CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 28/Nov/2018 CERTIFICATE NUMBER : 12134289JD01A

5248

UL VS LTD
UNIT 1 HORIZON
KINGSLAND PARK, WADE ROAD
BASINGSTOKE, HAMPSHIRE
RG24 8AH, UK
TEL: +44 (0) 1256 312000
FAX: +44 (0) 1256 312001
Email: LST.UK.Calibration@ul.com

APPROVED SIGNATORY

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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:	D750V3		
Serial Number:	1071		
Calibration Date:	28/Nov/2018		
Calibrated By:	Chanthu Thevarajah Senior Engineer		
Signature:			

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

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)
PRE0178318	Data Acquisition Electronics	SPEAG	DAE4	1543	08 Mar 2018	12
PRE0178315	Probe	SPEAG	ES3DV3	3360	17 Aug 2018	12
A1985	Dipole	SPEAG	D750V3	1011	07 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
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2017	12
PRE0151877	Calibration Kit	Rhode & Schwarz	ZV-Z135	102947-Bt	27 Apr 2018	12
PRE0178154	Signal Generator	Rhode & Schwarz	SMB 100A	175325	09 Apr 2018	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F17/5ENYG1/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:	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	20.0 ℃	20.5 ℃	20.5℃	20.5℃	**εr**	41.96	41.83	± 5%
						σ	0.89	0.90	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	2.09 W/Kg	**8.32 W/Kg**	± 17.57%
	SAR averaged over 10g	1.37 W/Kg	**5.45 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	47.158 Ω 3.05 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-26.81	± 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	750	20.0 ℃	20.0 ℃	19.3℃	20.0℃	**εr**	55.55	54.19	± 5%
						σ	0.96	0.96	± 5%

SAR Results – Body Simulating Liquid (MSL)

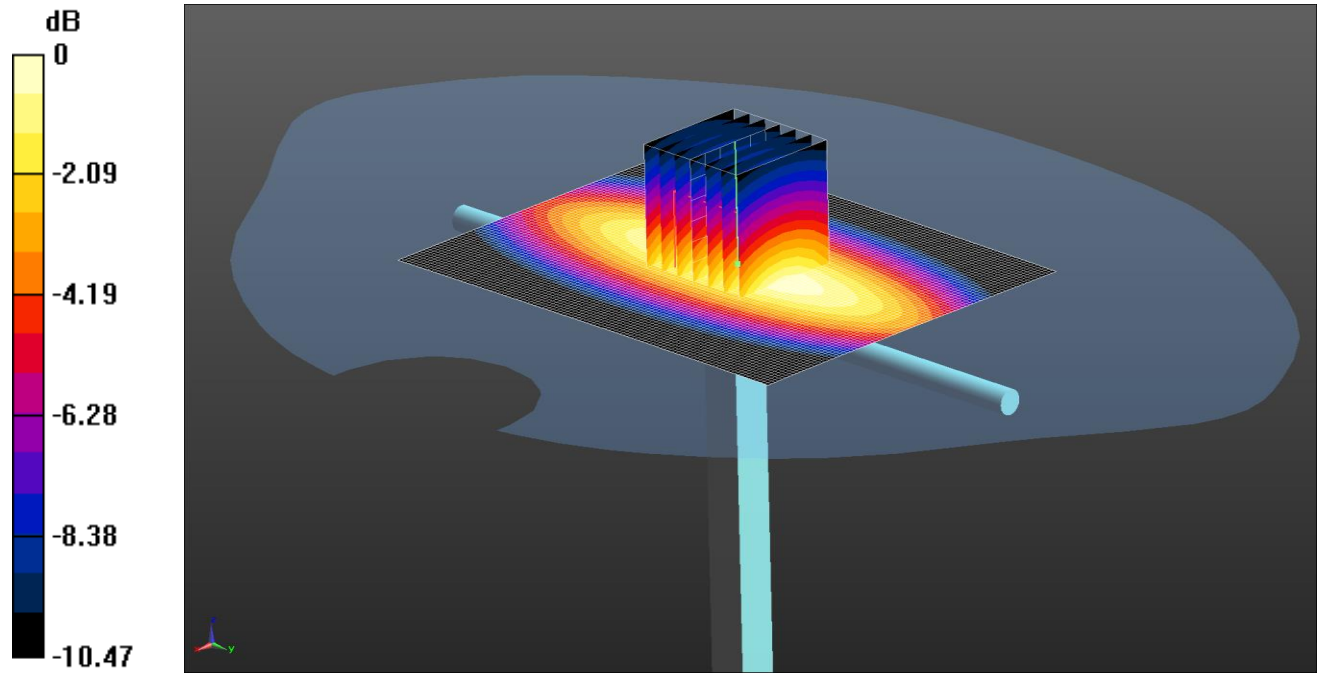
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	2.17 W/Kg	**8.63 W/Kg**	± 18.06%
	SAR averaged over 10g	1.42 W/Kg	**5.65 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	52.66 Ω 4.35 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-26.59	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D750V3 - SN1071; Type: D750V3; Serial: SN1071

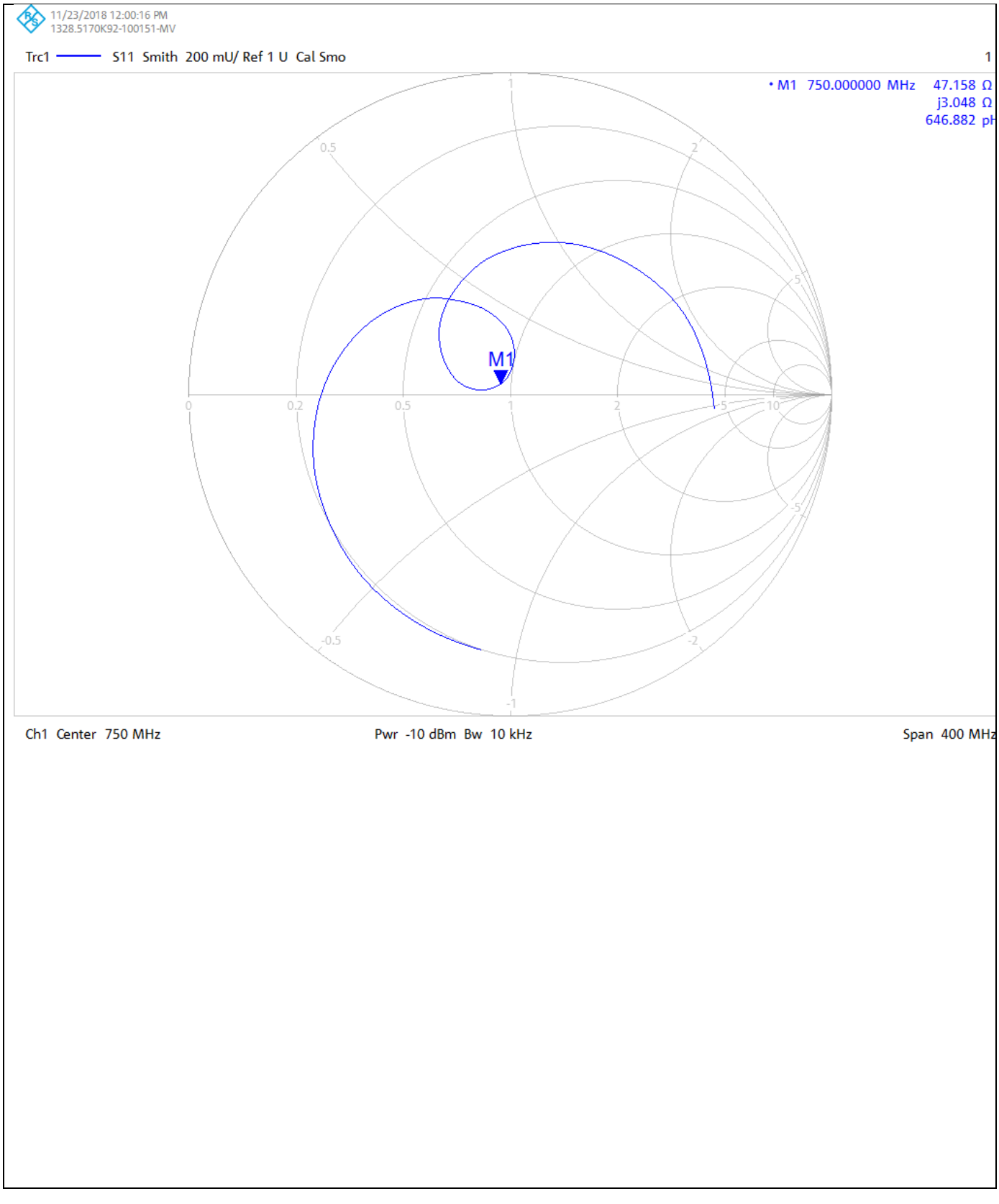


0 dB = 2.45 W/kg = 3.89 dBW/kg

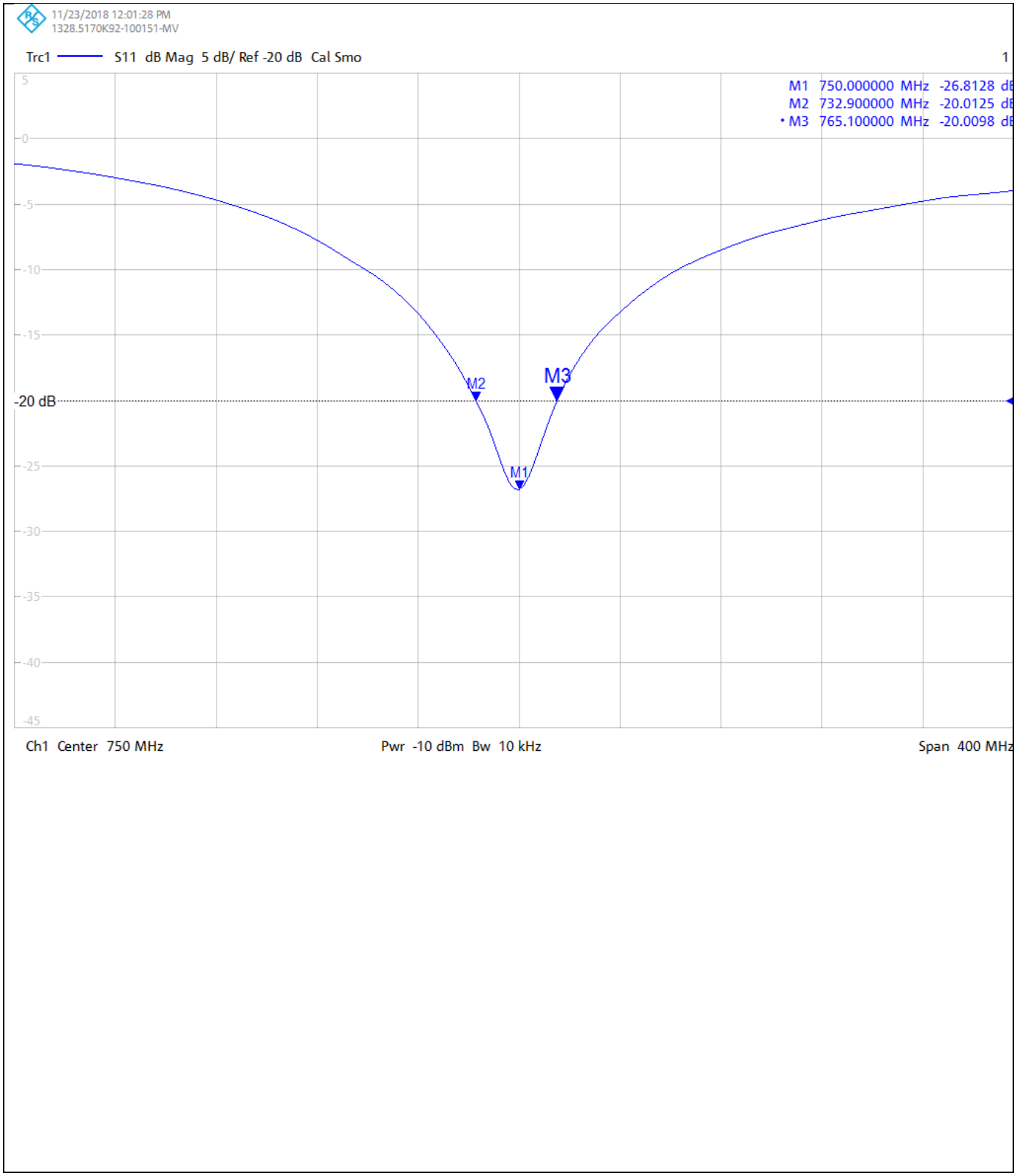
Communication System: UID 0, CW (0); Frequency: 750 MHz;Duty Cycle: 1:1
Medium: 750 835 900 1800 1900 MHz HSL Medium parameters used: f = 750 MHz; σ = 0.899 S/m; ε_r = 41.829; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(6.48, 6.48, 6.48); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM A (Site 65); Type: SAM 8.0; Serial: TP:1945
- ; SEMCAD X Version 14.6.10 (7417)

Configuration/d=10mm, Pin=250mW 2/Area Scan (81x101x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 2.45 W/kg
Configuration/d=10mm, Pin=250mW 2/Zoom Scan 2 (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 53.77 V/m; Power Drift = -0.03 dB
Peak SAR (extrapolated) = 3.13 W/kg
SAR(1 g) = 2.09 W/kg; SAR(10 g) = 1.37 W/kg
Maximum value of SAR (measured) = 2.45 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

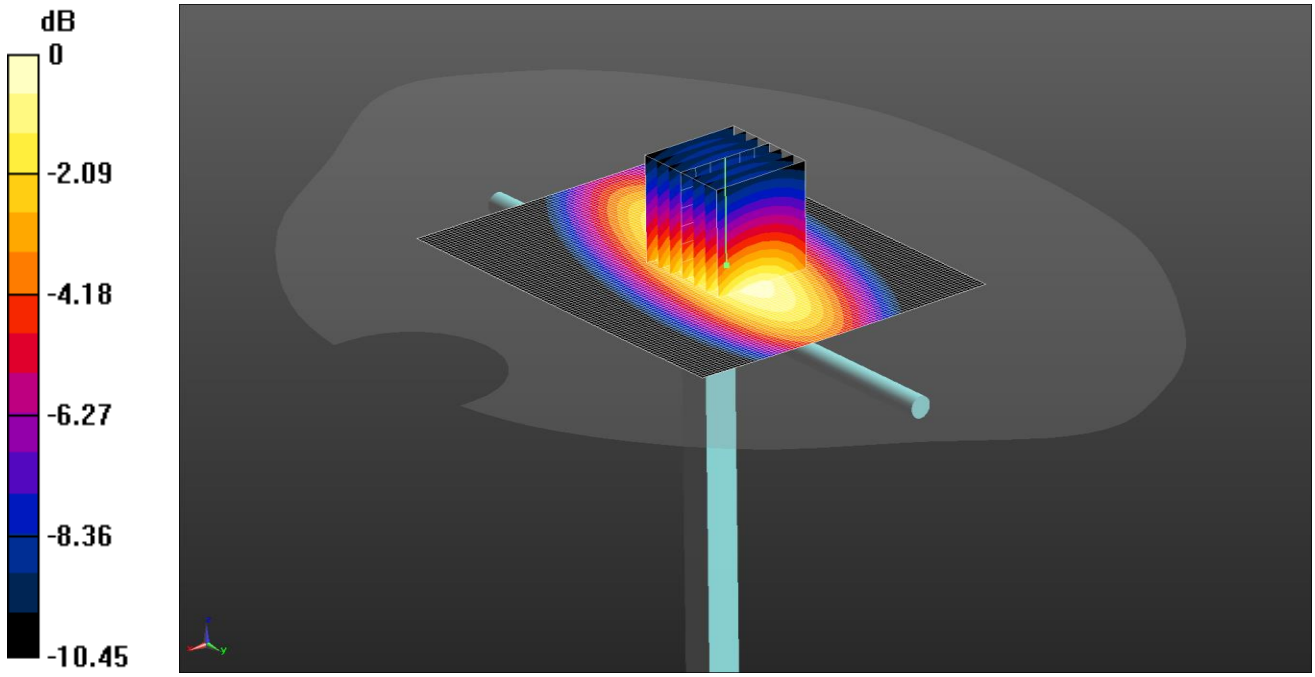


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D750V3 - SN1071; Type: D750V3; Serial: SN1071

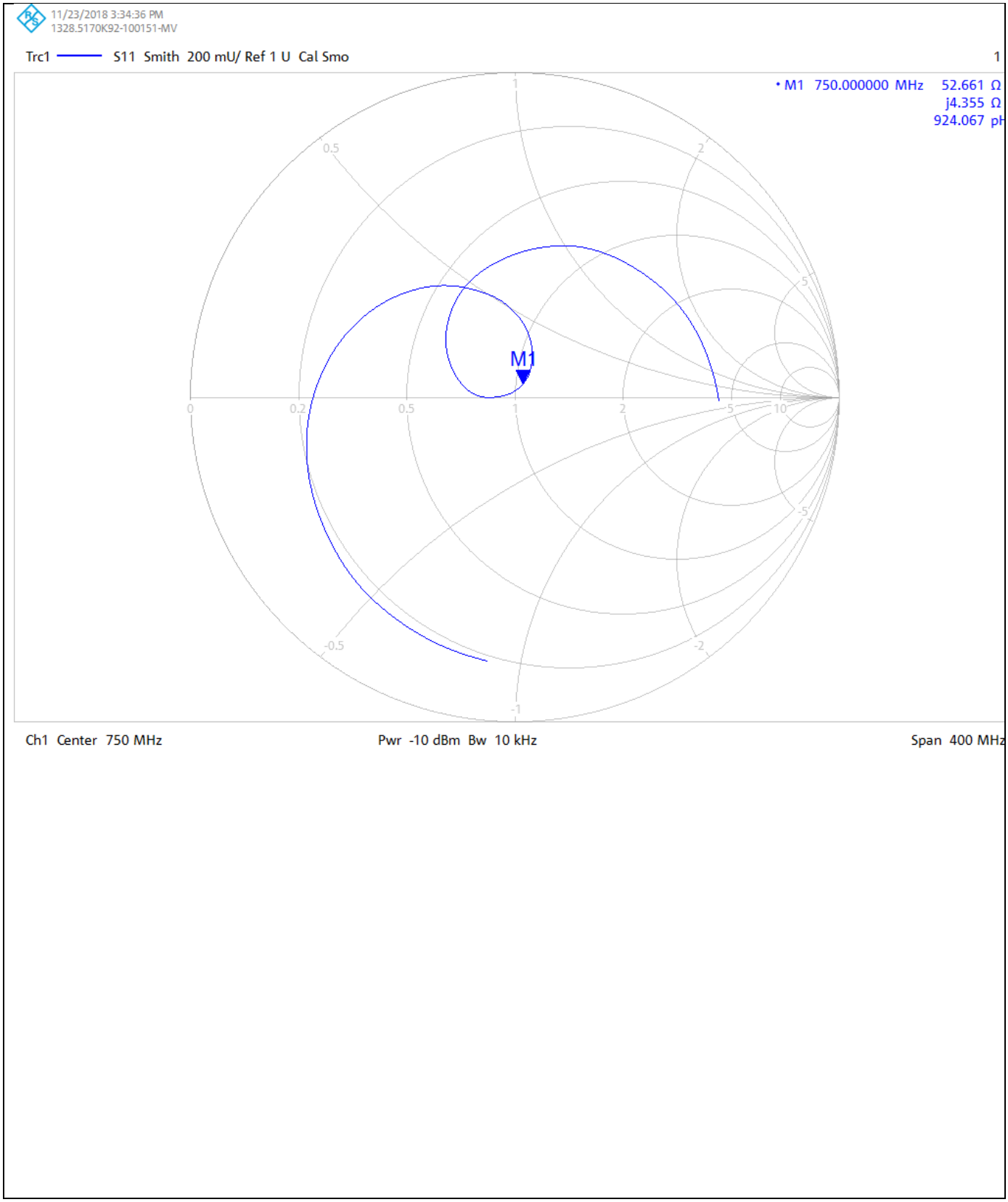


0 dB = 2.54 W/kg = 4.05 dBW/kg

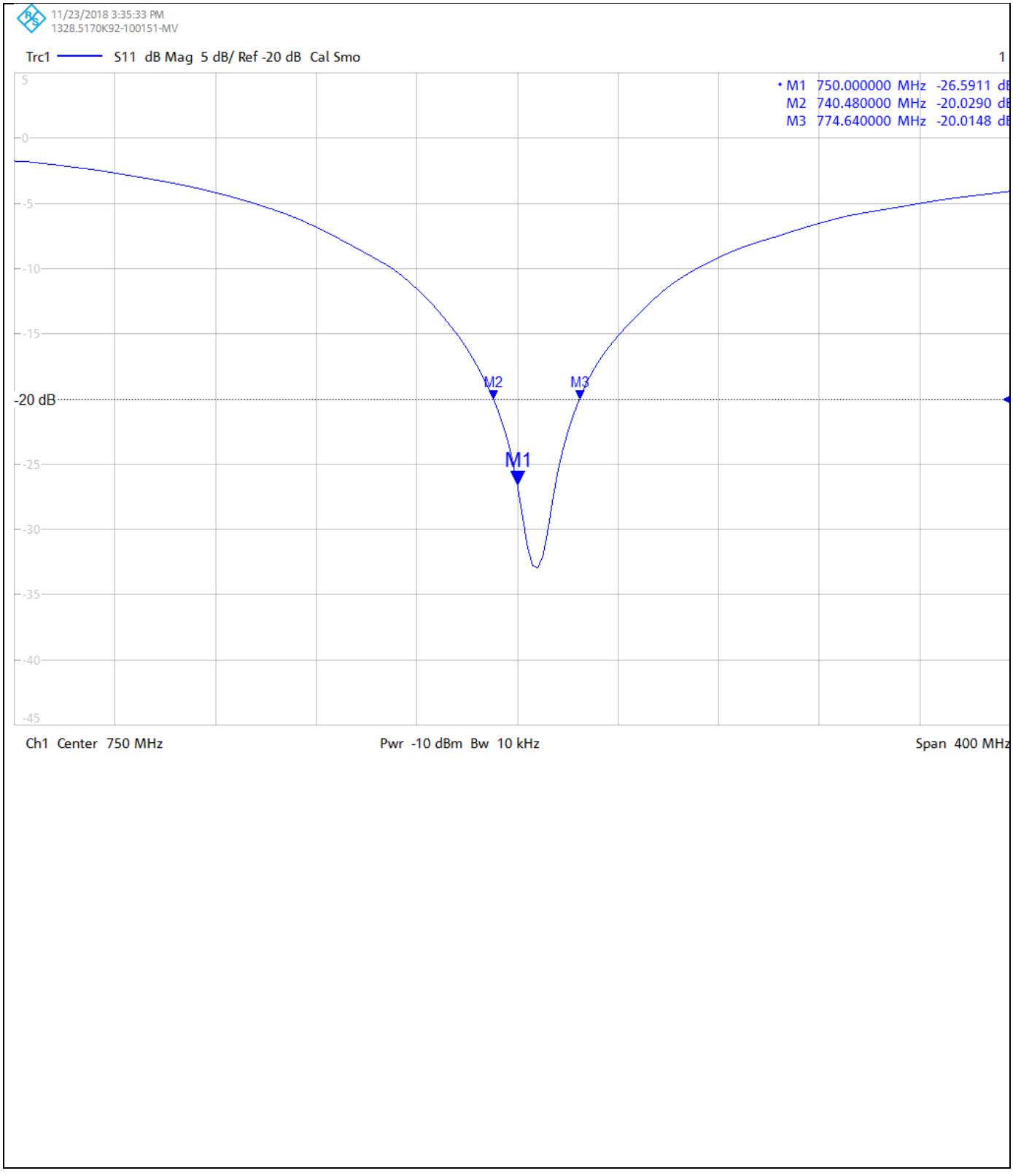
Communication System: UID 0, CW (0); Frequency: 750 MHz;Duty Cycle: 1:1
Medium: 750 835 900 1800 MHz MSL Medium parameters used: f = 750 MHz; σ = 0.959 S/m; ε_r = 54.189; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(6.55, 6.55, 6.55); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM B (Site 65); Type: SAM 5.0; Serial: TP:1836
- ; SEMCAD X Version 14.6.10 (7417)

Configuration/d=10mm, Pin=250mW 2/Area Scan (81x101x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 2.53 W/kg
Configuration/d=10mm, Pin=250mW 2/Zoom Scan 2 (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 51.97 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 3.28 W/kg
SAR(1 g) = 2.17 W/kg; SAR(10 g) = 1.42 W/kg
Maximum value of SAR (measured) = 2.54 W/kg

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134289JD01A Instrument ID: 1071 Calibration Date: 28/Nov/2018 Calibration Due Date:

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CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 28/Nov/2018 CERTIFICATE NUMBER : 12134289JD01B

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APPROVED SIGNATORY

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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:	28/Nov/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%

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)
PRE0178318	Data Acquisition Electronics	SPEAG	DAE4	1543	08 Mar 2018	12
PRE0178315	Probe	SPEAG	ES3DV3	3360	17 Aug 2018	12
A2588	Dipole	SPEAG	D900V2	1d168	18 Sep 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
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2017	12
PRE0151877	Calibration Kit	Rhode & Schwarz	ZV-Z135	102947-Bt	27 Apr 2018	12
PRE0178154	Signal Generator	Rhode & Schwarz	SMB 100A	175325	09 Apr 2018	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F17/5ENYG1/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	20.0 ℃	20.0 ℃	20.5℃	20.0℃	**εr**	41.50	41.57	± 5%
						σ	0.90	0.93	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	2.48 W/Kg	**9.87 W/Kg**	± 17.57%
	SAR averaged over 10g	1.60 W/Kg	**6.36 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	47.85 Ω 0.47 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-31.95	± 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	835	20.0 ℃	20.0 ℃	19.3℃	20.0℃	**εr**	55.20	54.10	± 5%
						σ	0.97	0.99	± 5%

SAR Results – Body Simulating Liquid (MSL)

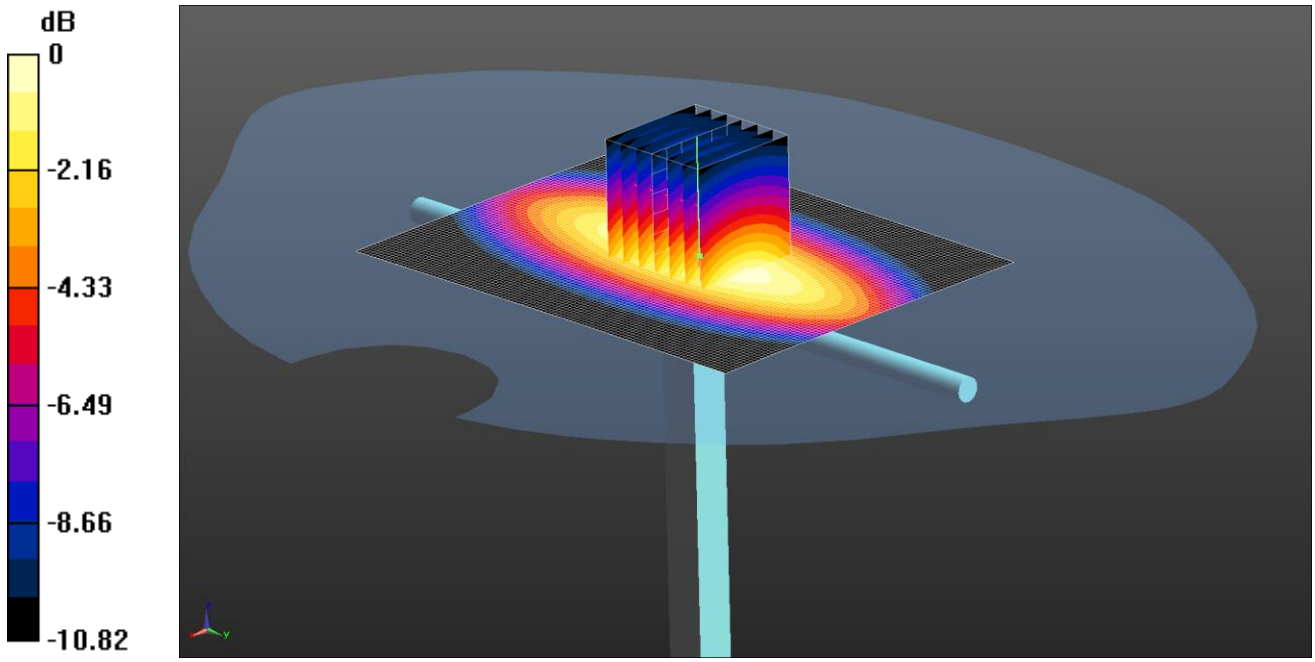
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	2.53 W/Kg	**10.07 W/Kg**	± 18.06%
	SAR averaged over 10g	1.65 W/Kg	**6.56 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	46.49 Ω 5.59 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-23.73	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D835V2 - SN4d002; Type: D835V2; Serial: SN4d002

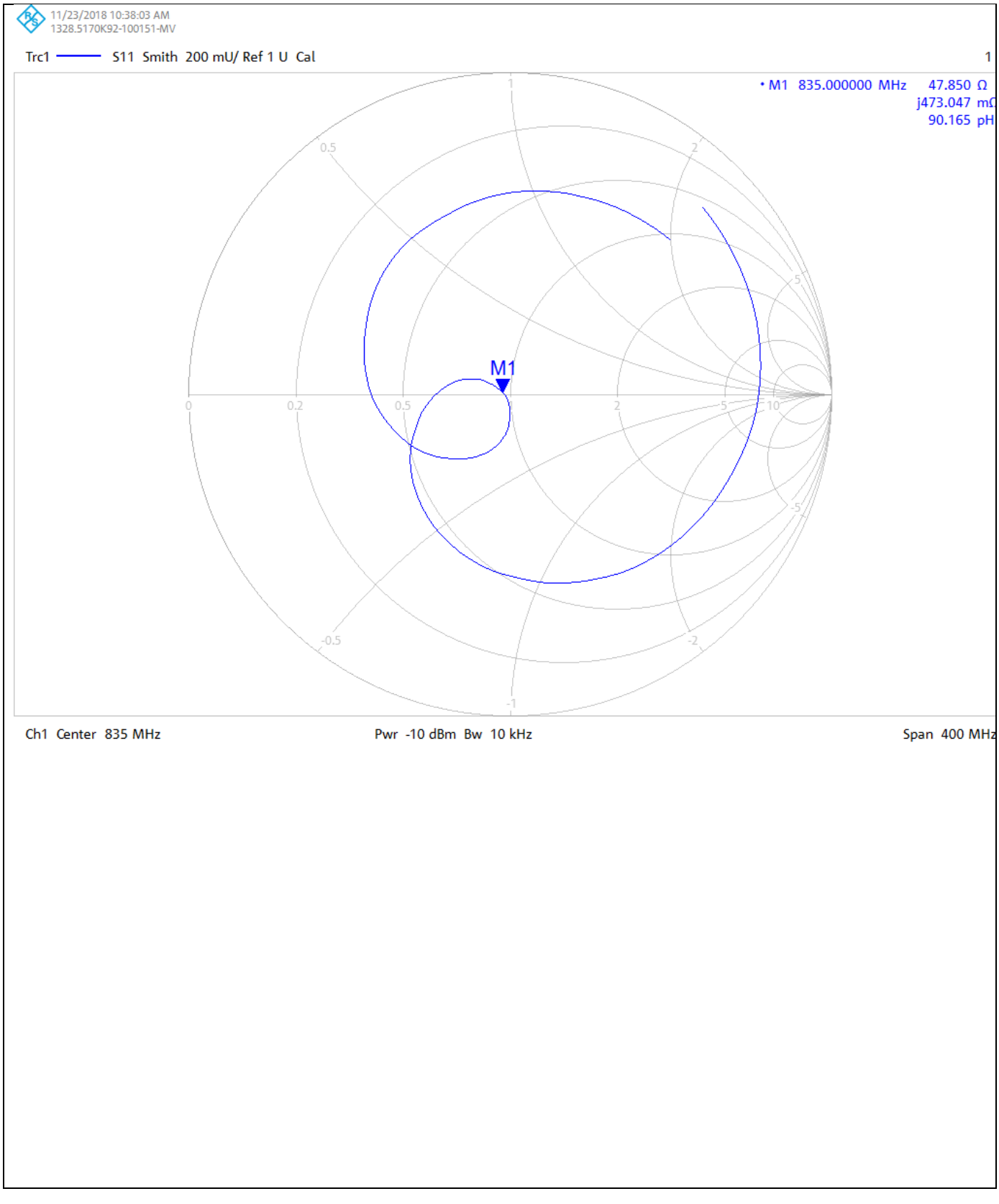


0 dB = 2.91 W/kg = 4.64 dBW/kg

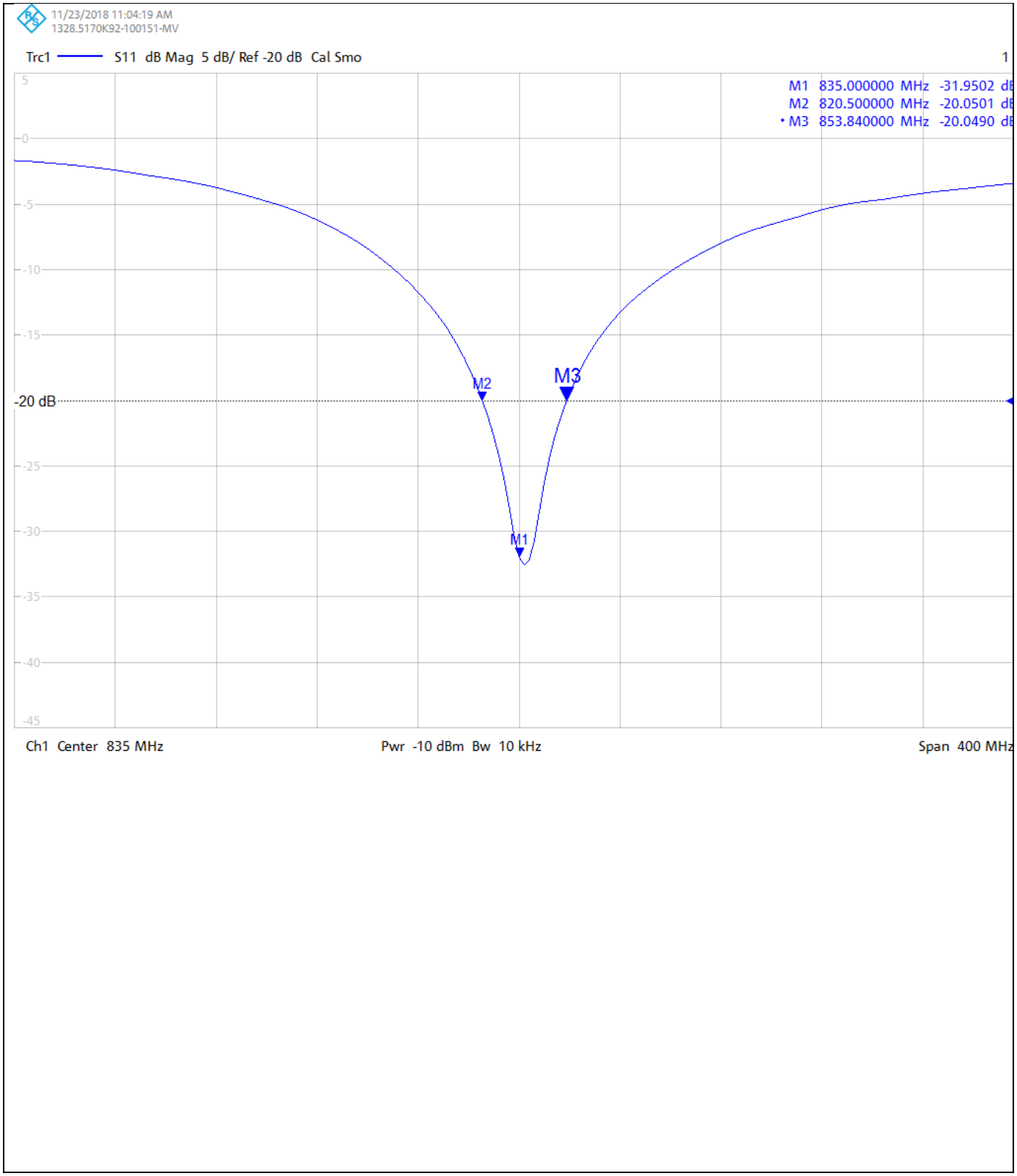
Communication System: UID 0, CW (0); Frequency: 835 MHz;Duty Cycle: 1:1
Medium: 750 835 900 1800 1900 MHz HSL Medium parameters used (interpolated): f = 835 MHz; σ = 0.931 S/m; ε_r = 41.573; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(6.23, 6.23, 6.23); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM A (Site 65); Type: SAM 8.0; Serial: TP:1945
- ; SEMCAD X Version 14.6.10 (7417)

Configuration/d=10mm, Pin=250mW 2/Area Scan (81x101x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 2.90 W/kg
Configuration/d=10mm, Pin=250mW 2/Zoom Scan 2 (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 57.40 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 3.75 W/kg
SAR(1 g) = 2.48 W/kg; SAR(10 g) = 1.6 W/kg
Maximum value of SAR (measured) = 2.91 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

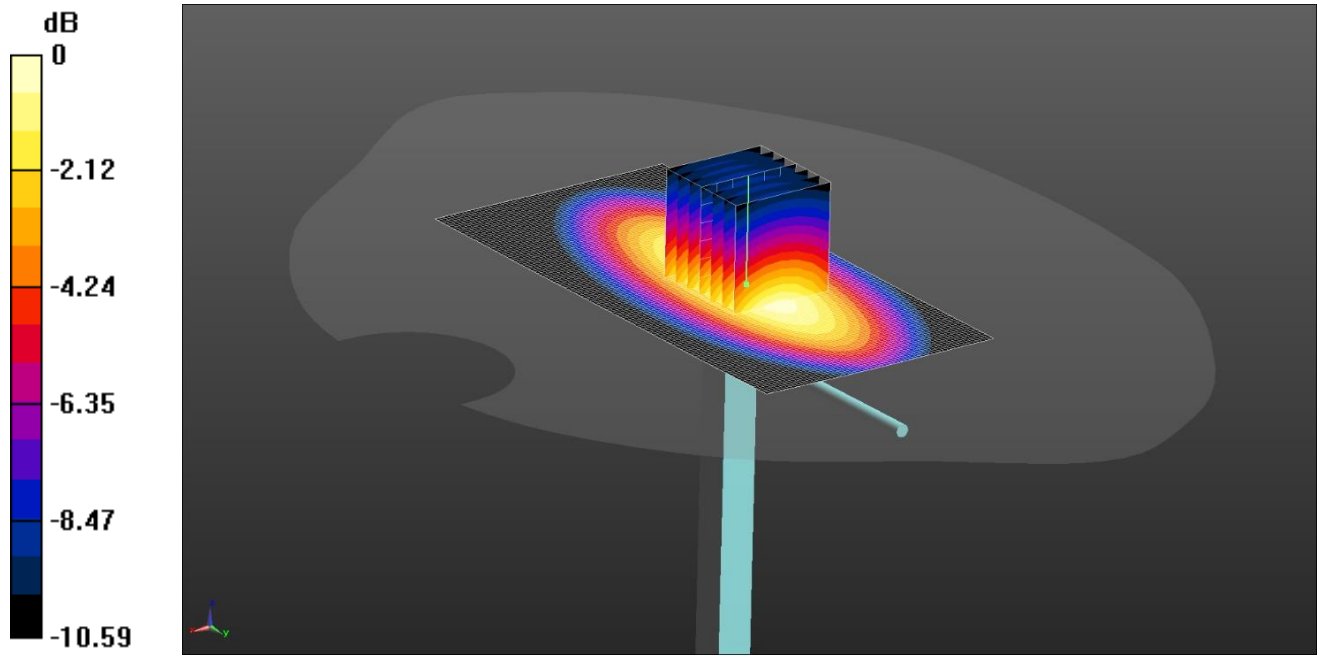


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D835V2 - SN4d002; Type: D900V2; Serial: SN4d002

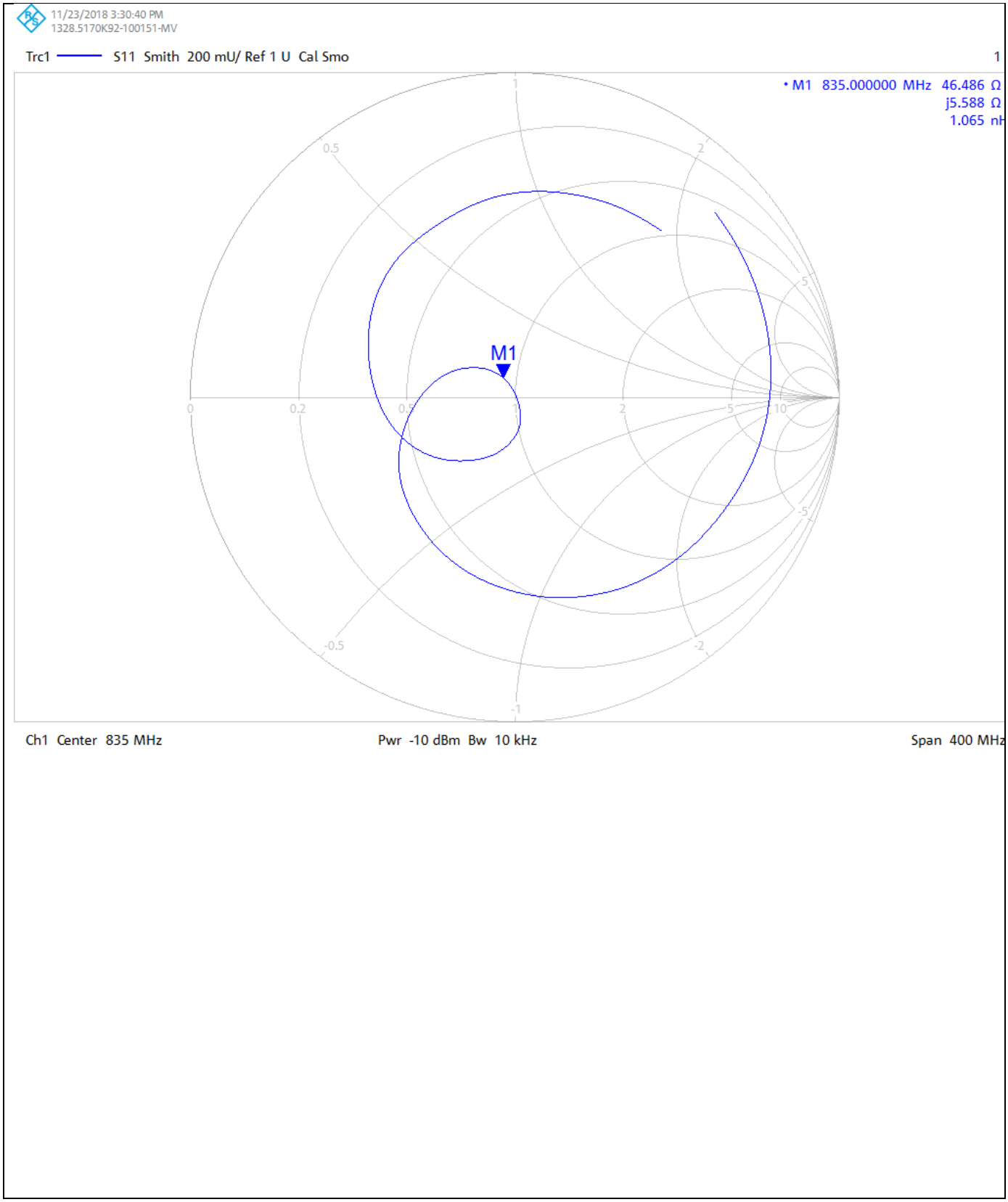


0 dB = 2.97 W/kg = 4.73 dBW/kg

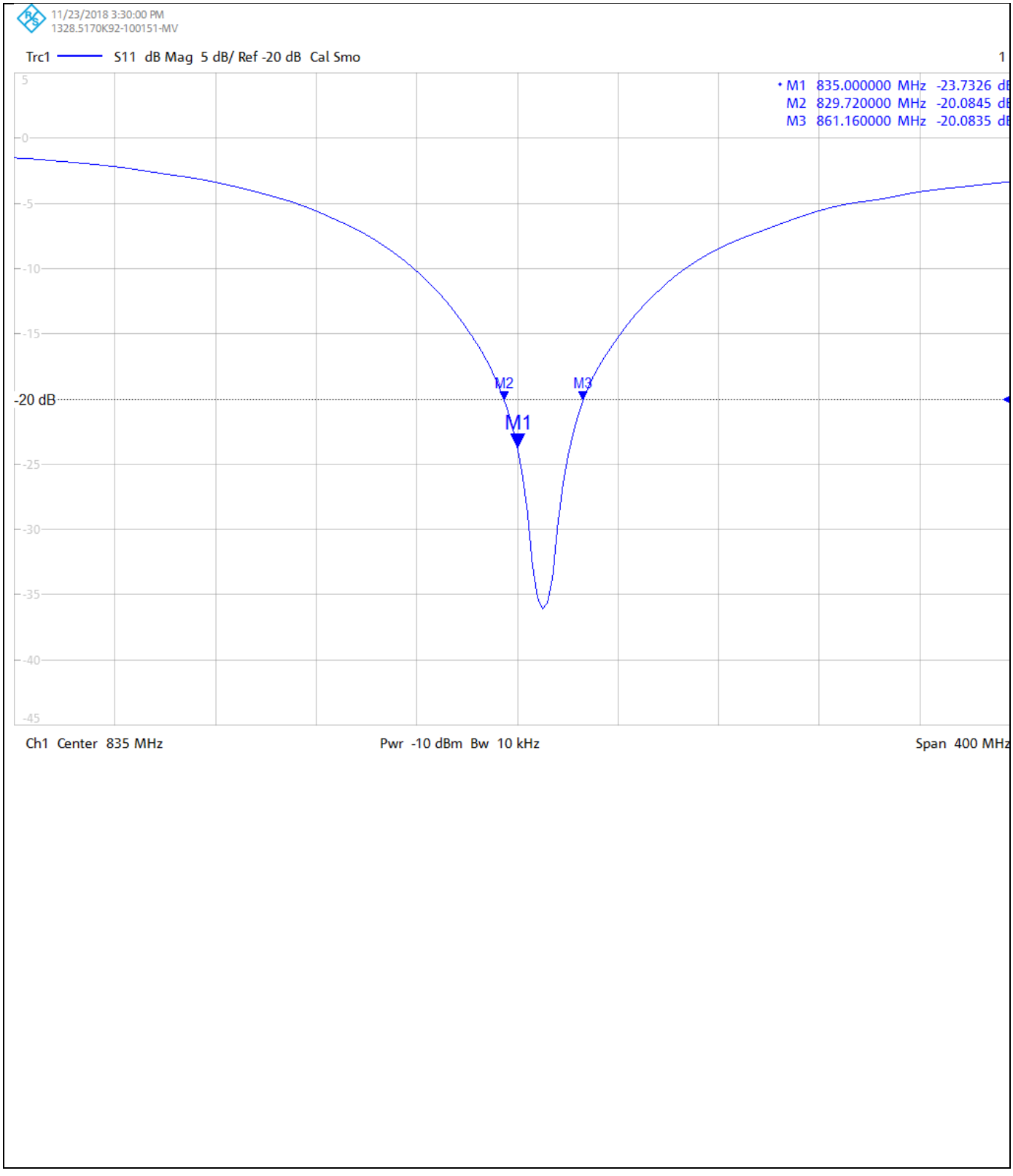
Communication System: UID 0, CW (0); Frequency: 835 MHz;Duty Cycle: 1:1
Medium: 750,835,900,1800 5%MHz MSL Medium parameters used (interpolated): f = 835 MHz; σ = 0.992 S/m; ε_r = 54.099; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(6.31, 6.31, 6.31); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM B (Site 65); Type: SAM 5.0; Serial: TP:1836
- ; SEMCAD X Version 14.6.10 (7417)

SAR/d=10mm, Pin=50 mW/Area Scan (61x121x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 2.96 W/kg
SAR/d=10mm, Pin=50 mW/Zoom Scan 2 2 (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 56.17 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 3.82 W/kg
SAR(1 g) = 2.53 W/kg; SAR(10 g) = 1.65 W/kg
Maximum value of SAR (measured) = 2.97 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: 12134289JD01B Instrument ID: 4d002 Calibration Date: 28/Nov/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134289JD01B Instrument ID: 4d002 Calibration Date: 28/Nov/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134289JD01B Instrument ID: 4d002 Calibration Date: 28/Nov/2018 Calibration Due Date:

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 03/Oct/2018 CERTIFICATE NUMBER : 11903949JD01B

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

APPROVED SIGNATORY

M. Naseer

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Naseer Mirza

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

Equipment Details:

Description:	Dipole Validation Kit	Date of Receipt:	07/Sep/2018
Manufacturer:	Speag		
Type/Model Number:	D1750V2		
Serial Number:	1053		
Calibration Date:	02/Oct/2018		
Calibrated By:	Chanthu Thevarajah Senior Engineer		
Signature:			

.....

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1. **IEC 62209-1:2016**: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)
2. **IEC 62209-2:2010:** Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)
3. **IEEE 1528: 2013:** IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communication Devices: Measurement Techniques
4. FCC KDB Publication Number: **"KDB865664 D01 SAR Measurement 100 MHz to 6 GHz"**
5. **SPEAG DASY4/ DASY5 System Handbook**

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PRE0178318	Data Acquisition Electronics	SPEAG	DAE4	1543	08 Mar 2018	12
PRE0178315	Probe	SPEAG	ES3DV3	3360	17 Aug 2018	12
A1236	Dipole	SPEAG	D1800V2	2d009	06 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	103246	05 Feb 2018	12
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2017	24
PRE0151877	Calibration Kit	Rhode & Schwarz	Z135	102947	27 Apr 2018	12
PRE0178154	Signal Generator	Rhode & Schwarz	SMB 100A	175325	09 Apr 2018	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F17/5ENYG1/C/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	22.2 °C	22.2 °C	22.4°C	22.4°C	εr	40.10	38.34	± 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	9.91 W/Kg	**39.45 W/Kg**	± 17.57%
	SAR averaged over 10g	5.23 W/Kg	**20.82 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	49.35 Ω - 0.47 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	41.61	± 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	1750	22.2 °C	22.2 °C	21.0°C	21.0°C	εr	53.40	52.06	± 5%
						σ	1.49	1.48	± 5%

SAR Results – Body Simulating Liquid (MSL)

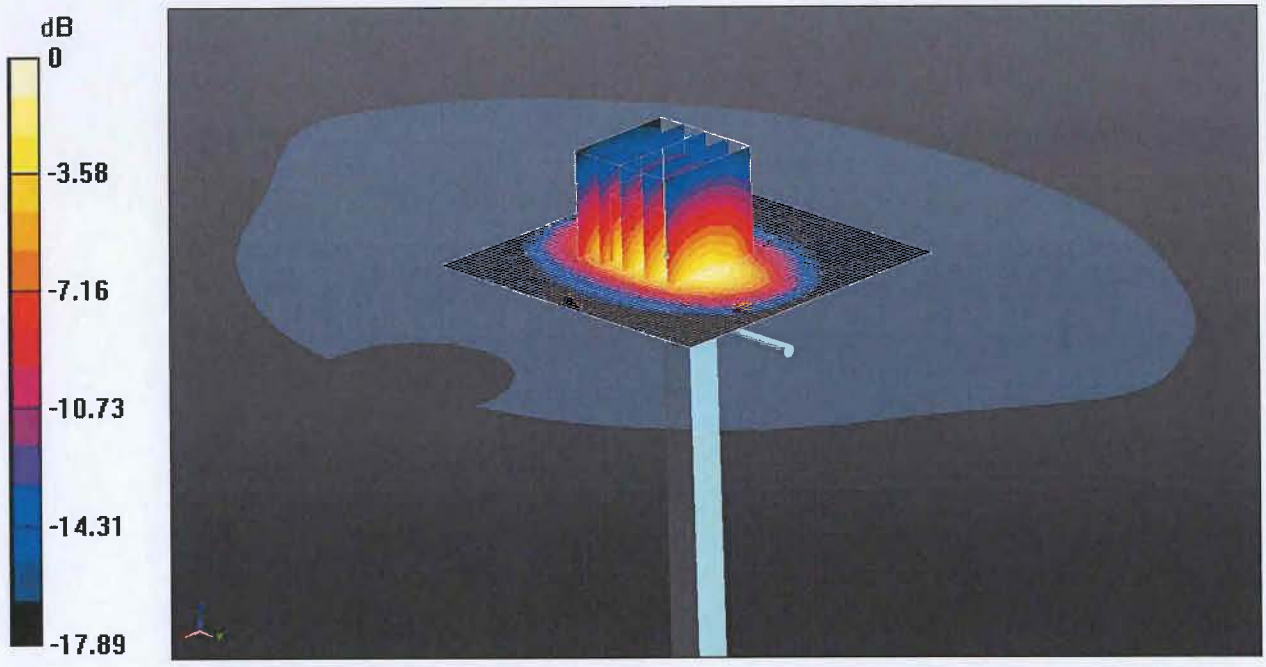
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	10.10 W/Kg	**40.20 W/Kg**	± 18.06%
	SAR averaged over 10g	5.41 W/Kg	**21.53 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	49.38 Ω + 4.41 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	26.86	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D1750V2 - SN1053; Type: D1750V2; Serial: SN1053



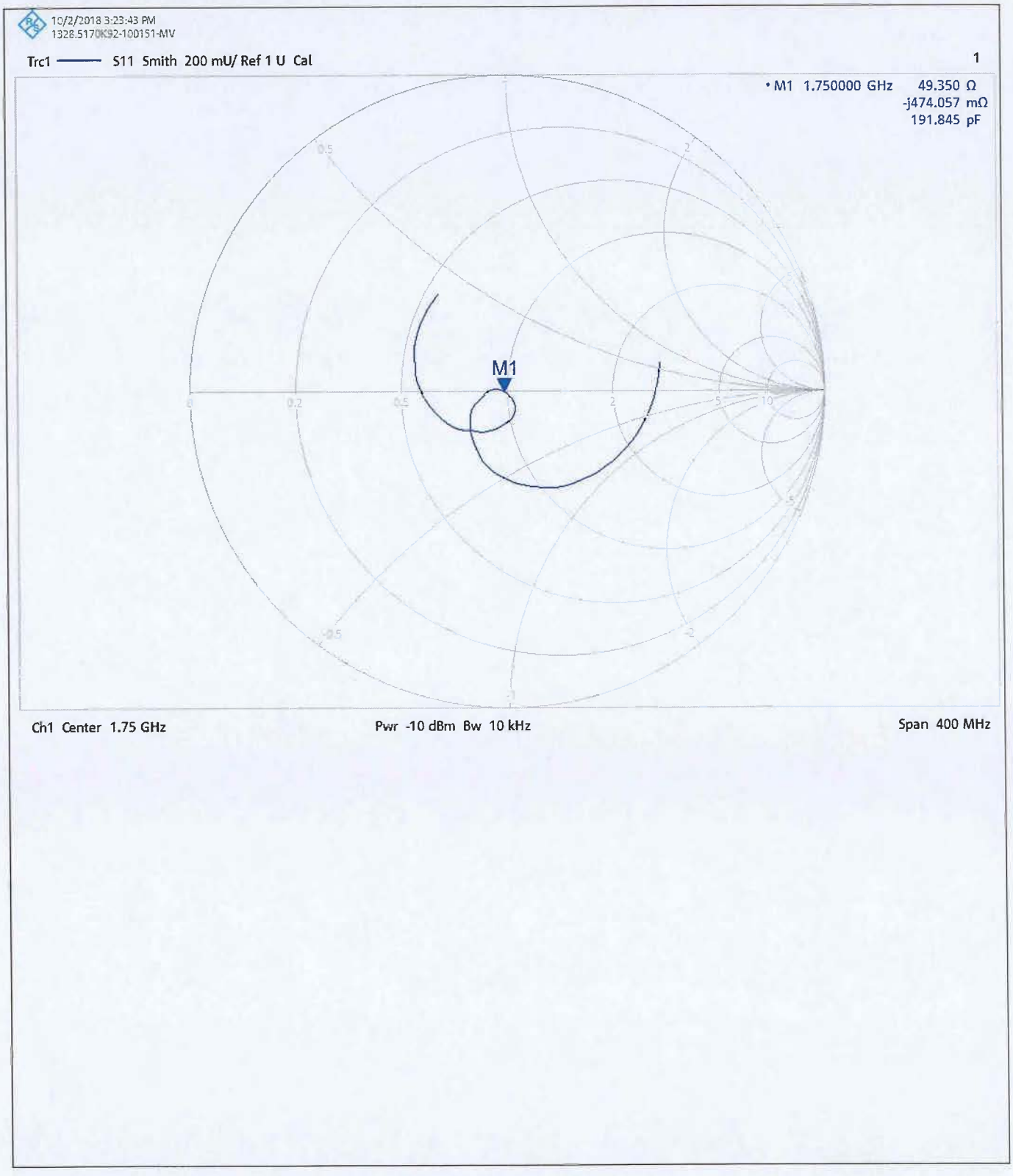
0 dB = 12.5 W/kg = 10.97 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1750 MHz;Duty Cycle: 1:1
Medium: 1450, 1750, 2300 5% MHz HSL Medium parameters used: f = 1750 MHz; σ = 1.394 S/m; ε_r = 38.335; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(5.27, 5.27, 5.27); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM A (Site 65); Type: SAM 4.0; Serial: 1031
- ; SEMCAD X Version 14.6.10 (7417)

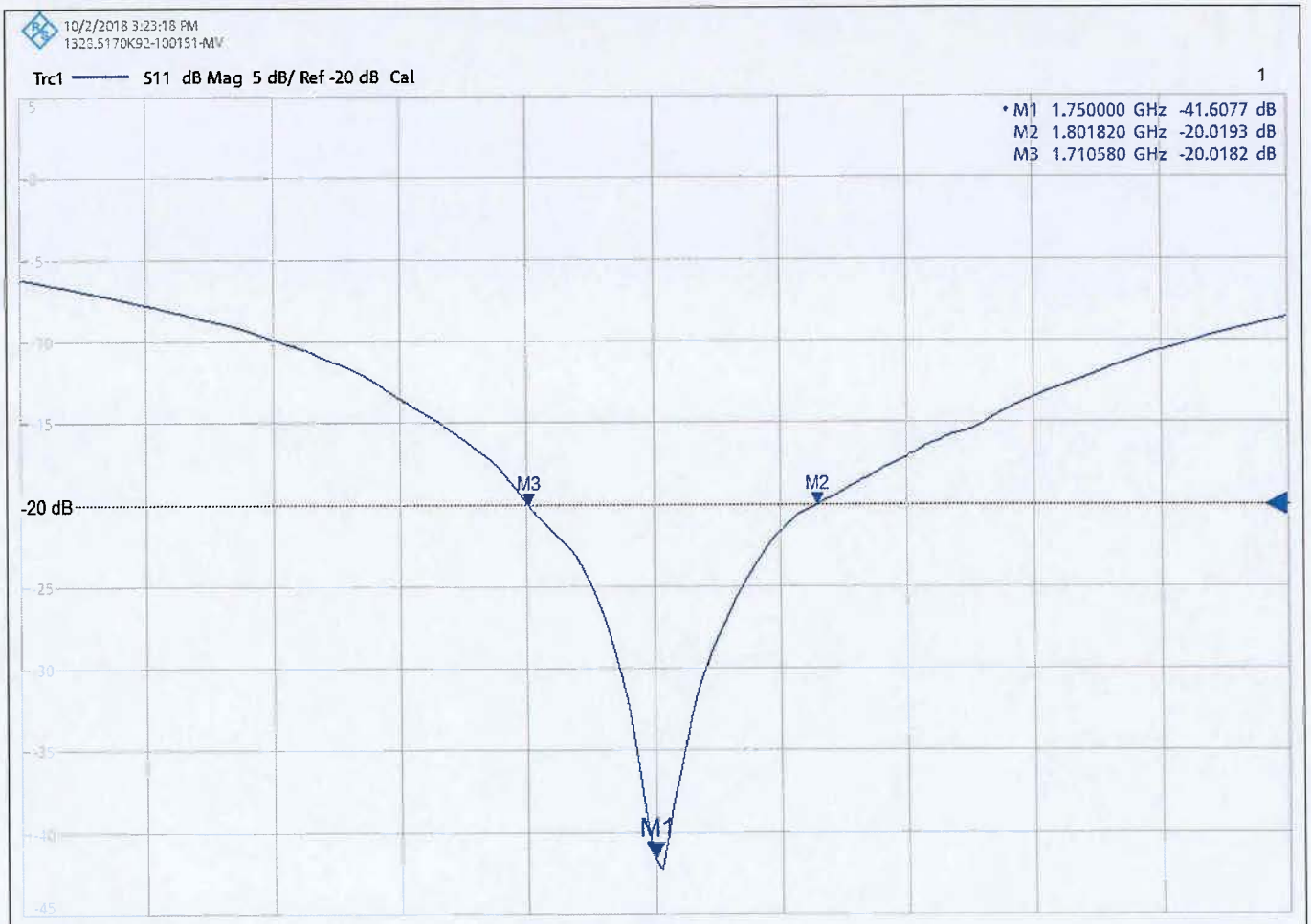
Configuration/d=10mm, Pin=250mW/Area Scan (61x61x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 12.9 W/kg

Configuration/d=10mm, Pin=250mW/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 97.38 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 17.8 W/kg
SAR(1 g) = 9.91 W/kg; SAR(10 g) = 5.23 W/kg
Maximum value of SAR (measured) = 12.5 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

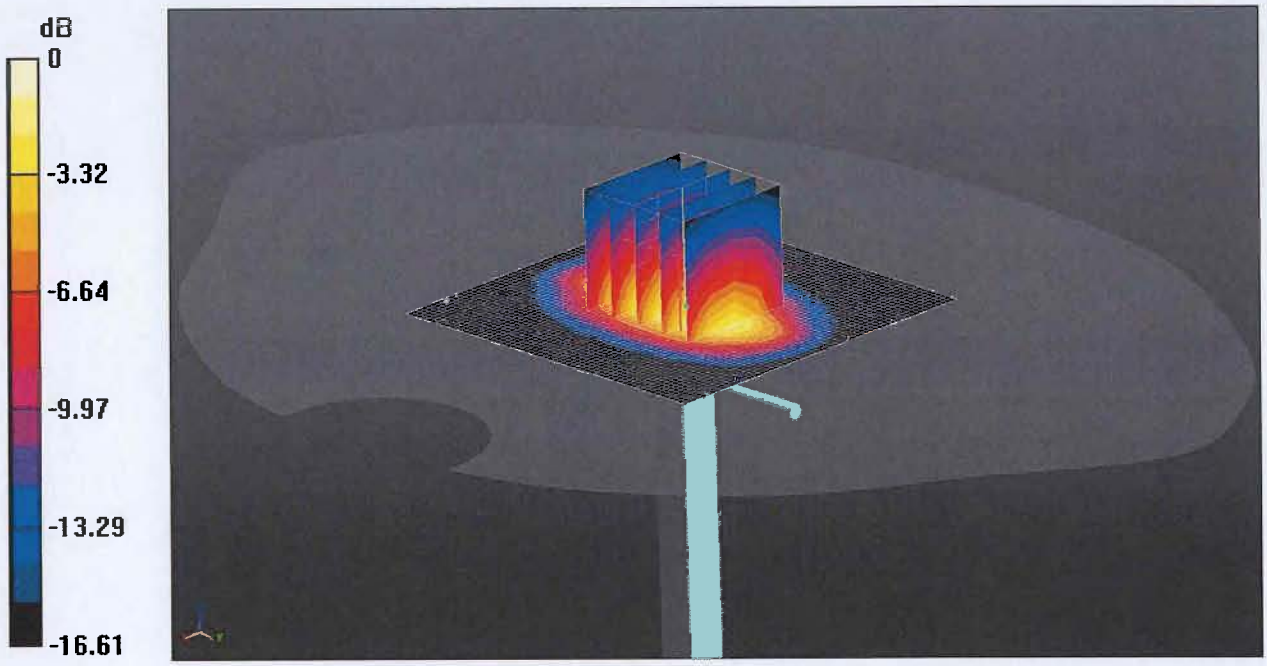


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D1750V2 - SN1053; Type: D1750V2; Serial: SN1053



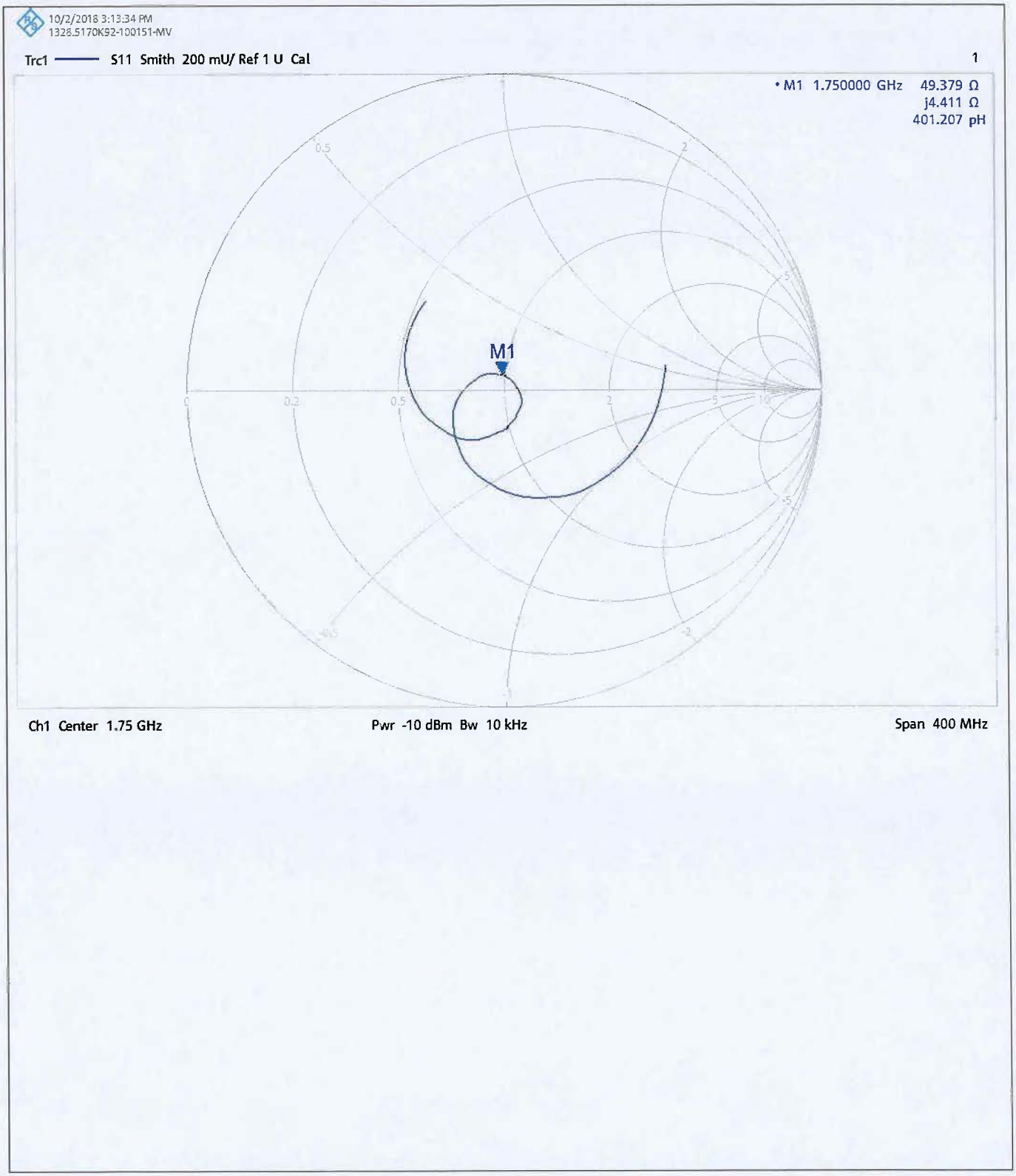
0 dB = 12.8 W/kg = 11.07 dBW/kg

Communication System: UID 0, CW (0); Frequency: 1750 MHz;Duty Cycle: 1:1
Medium: 1450, 1750, 2300 5% MHz MSL Medium parameters used: f = 1750 MHz; σ = 1.478 S/m; ε_r = 52.059; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(4.92, 4.92, 4.92); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM B (Site 65); Type: SAM 8.0; Serial: 1945
- ; SEMCAD X Version 14.6.10 (7417)

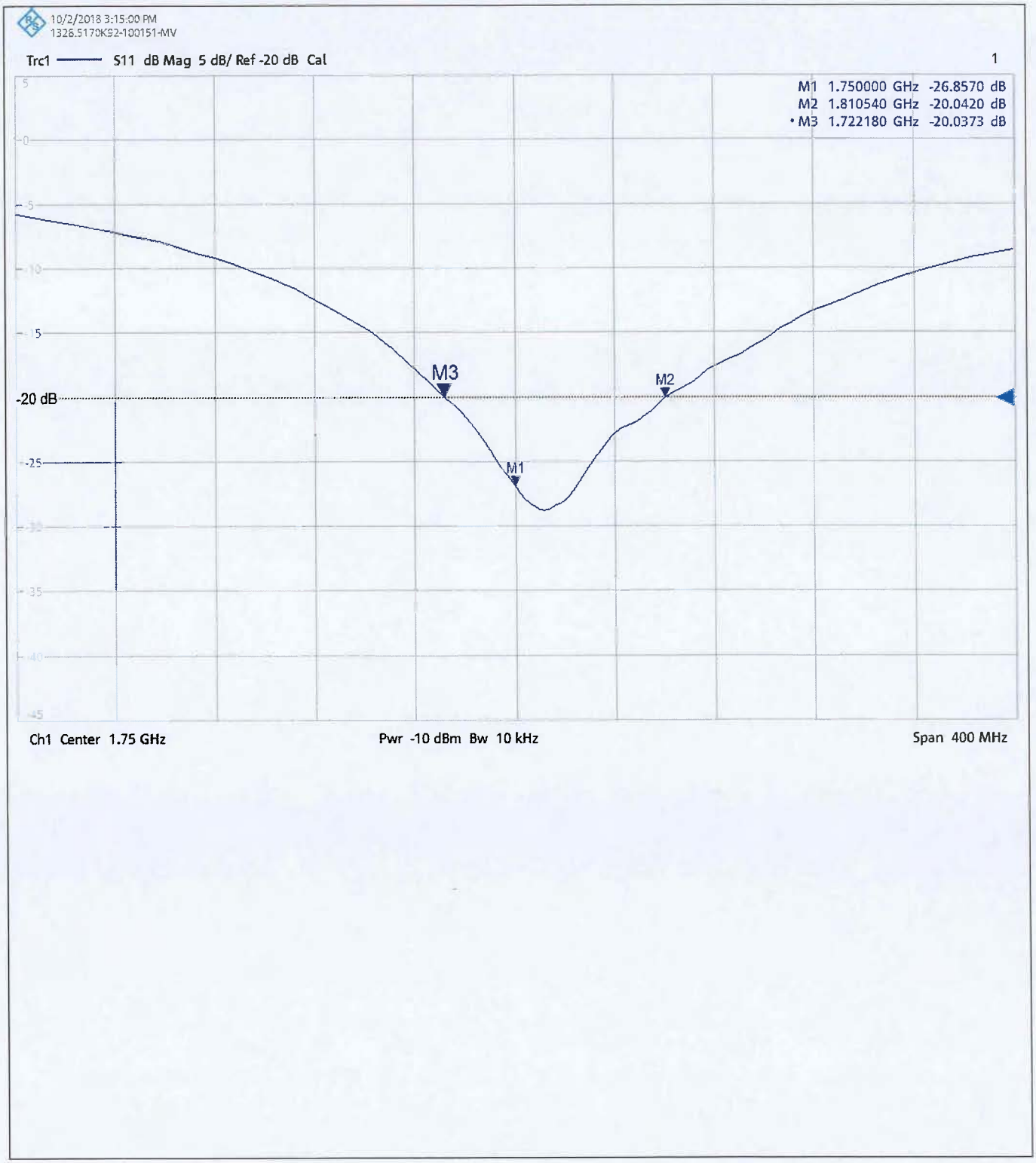
Configuration/d=10mm, Pin=250mW/Area Scan (61x61x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 12.8 W/kg

Configuration/d=10mm, Pin=250mW/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 96.33 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 17.9 W/kg
SAR(1 g) = 10.1 W/kg; SAR(10 g) = 5.41 W/kg
Maximum value of SAR (measured) = 12.8 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: 11903949JD01B Instrument ID: 1053 Calibration Date: 02/Oct/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903949JD01B Instrument ID: 1053 Calibration Date: 02/Oct/2018 Calibration Due Date:

UKAS CALIBRATION 5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 11903949JD01B Instrument ID: 1053 Calibration Date: 02/Oct/2018 Calibration Due Date:

CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 16/Oct/2018 CERTIFICATE NUMBER : 12134285JD01D

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:	08/Oct/2018
Manufacturer:	SPEAG		
Type/Model Number:	D1900V2		
Serial Number:	5d163		
Calibration Date:	16/Oct/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%

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)
PRE0178318	Data Acquisition Electronics	SPEAG	DAE4	1543	08 Mar 2018	12
PRE0178315	Probe	SPEAG	ES3DV3	3360	17 Aug 2018	12
PRE0178326	Dipole	SPEAG	D1900V2	5d227	07 Mar 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
PRE0151154	Network Analyser	Rhode & Schwarz	ZND8	100151	14 Dec 2017	12
PRE0151877	Calibration Kit	Rhode & Schwarz	ZV-Z135	102947-Bt	27 Apr 2018	12
PRE0178154	Signal Generator	Rhode & Schwarz	SMB 100A	175325	09 Apr 2018	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F17/5ENYG1/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 ℃	21.1℃	21.5℃	**εr**	40.00	39.71	± 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	10.60 W/Kg	**42.19 W/Kg**	± 17.57%
	SAR averaged over 10g	5.46 W/Kg	**21.73 W/Kg**	± 17.32%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	47.246 Ω -3.29 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	27.20	± 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	20.0 ℃	21.0 ℃	19.9℃	20.5℃	**εr**	53.30	53.10	± 5%
						σ	1.52	1.58	± 5%

SAR Results – Body Simulating Liquid (MSL)

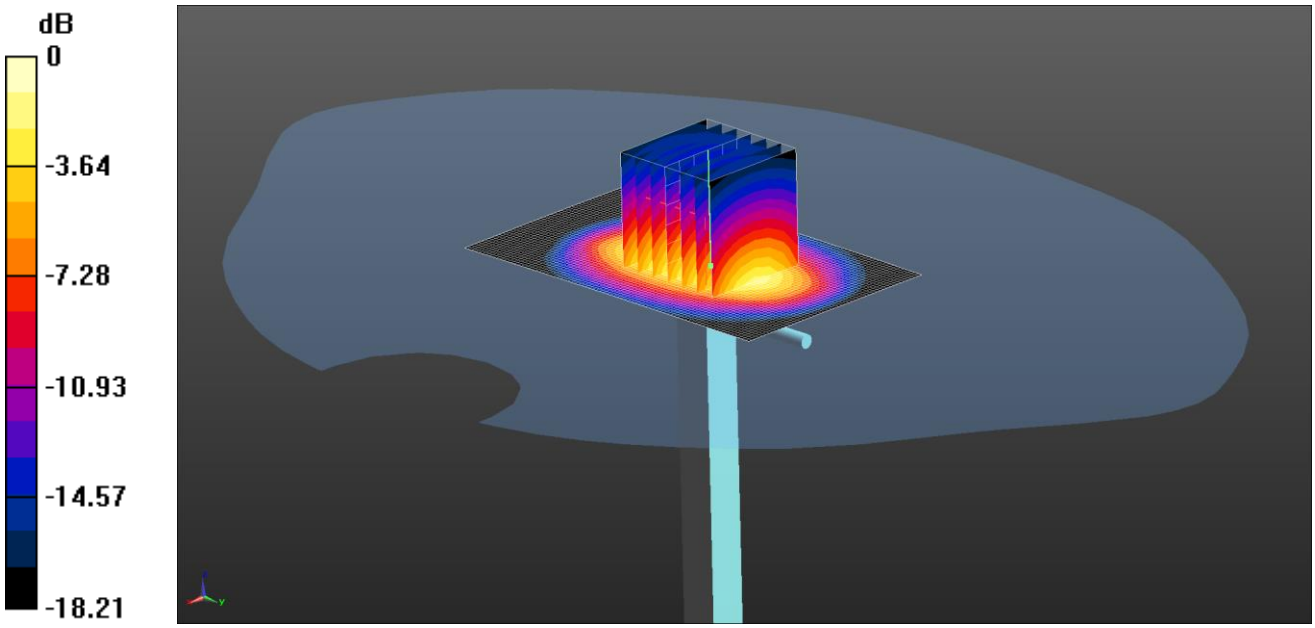
Simulant Liquid	**SAR Measured**	250 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	10.70 W/Kg	**42.59 W/Kg**	± 18.06%
	SAR averaged over 10g	5.57 W/Kg	**22.17 W/Kg**	± 17.44%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	52.08 Ω -5.44 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	25.11	± 2.03 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

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

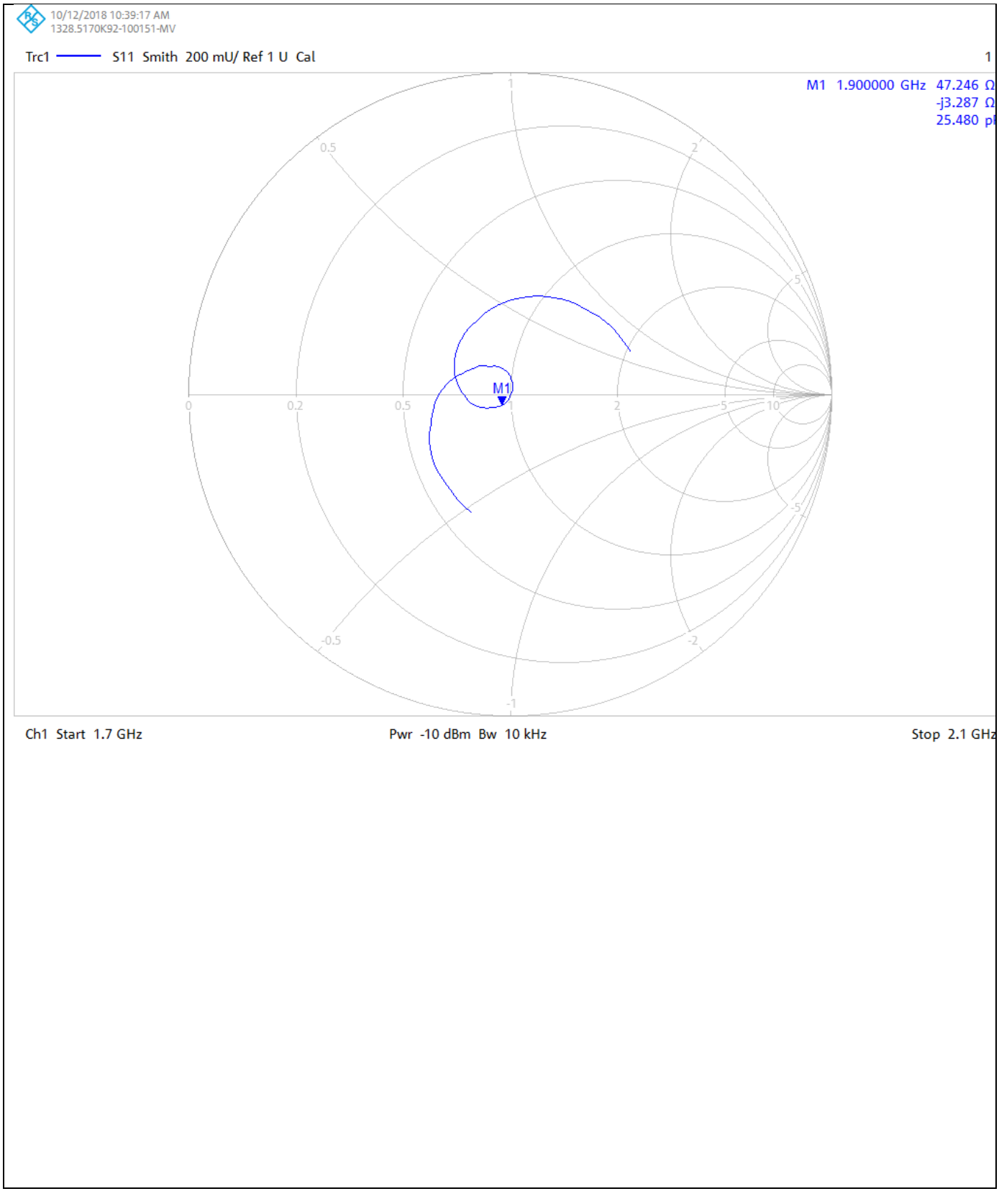


0 dB = 13.5 W/kg = 11.30 dBW/kg

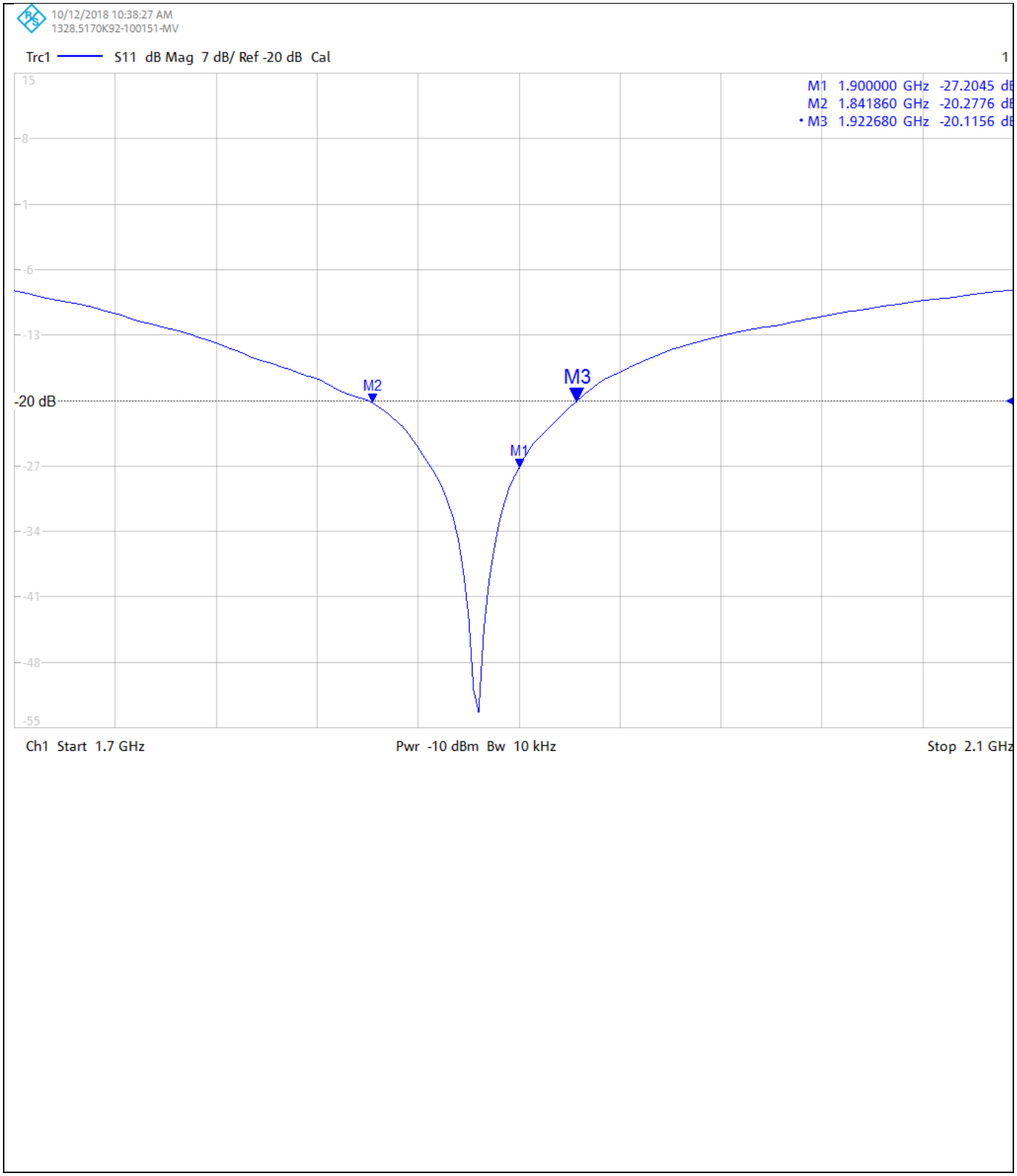
Communication System: UID 0, CW (0); Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 1900 5% MHz HSL Medium parameters used: f = 1900 MHz; σ = 1.444 S/m; ε_r = 39.709; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(5.11, 5.11, 5.11); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM A (Site 65); Type: SAM 8.0; Serial: TP:1945
- ; SEMCAD X Version 14.6.10 (7417)

SAR/d=10mm, Pin=250mW/Area Scan (51x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 13.8 W/kg
SAR/d=10mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 100.1 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 19.9 W/kg
SAR(1 g) = 10.6 W/kg; SAR(10 g) = 5.46 W/kg
Maximum value of SAR (measured) = 13.5 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

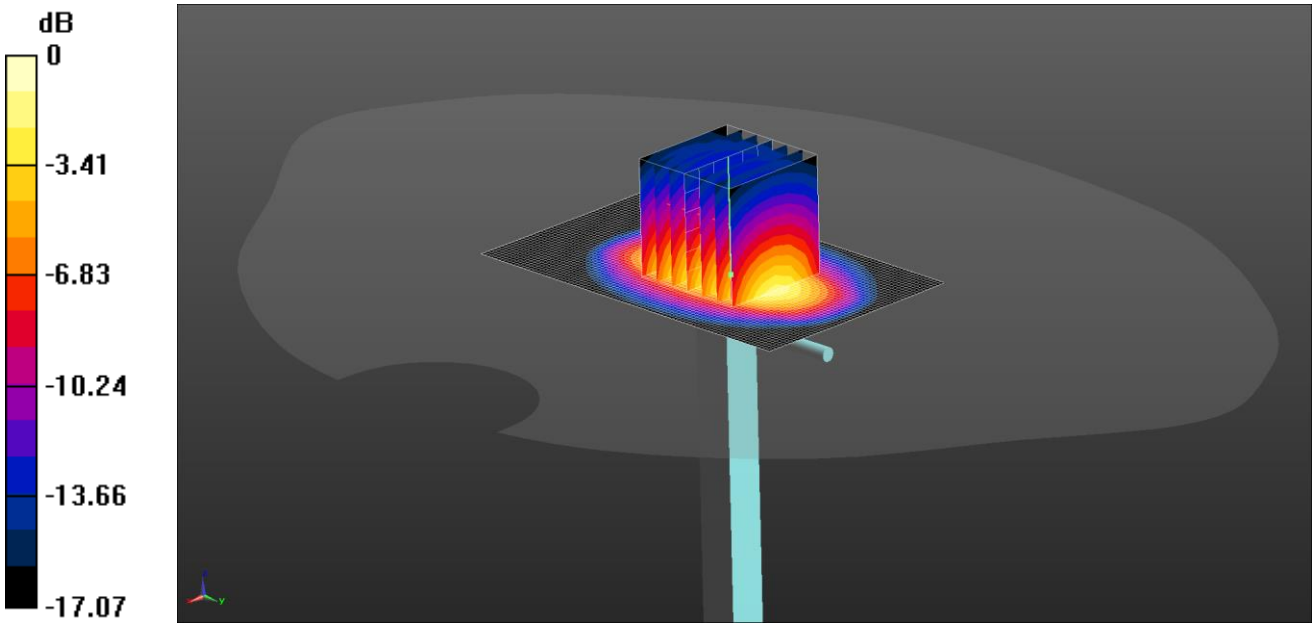


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

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

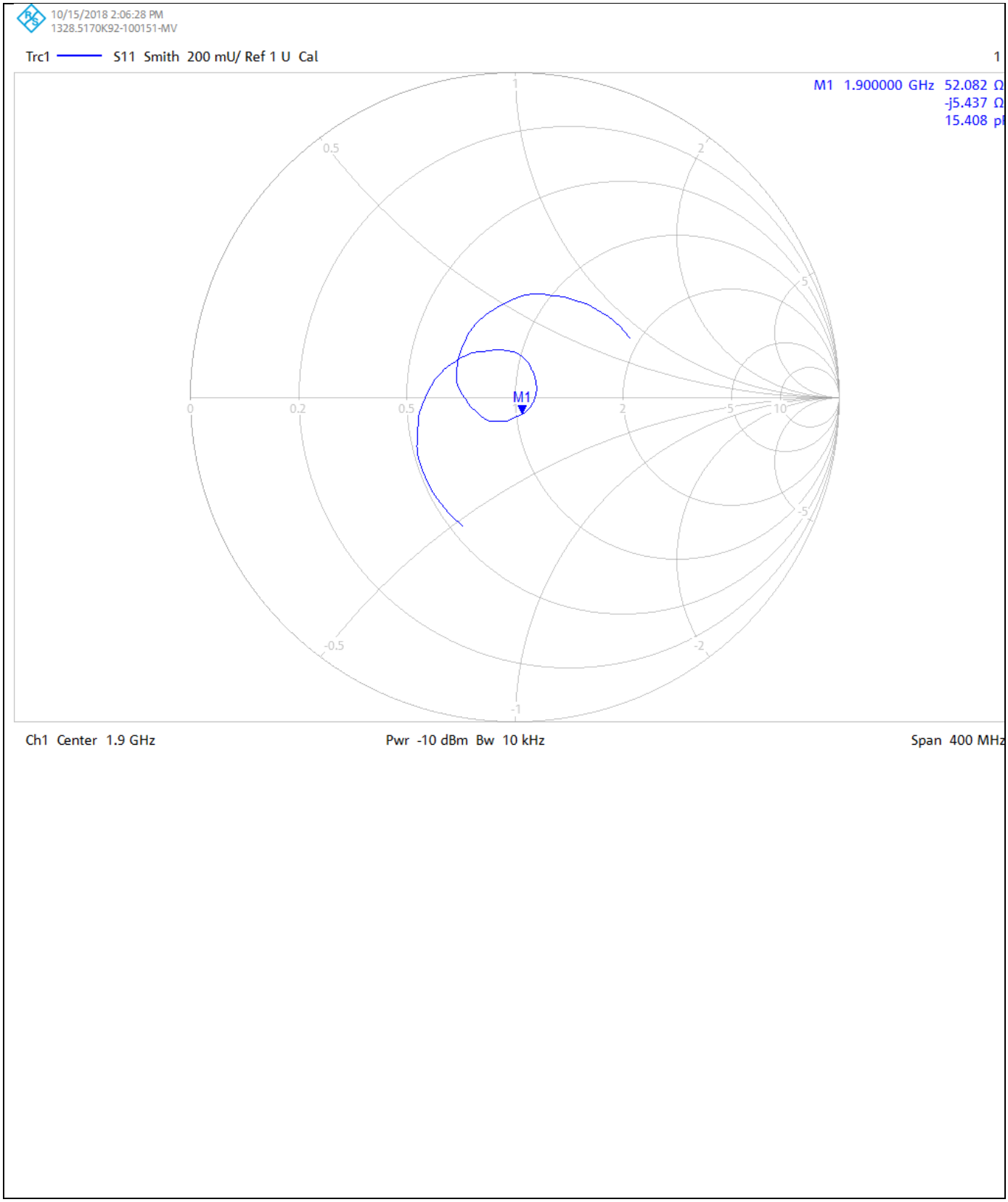


0 dB = 13.7 W/kg = 11.37 dBW/kg

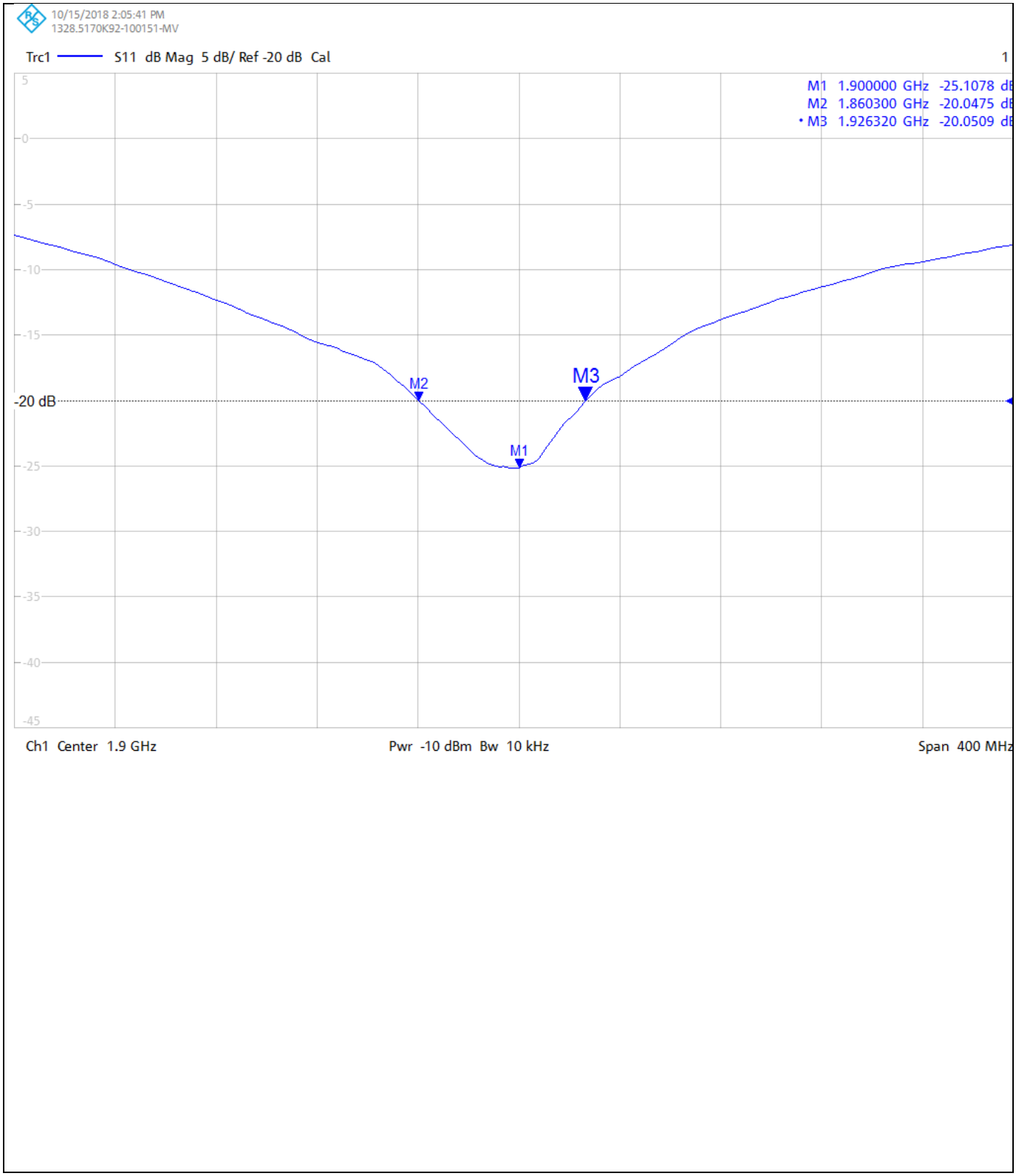
Communication System: UID 0, CW (0); Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: 900, 1750, 1800, 1900 5% MHz MSL Medium parameters used: f = 1900 MHz; σ = 1.583 S/m; ε_r = 53.097; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: ES3DV3 - SN3360; ConvF(4.77, 4.77, 4.77); Calibrated: 17/08/2018;
- Sensor-Surface: 3mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1543; Calibrated: 08/03/2018
- Phantom: Twin SAM A (Site 65); Type: SAM 5.0; Serial: TP:1836
- ; SEMCAD X Version 14.6.10 (7417)

SAR/d=10mm, Pin=250mW/Area Scan (51x81x1): Interpolated grid: dx=1.200 mm, dy=1.200 mm
Maximum value of SAR (interpolated) = 14.3 W/kg
SAR/d=10mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm
Reference Value = 3.856 V/m; Power Drift = 0.19 dB
Peak SAR (extrapolated) = 19.2 W/kg
SAR(1 g) = 10.7 W/kg; SAR(10 g) = 5.57 W/kg
Maximum value of SAR (measured) = 13.7 W/kg

Impedance Measurement Plot for Body Stimulating Liquid (MSL)



Return Loss Measurement Plot for Body Stimulating Liquid (MSL)



Calibration Certificate Label:

5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134285JD01D Instrument ID: 5d163 Calibration Date: 16/Oct/2018 Calibration Due Date:

5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134285JD01D Instrument ID: 5d163 Calibration Date: 16/Oct/2018 Calibration Due Date:

5248	**UL VS LTD - Tel: +44 (0) 1256312000** Certificate Number: 12134285JD01D Instrument ID: 5d163 Calibration Date: 16/Oct/2018 Calibration Due Date: