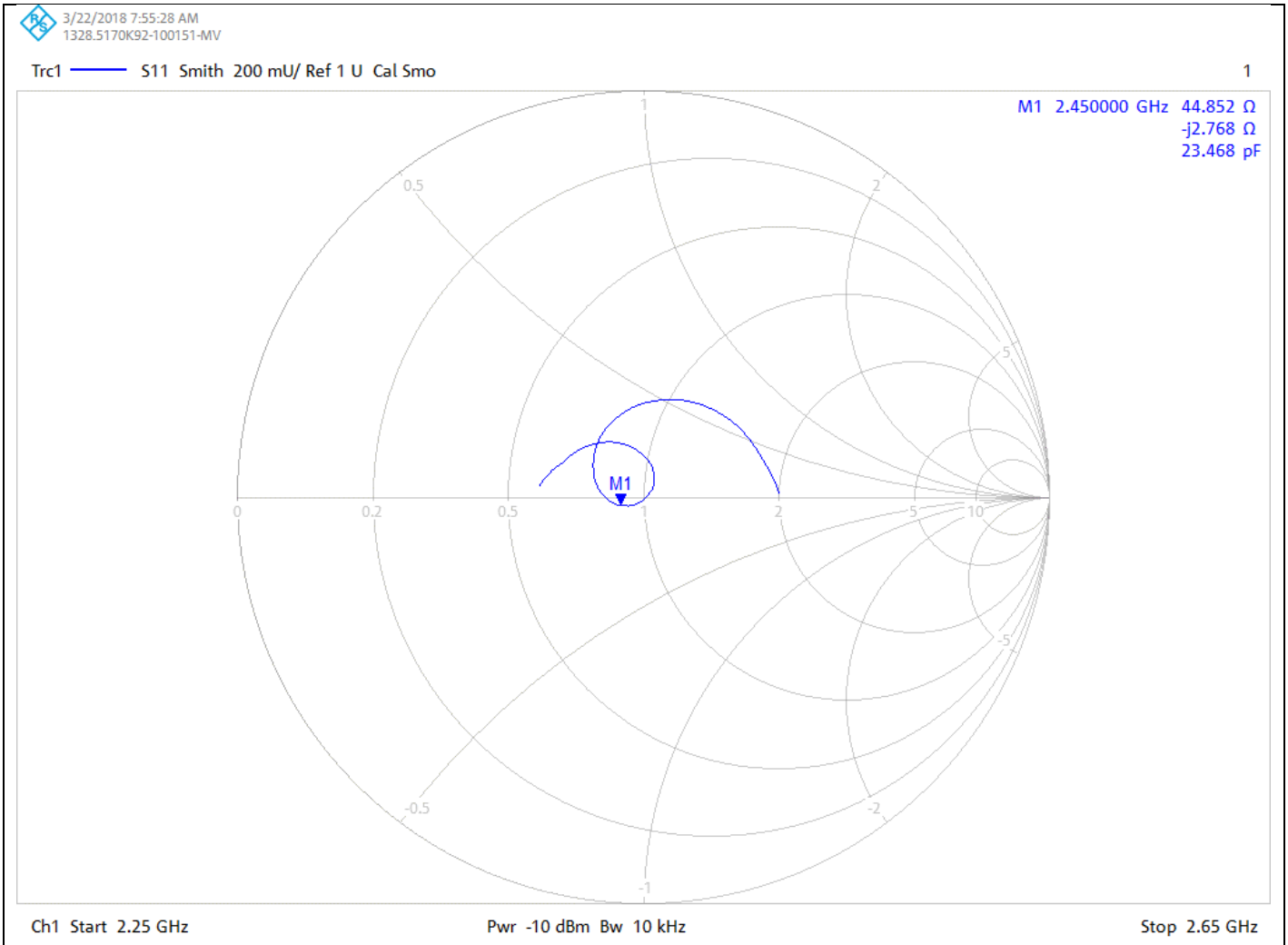


0 dB = 19.2 W/kg = 12.83 dBW/kg

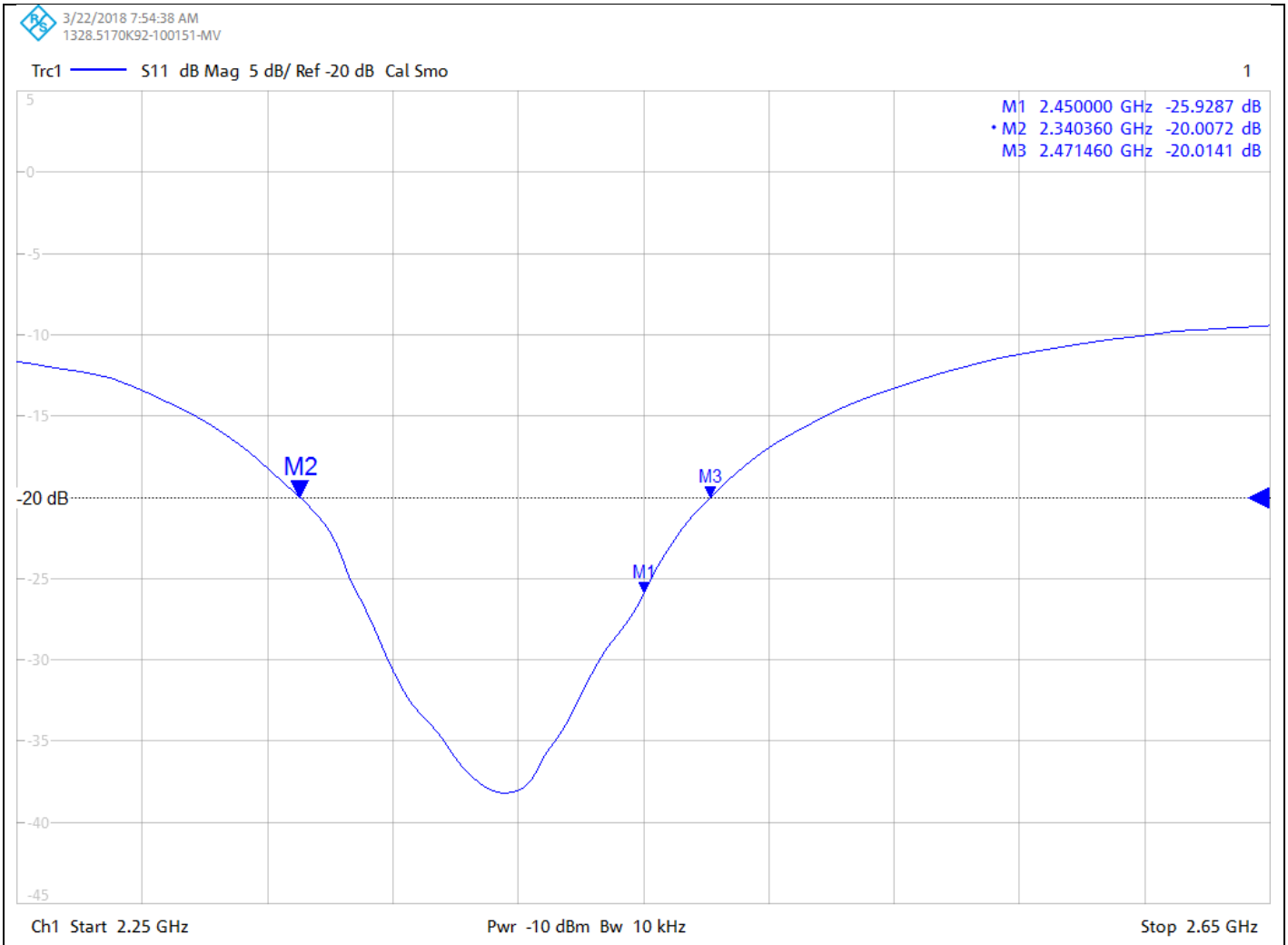
Communication System: UID 0, CW (0); Frequency: 2450 MHz;Duty Cycle: 1:1
Medium: 2450 MHz HSL Medium parameters used: f = 2450 MHz; σ = 2.003 S/m; ε_r = 51.711; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3814; ConvF(7.2, 7.2, 7.2); Calibrated: 28/09/2017;
- 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:1817
- ; 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) = 15.1 W/kg
Configuration/d=10mm, Pin=250mW/Zoom Scan (7x7x7) (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 84.15 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 25.9 W/kg
SAR(1 g) = 12.7 W/kg; SAR(10 g) = 5.83 W/kg
Maximum value of SAR (measured) = 19.2 W/kg

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134276JD01C Instrument ID: 899 Calibration Date: 16/Mar/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134276JD01C Instrument ID: 899 Calibration Date: 16/Mar/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134276JD01C Instrument ID: 899 Calibration Date: 16/Mar/2018 Calibration Due Date:

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 10/Oct/2017 CERTIFICATE NUMBER : 11903941JD01E

UKAS CALIBRATION 5248

UL VS LTD
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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

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) ^{0}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.

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

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	εr	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 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	23.52	± 1.27 dB

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	εr	52.50	51.39	± 5%
						σ	2.16	2.19	± 5%

SAR Results – Body Simulating Liquid (MSL)

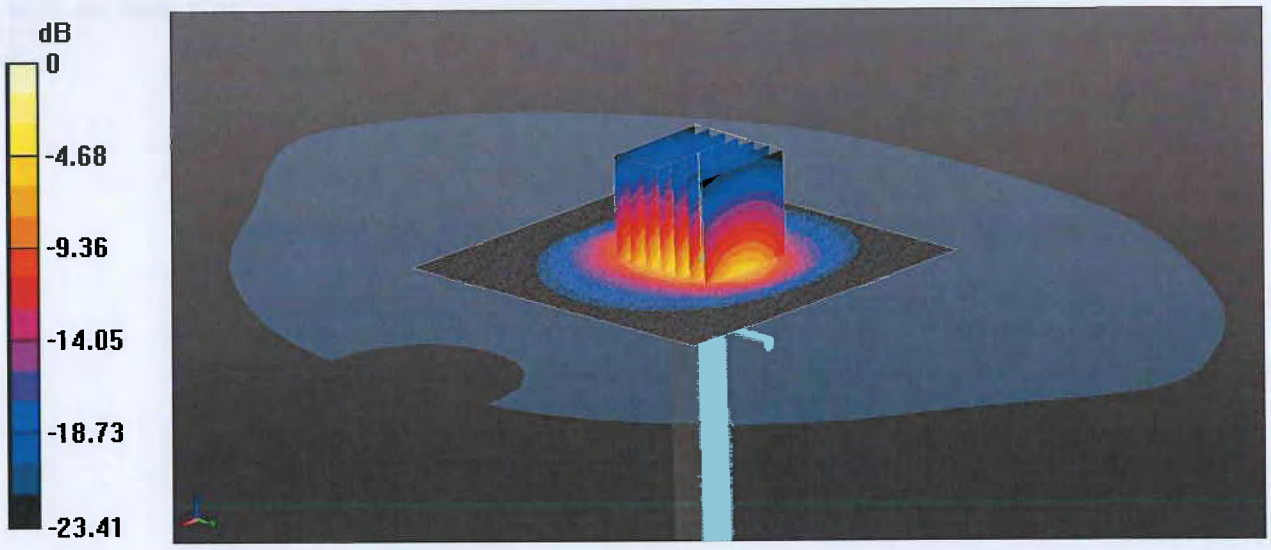
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	14.10 W/Kg	**56.13 W/Kg**	± 18.06%
	SAR averaged over 10g	6.28 W/Kg	**25.00 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

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

DASY Validation Scan for Head Stimulating Liquid (HSL)

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

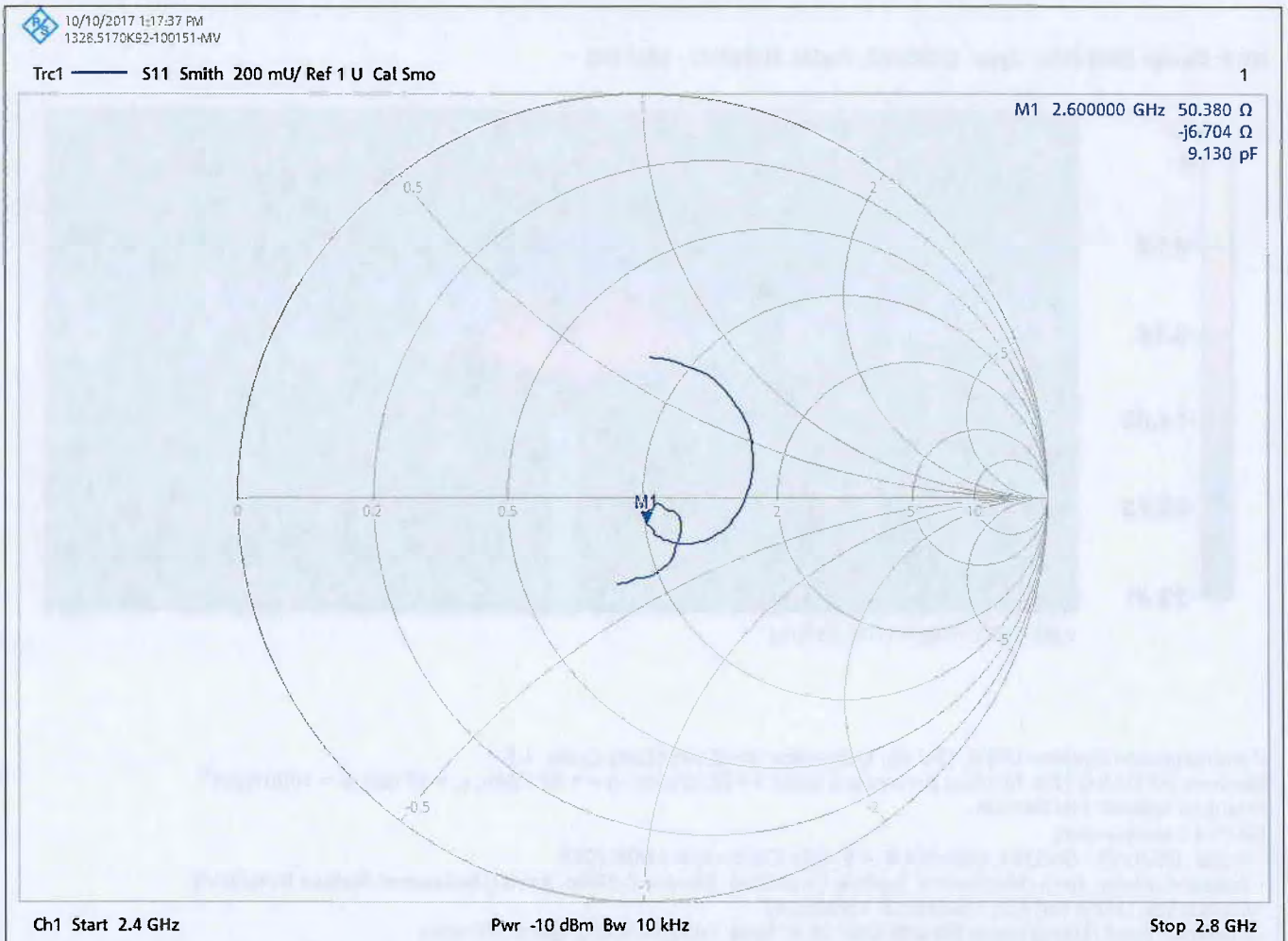


0 dB = 21.7 W/kg = 13.36 dBW/kg

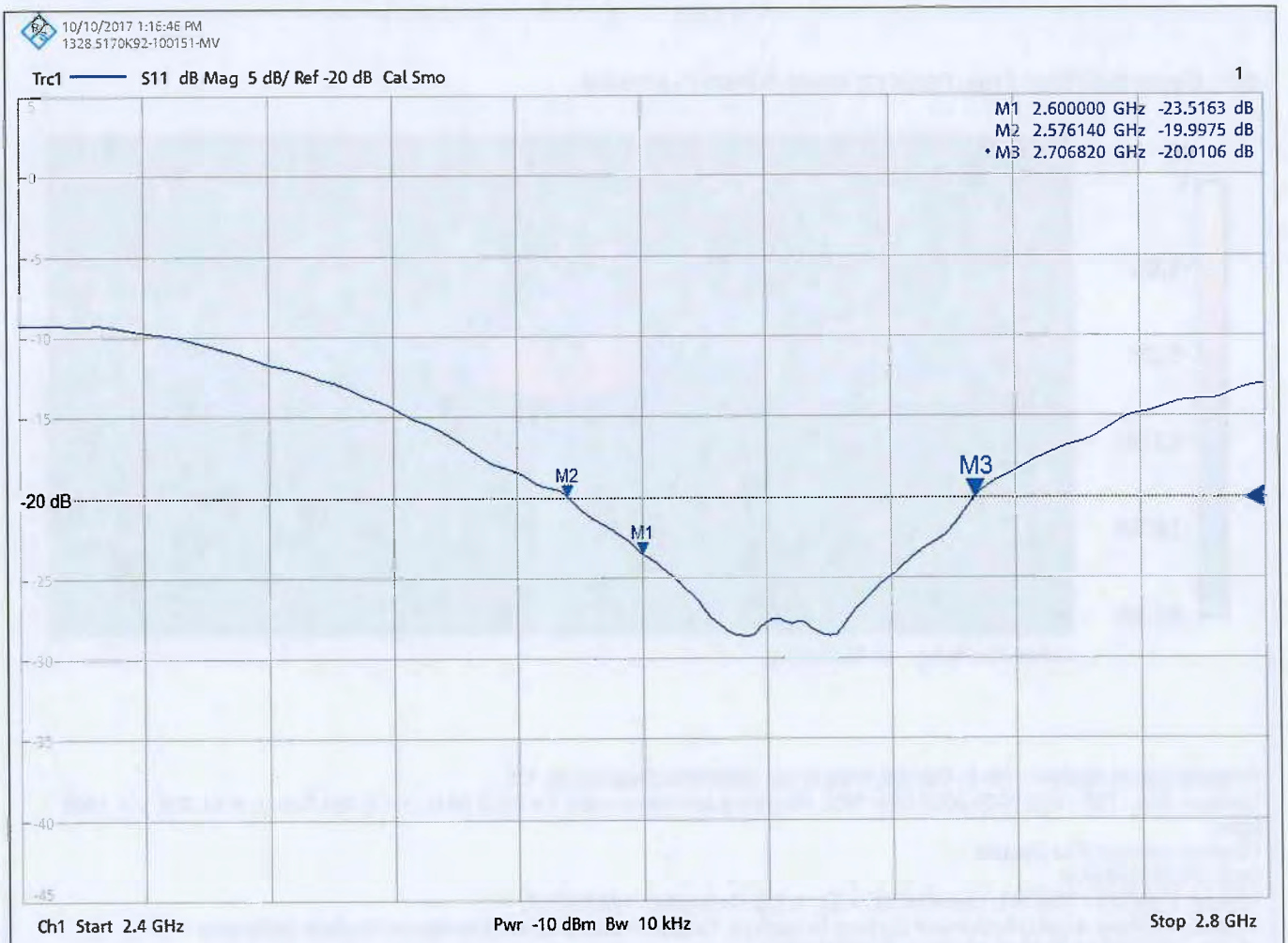
Communication System: UID 0, CW (0); Frequency: 2600 MHz;Duty Cycle: 1:1
Medium: 2600 MHz HSL Medium parameters used: f = 2600 MHz; σ = 1.971 S/m; ε_r = 37.058; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3341; ConvF(4.5, 4.5, 4.5); Calibrated: 14/08/2017;
- 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 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 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

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

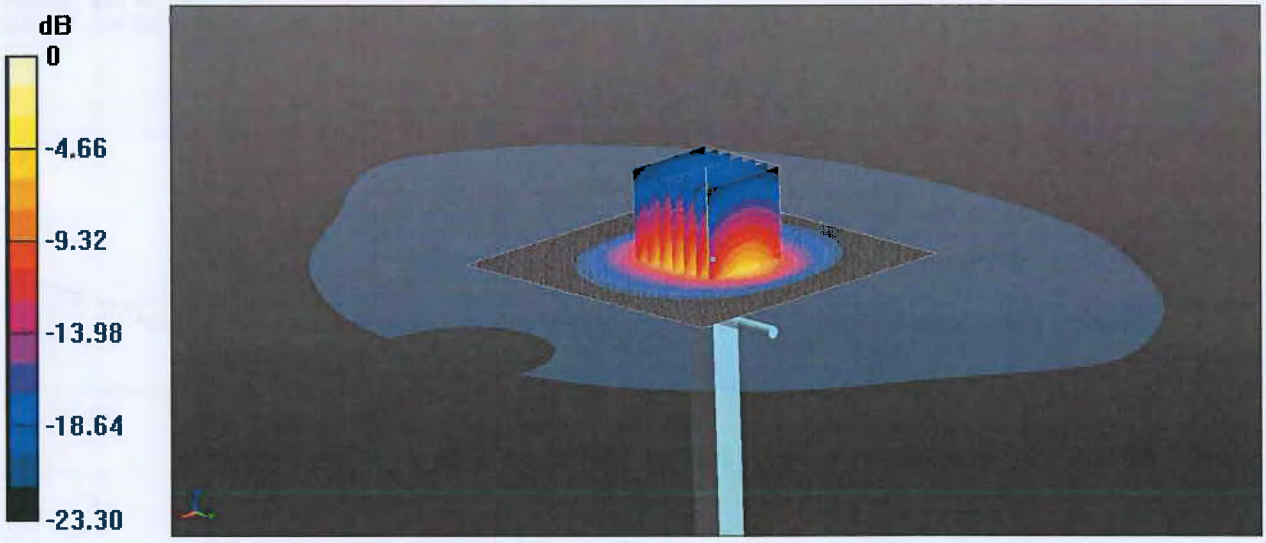


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

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

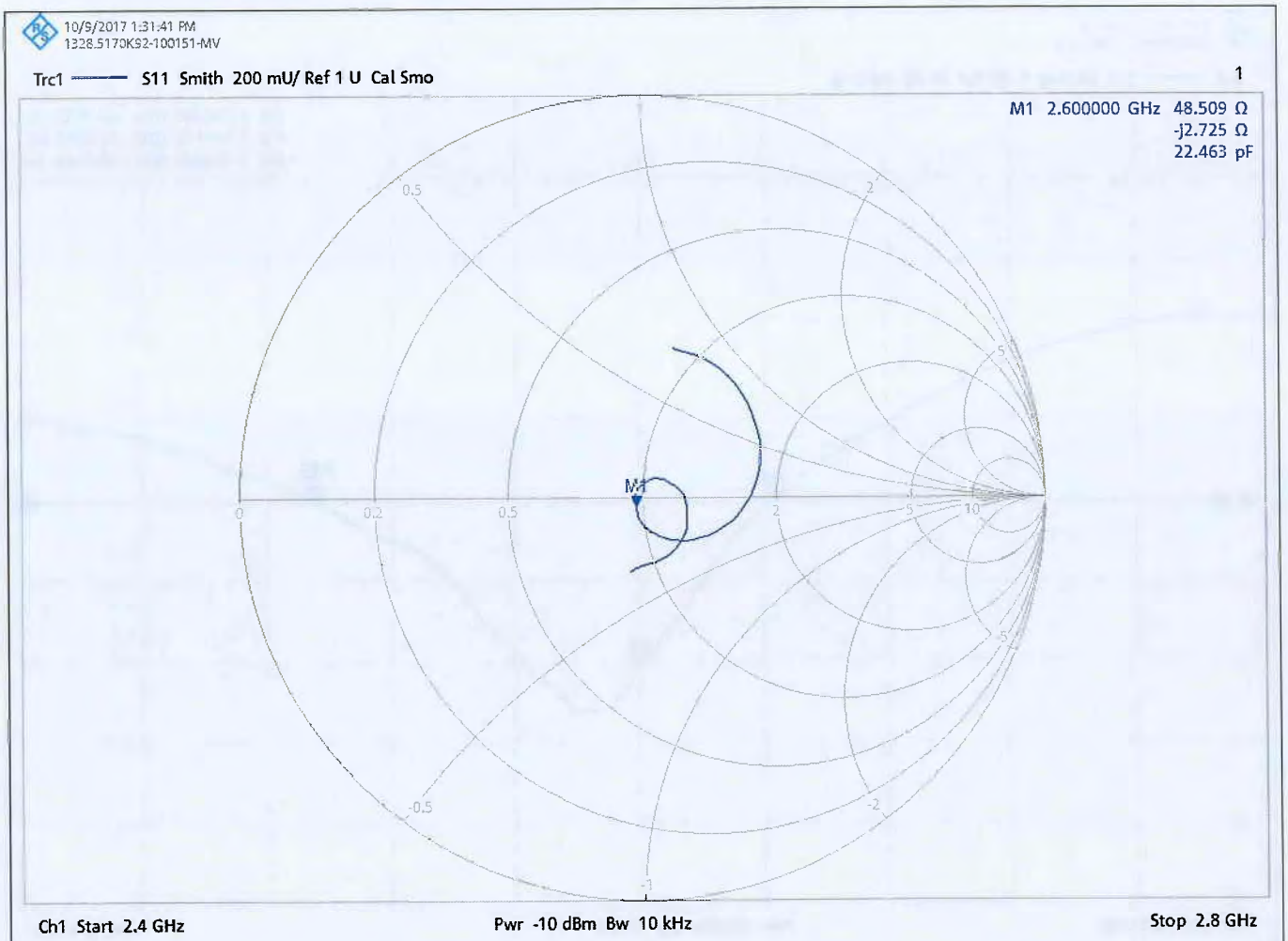


0 dB = 22.3 W/kg = 13.48 dBW/kg

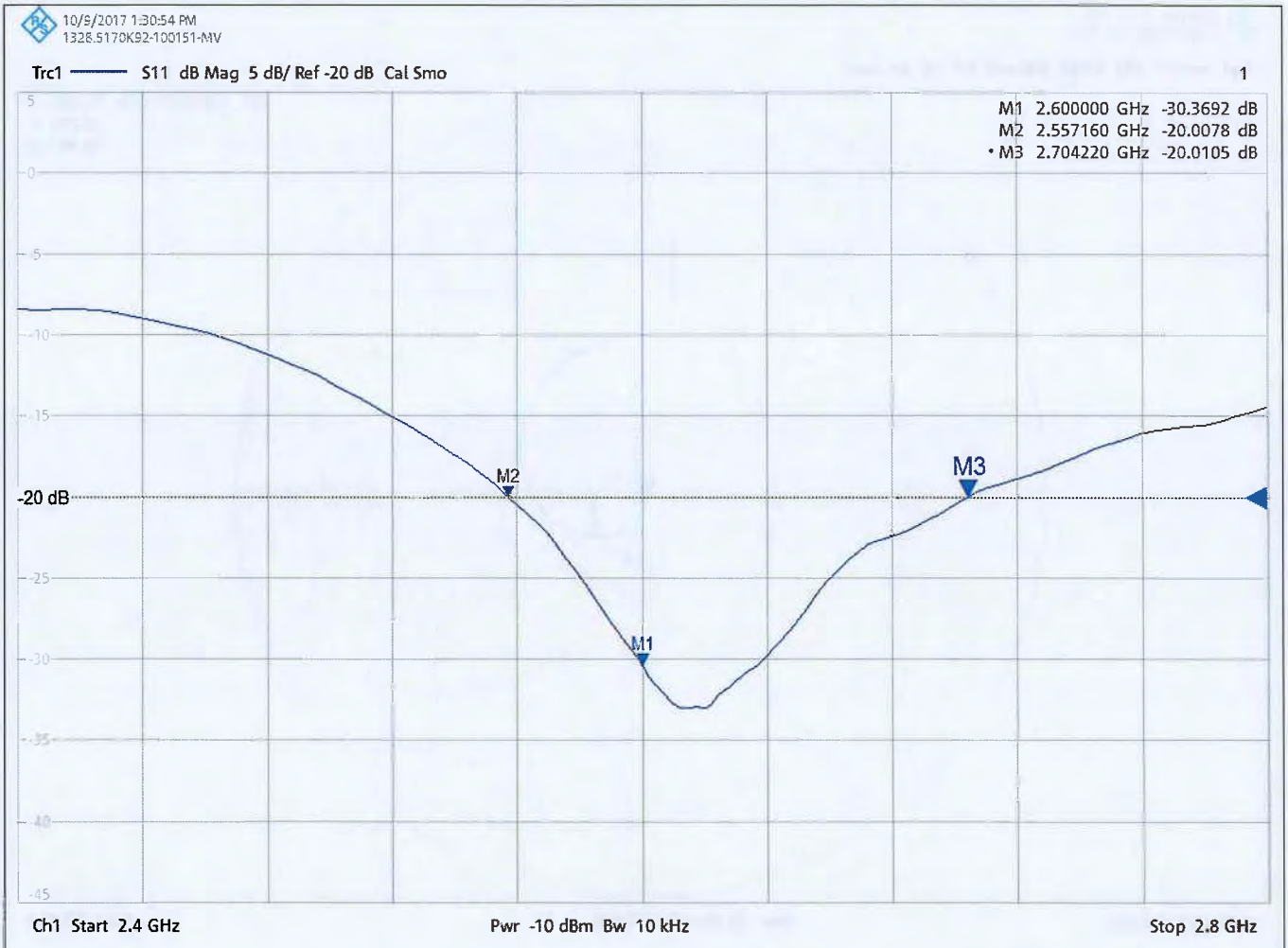
Communication System: UID 0, CW (0); Frequency: 2600 MHz;Duty Cycle: 1:1
Medium: 900,1750,1800,1900,2600 MHz MSL Medium parameters used: f = 2600 MHz; σ = 2.189 S/m; ε_r = 51.388; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3341; ConvF(4.32, 4.32, 4.32); Calibrated: 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

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903941JD01E Instrument ID: 1006 Calibration Date: 05/Oct/2017 Calibration Due Date: