CERTIFICATE OF CALIBRATION

ISSUED BY **UL VS LTD**

DATE OF ISSUE: 12/Mar/2020 CERTIFICATE NUMBER : 13252596JD01C

5248

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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:	26/Feb/2020
Manufacturer:	SPEAG		
Type/Model Number:	D5GHzV2		
Serial Number:	1003		
Calibration Date:	12/Mar/2020		
Calibrated By:	Harmohan Sahota Laboratory 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 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)
A2547	Data Acquisition Electronics	SPEAG	DAE4	1438	11 Apr 2019	12
A2545	Probe	SPEAG	EX3DV4	3995	24 Apr 2019	12
A1377	Dipole	SPEAG	D5GHzv2	1016	18 Feb 2020	12
PRE0151451	Power Monitoring Kit	Art-Fi	ART 100850-01	0001	Cal as part of System	-
PRE0151441	Power Sensor	Rhode & Schwarz	NRP8S	102481	27 Mar 2019	12
PRE0151154	Vector Network Analyser	Rhode & Schwarz	ZND8	100151	30 Jan 2020	12
PRE0151877	Calibration Kit	Rhode & Schwarz	ZV-Z135	102947	17 Oct 2019	12
PRE0178154	Signal Generator	Rhode & Schwarz	SMB 100A	175325	30 Apr 2019	12

SAR System Specification

Robot System Positioner:	Stäubli Unimation Corp. Robot Model: TX60L
Robot Serial Number:	F17/5ENYG1/A/01
DASY Version:	DASY 52 (v52.10.0.1446)
Phantom:	Flat section of SAM Twin Phantom
Distance Dipole Centre:	10 mm (with spacer)

Frequency: 5250 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	5250	20.6 ℃	21.6 ℃	20.4℃	20.6℃	**εr**	35.9	36.151	± 5%
						σ	4.71	4.652	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	8.01 W/Kg	**80.1 W/Kg**	± 18.75%
	SAR averaged over 10g	2.29 W/Kg	**22.9 W/Kg**	± 18.63%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	58.014 Ω + 5.272 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-21.04	± 2.23 dB

Frequency: 5600 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	5600	20.6 ℃	21.6 ℃	20.4℃	20.6℃	**εr**	35.5	35.524	± 5%
						σ	5.07	5.047	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	7.98 W/Kg	**79.8 W/Kg**	± 18.75%
	SAR averaged over 10g	2.25 W/Kg	**22.5 W/Kg**	± 18.63%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	45.328 Ω + 2.547 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-25.05	± 2.23 dB

Frequency: 5750 MHz

Dielectric Property Measurements – Head Simulating Liquid (HSL)

Simulant Liquid	Frequency (MHz)	Room Temp		Liquid Temp		Parameters	Target Value	Measured Value	Uncertainty (%)
		Start	End	Start	End				
Head	5750	20.6 ℃	21.6 ℃	20.4℃	20.6℃	**εr**	35.4	35.25	± 5%
						σ	5.22	5.217	± 5%

SAR Results – Head Simulating Liquid (HSL)

Simulant Liquid	SAR Measured	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Head	SAR averaged over 1g	7.37 W/Kg	**73.7 W/Kg**	± 18.75%
	SAR averaged over 10g	2.10 W/Kg	**21.0 W/Kg**	± 18.63%

Antenna Parameters – Head Simulating Liquid (HSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Head	Impedance	59.08 Ω + 1.306 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-21.52	± 2.23 dB

Frequency: 5250 MHz

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	5250	21.0 ℃	21.2 ℃	20.7℃	20.8℃	**εr**	48.9	48.462	± 5%
						σ	5.36	5.402	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	**SAR Measured**	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	7.96 W/Kg	**79.6 W/Kg**	± 18.53%
	SAR averaged over 10g	2.23 W/Kg	**22.3 W/Kg**	± 18.61%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	58.686 Ω + 5.831 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-20.33	± 2.23 dB

Frequency: 5600 MHz

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	5600	21.0 ℃	21.2 ℃	20.7℃	20.8℃	**εr**	48.5	47.929	± 5%
						σ	5.77	5.93	± 5%

SAR Results – Body Simulating Liquid (MSL)

Simulant Liquid	**SAR Measured**	50 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	3.86 W/Kg	**77.01 W/Kg**	± 18.53%
	SAR averaged over 10g	1.07 W/Kg	**21.34 W/Kg**	± 18.61%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	45.54 Ω + 2.691 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-25.30	± 2.23 dB

Frequency: 5750 MHz

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	5750	21.0 ℃	21.2 ℃	20.7℃	20.8℃	**εr**	48.3	47.506	± 5%
						σ	5.94	6.12	± 5%

SAR Results – Body Simulating Liquid (MSL)

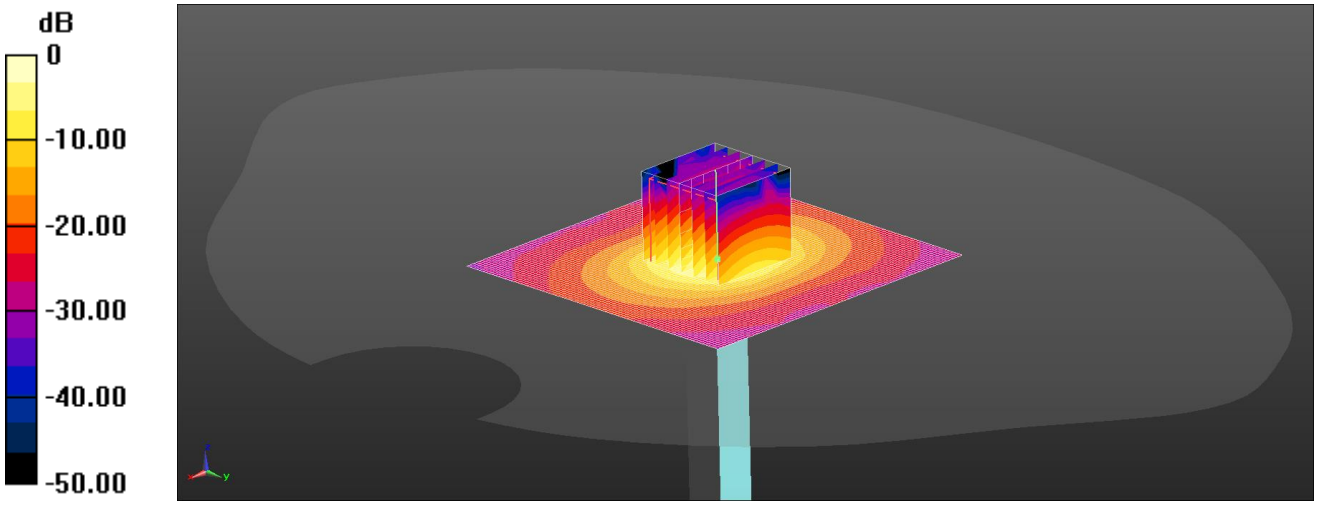
Simulant Liquid	**SAR Measured**	100 mW input Power	Normalised to 1.00 W	Uncertainty (%)
Body	SAR averaged over 1g	7.48 W/Kg	**74.8 W/Kg**	± 18.53%
	SAR averaged over 10g	2.09 W/Kg	**20.9 W/Kg**	± 18.61%

Antenna Parameters – Body Simulating Liquid (MSL)

Simulant Liquid	Parameter	Measured Level	Uncertainty (%)
Body	Impedance	58.526 Ω + 4.072 jΩ	± 0.28 Ω ± 0.044 jΩ
	Return Loss	-21.24	± 2.23 dB

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2 - SN1003; Type: D5GHzV2; Serial: SN1003



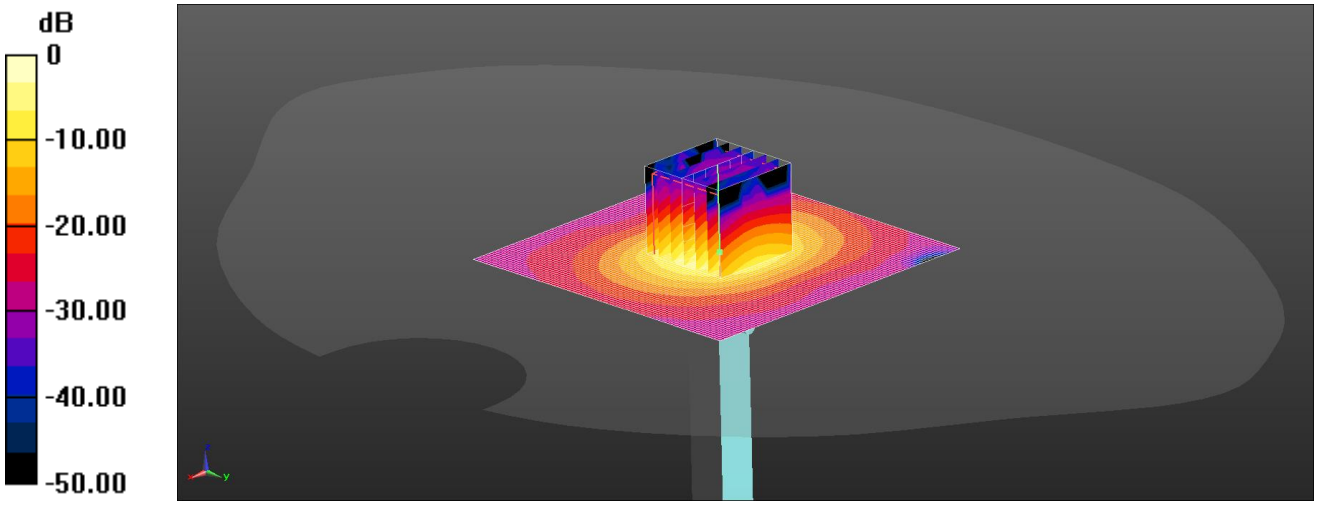
0 dB = 20.2 W/kg = 13.05 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5250 MHz;Duty Cycle: 1:1
Medium: HSL 09 03 20 - 2450 3500 5250 5600 5750 5% Medium parameters used: f = 5250 MHz; σ = 4.659 S/m; ε_r = 36.152; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(5.34, 5.34, 5.34); Calibrated: 24/04/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1438; Calibrated: 11/04/2019
- Phantom: Twin-SAM V8.0 (20deg probe tilt); Type: QD 000 P41 Ax; Serial: 1945
- ; SEMCAD X Version 14.6.10 (7417)

5250/PMK d=10mm, Pin=100mW/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 20.9 W/kg
5250/PMK d=10mm, Pin=100mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 73.94 V/m; Power Drift = -0.12 dB
Peak SAR (extrapolated) = 32.3 W/kg
SAR(1 g) = 8.01 W/kg; SAR(10 g) = 2.29 W/kg
Maximum value of SAR (measured) = 20.2 W/kg

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2 - SN1003; Type: D5GHzV2; Serial: SN1003



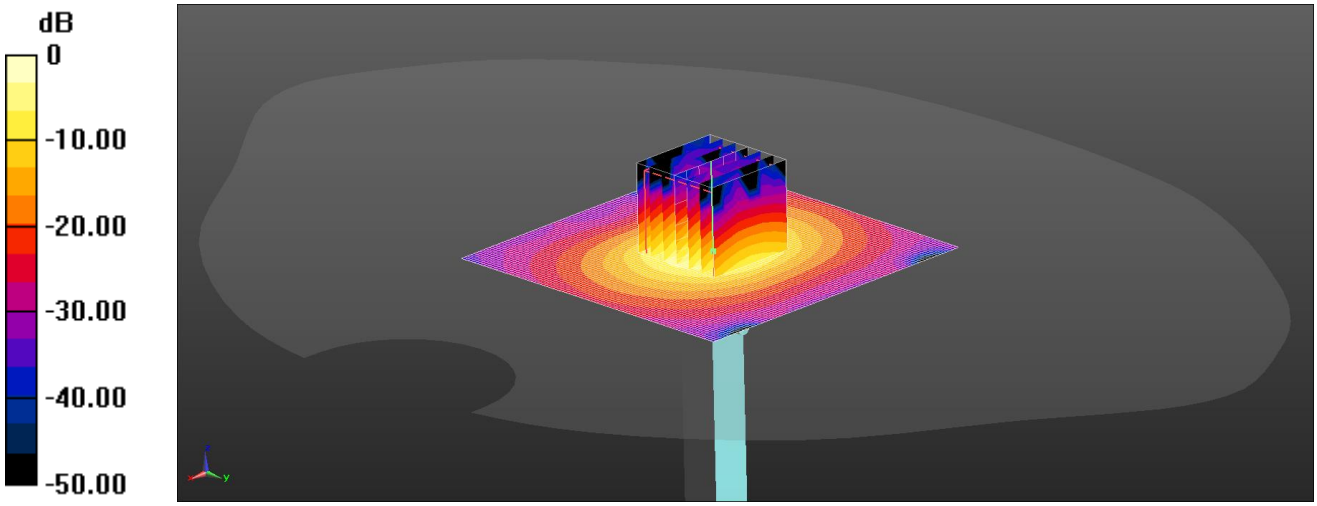
0 dB = 20.9 W/kg = 13.20 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5600 MHz;Duty Cycle: 1:1
Medium: HSL 09 03 20 - 2450 3500 5250 5600 5750 5% Medium parameters used: f = 5600 MHz; σ = 5.054 S/m; ε_r = 35.525; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(5.05, 5.05, 5.05); Calibrated: 24/04/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1438; Calibrated: 11/04/2019
- Phantom: Twin-SAM V8.0 (20deg probe tilt); Type: QD 000 P41 Ax; Serial: 1945
- ; SEMCAD X Version 14.6.10 (7417)

5600/PMK d=10mm, Pin=100mW/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 20.5 W/kg
5600/PMK d=10mm, Pin=100mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.02 V/m; Power Drift = 0.04 dB
Peak SAR (extrapolated) = 35.3 W/kg
SAR(1 g) = 7.98 W/kg; SAR(10 g) = 2.25 W/kg
Maximum value of SAR (measured) = 20.9 W/kg

DASY Validation Scan for Head Stimulating Liquid (HSL)

DUT: D5GHzV2 - SN1003; Type: D5GHzV2; Serial: SN1003

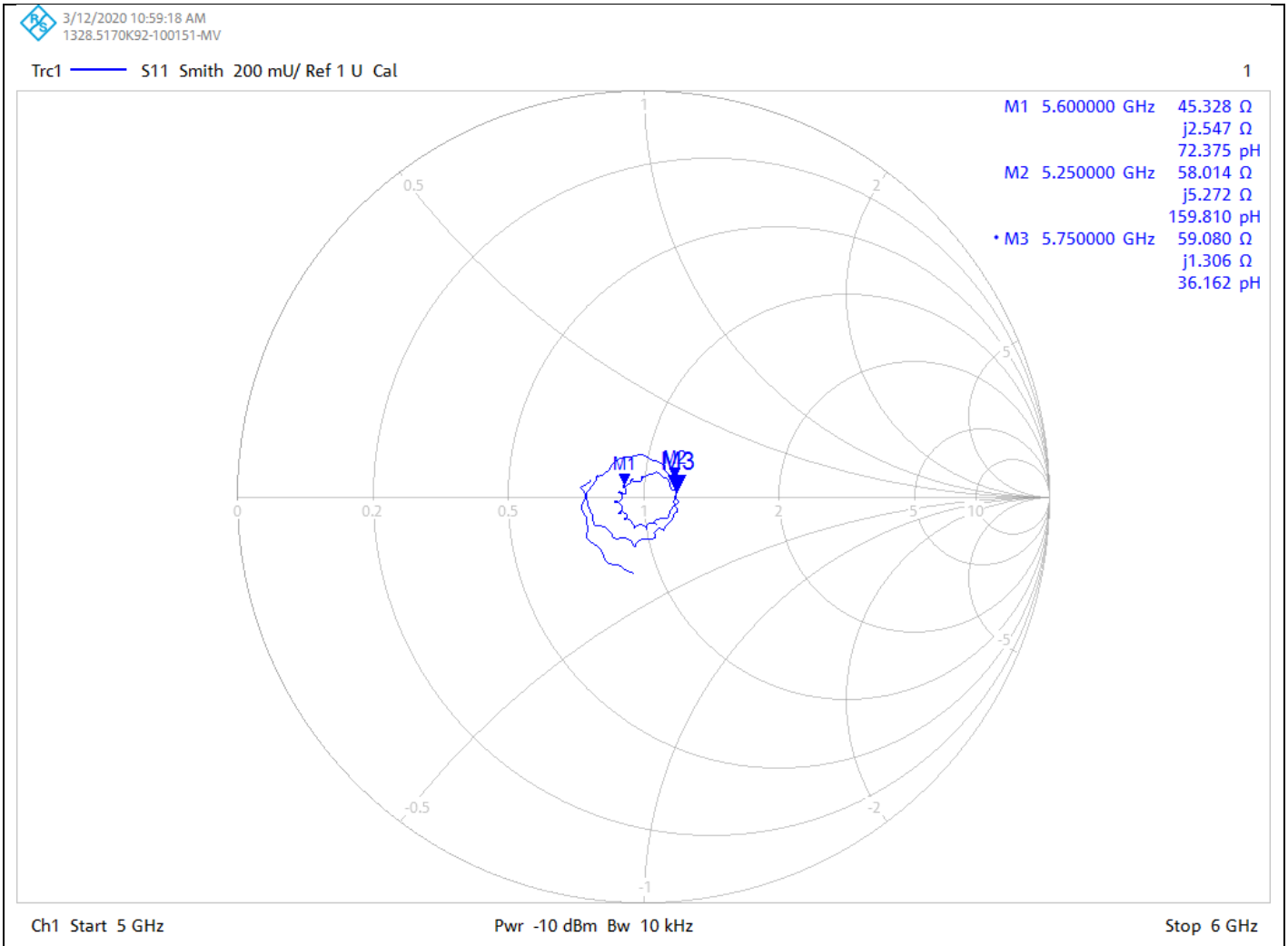


0 dB = 19.4 W/kg = 12.88 dBW/kg

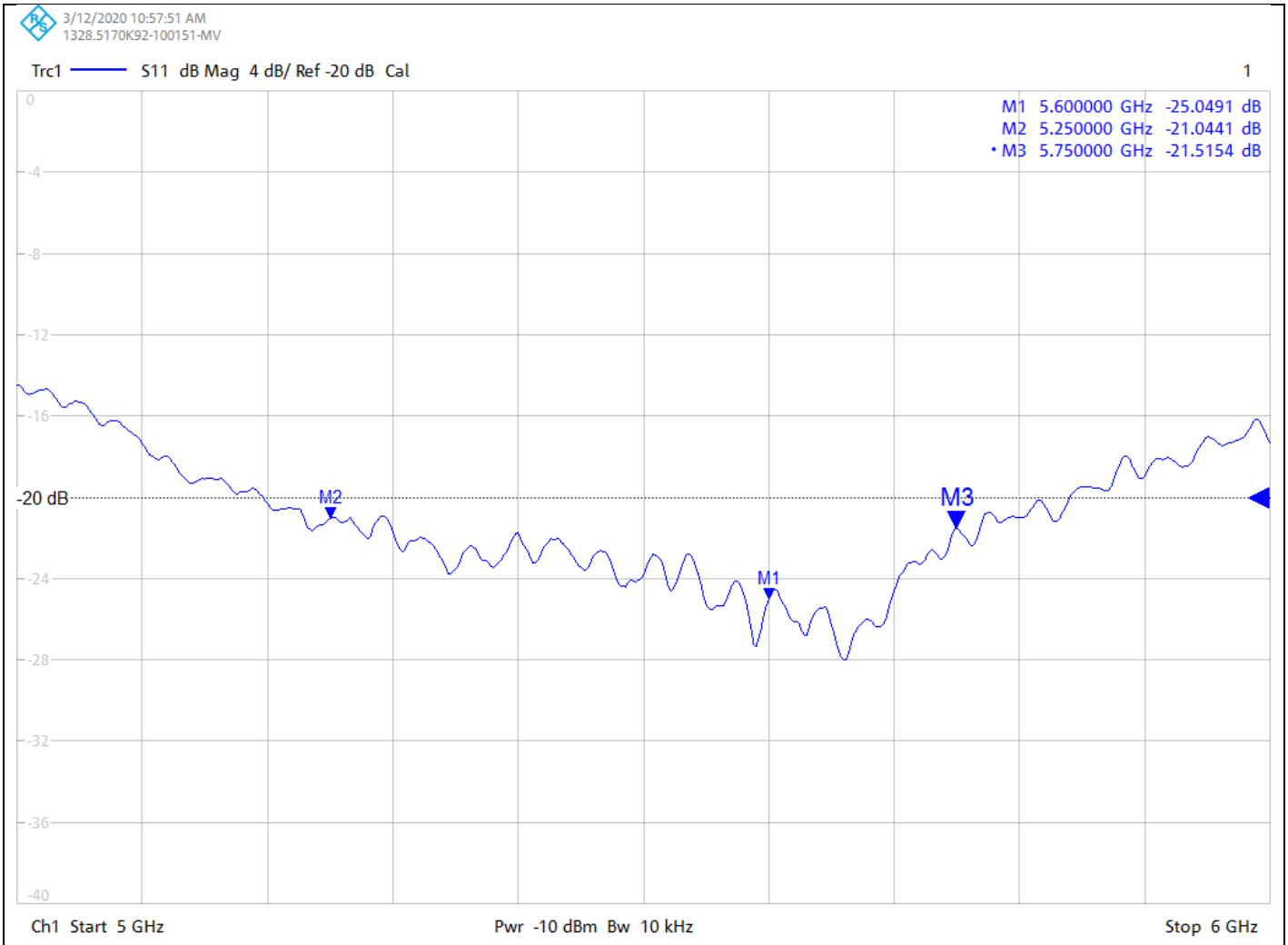
Communication System: UID 0, CW (0); Frequency: 5750 MHz;Duty Cycle: 1:1
Medium: HSL 09 03 20 - 2450 3500 5250 5600 5750 5% Medium parameters used: f = 5750 MHz; σ = 5.225 S/m; ε_r = 35.25; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(5.15, 5.15, 5.15); Calibrated: 24/04/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1438; Calibrated: 11/04/2019
- Phantom: Twin-SAM V8.0 (20deg probe tilt); Type: QD 000 P41 Ax; Serial: 1945
- ; SEMCAD X Version 14.6.10 (7417)

5750/PMK d=10mm, Pin=100mW/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 19.1 W/kg
5750/PMK d=10mm, Pin=100mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 66.19 V/m; Power Drift = 0.07 dB
Peak SAR (extrapolated) = 33.9 W/kg
SAR(1 g) = 7.37 W/kg; SAR(10 g) = 2.1 W/kg
Maximum value of SAR (measured) = 19.4 W/kg

Impedance Measurement Plot for Head Stimulating Liquid (HSL)

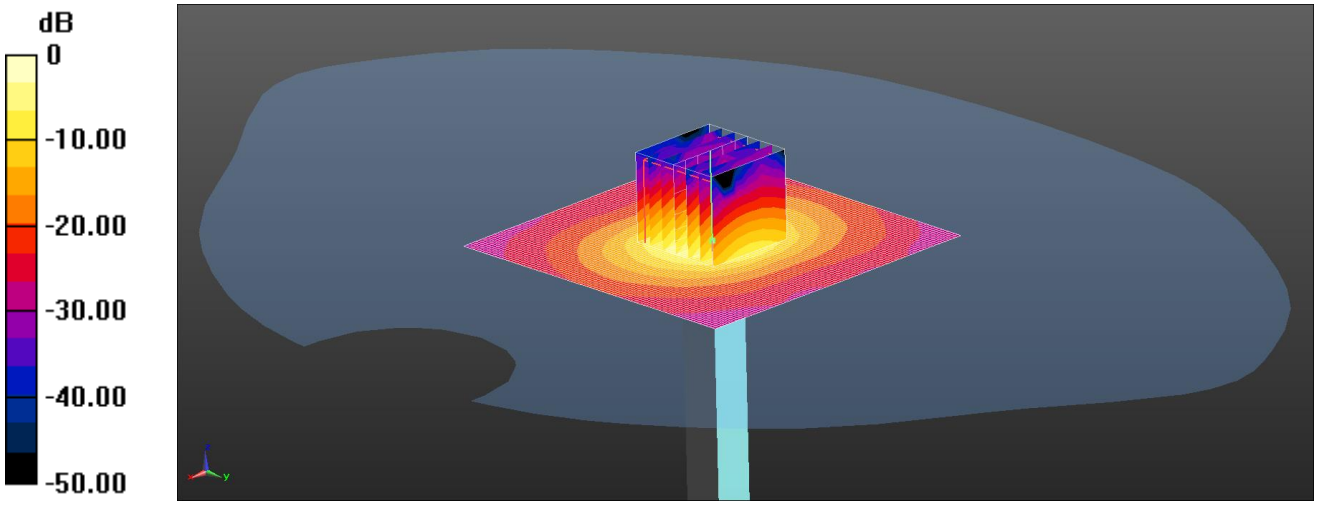


Return Loss Measurement Plot for Head Stimulating Liquid (HSL)



DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D5GHzV2 - SN1003; Type: D5GHzV2; Serial: SN1003



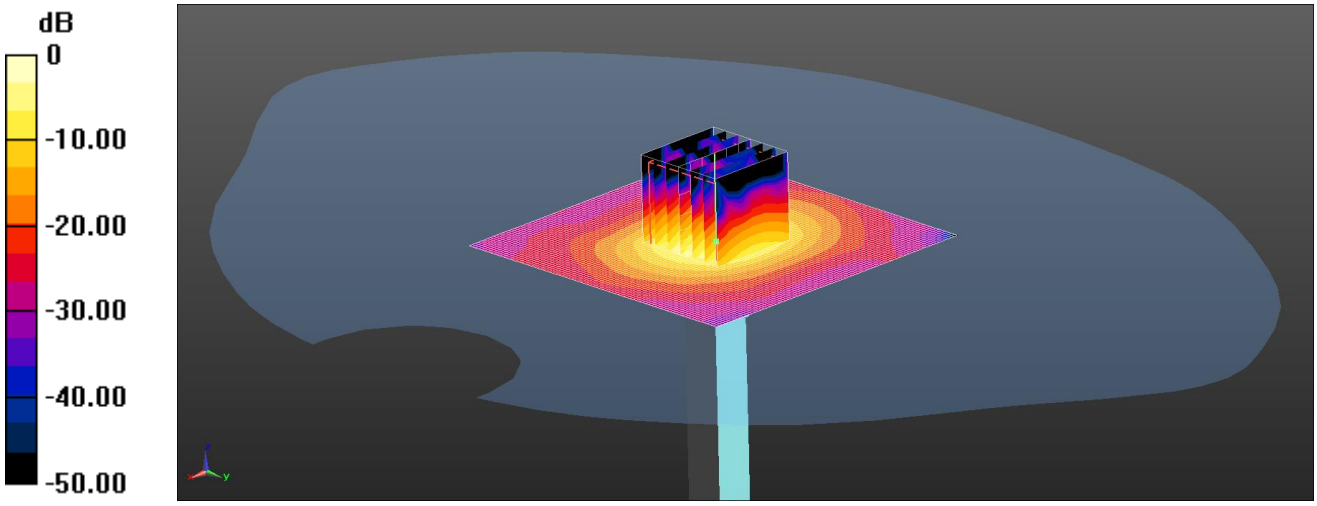
0 dB = 20.4 W/kg = 13.10 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5250 MHz;Duty Cycle: 1:1
Medium: MSL 10 03 20 - 5250, 5600, 5750 5% Medium parameters used: f = 5250 MHz; σ = 5.41 S/m; ε_r = 48.463; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(4.78, 4.78, 4.78); Calibrated: 24/04/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1438; Calibrated: 11/04/2019
- Phantom: Twin SAM A (Site 65); Type: SAM 5.0; Serial: SN1818
- ; SEMCAD X Version 14.6.10 (7417)

5250/d=10mm, Pin=100mW/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 20.5 W/kg
5250/d=10mm, Pin=100mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 70.27 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 32.2 W/kg
SAR(1 g) = 7.96 W/kg; SAR(10 g) = 2.23 W/kg
Maximum value of SAR (measured) = 20.4 W/kg

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D5GHzV2 - SN1003; Type: D5GHzV2; Serial: SN1003



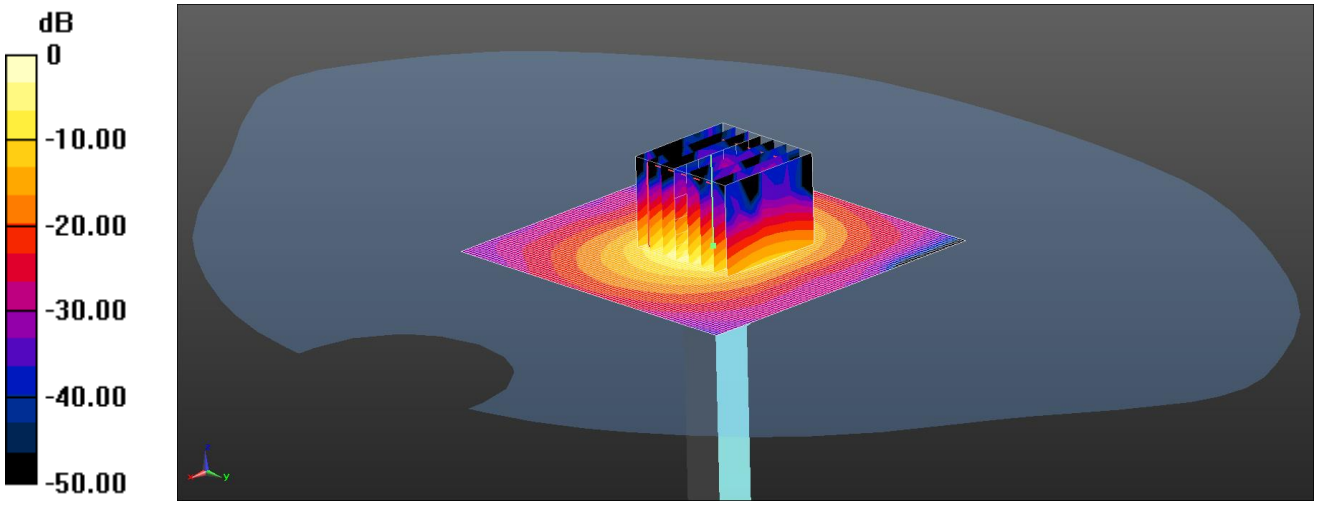
0 dB = 10.3 W/kg = 10.13 dBW/kg

Communication System: UID 0, CW (0); Frequency: 5600 MHz;Duty Cycle: 1:1
Medium: MSL 10 03 20 - 5250, 5600, 5750 5% Medium parameters used: f = 5600 MHz; σ = 5.939 S/m; ε_r = 47.929; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(4.32, 4.32, 4.32); Calibrated: 24/04/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1438; Calibrated: 11/04/2019
- Phantom: Twin SAM A (Site 65); Type: SAM 5.0; Serial: SN1818
- ; SEMCAD X Version 14.6.10 (7417)

5600/Power Source d=10mm, Pin=50mW/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 10.3 W/kg
5600/Power Source d=10mm, Pin=50mW/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 47.80 V/m; Power Drift = -0.08 dB
Peak SAR (extrapolated) = 17.2 W/kg
SAR(1 g) = 3.86 W/kg; SAR(10 g) = 1.07 W/kg
Maximum value of SAR (measured) = 10.3 W/kg

DASY Validation Scan for Body Stimulating Liquid (MSL)

DUT: D5GHzV2 - SN1003; Type: D5GHzV2; Serial: SN1003

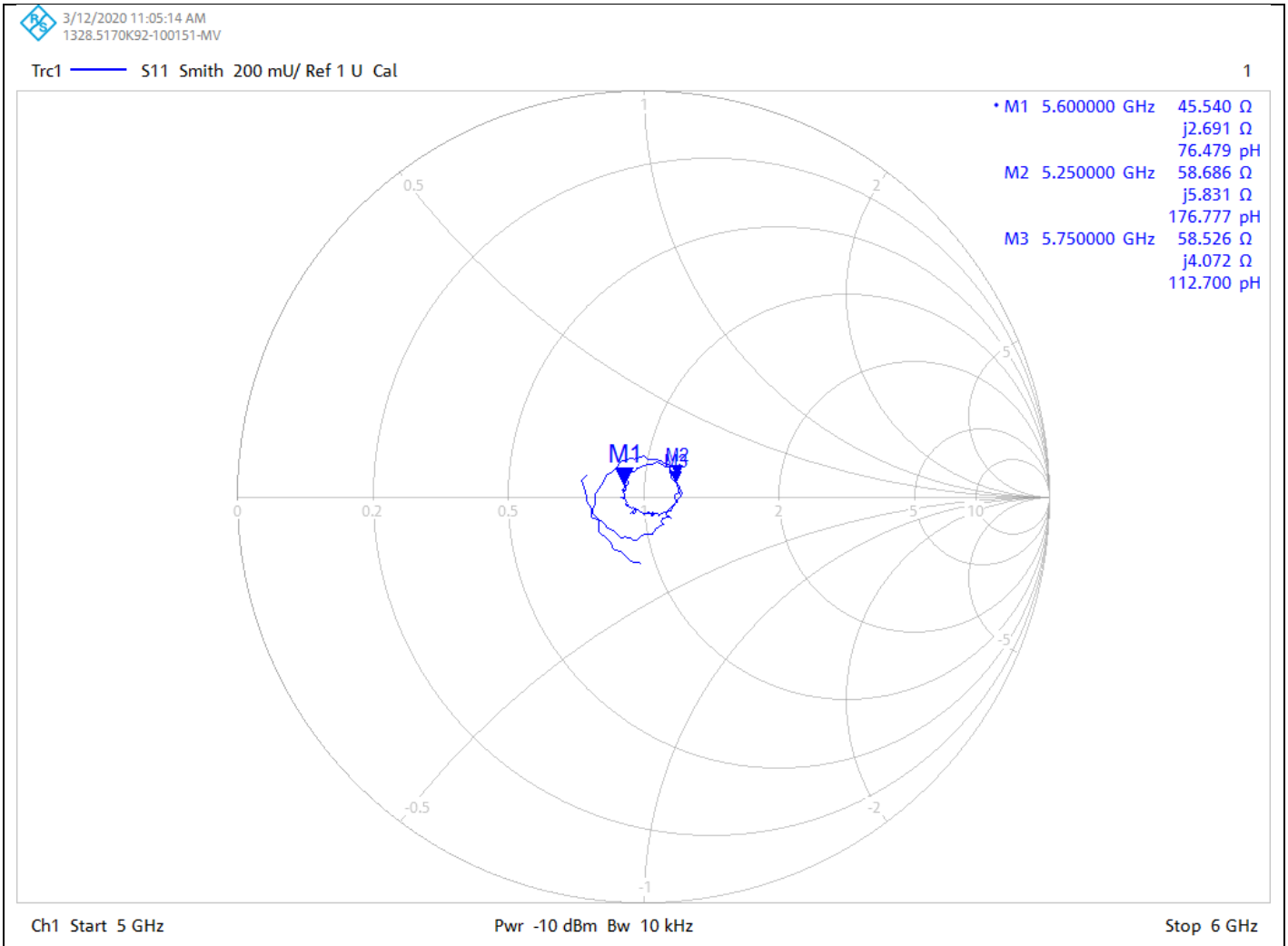


0 dB = 20.0 W/kg = 13.01 dBW/kg

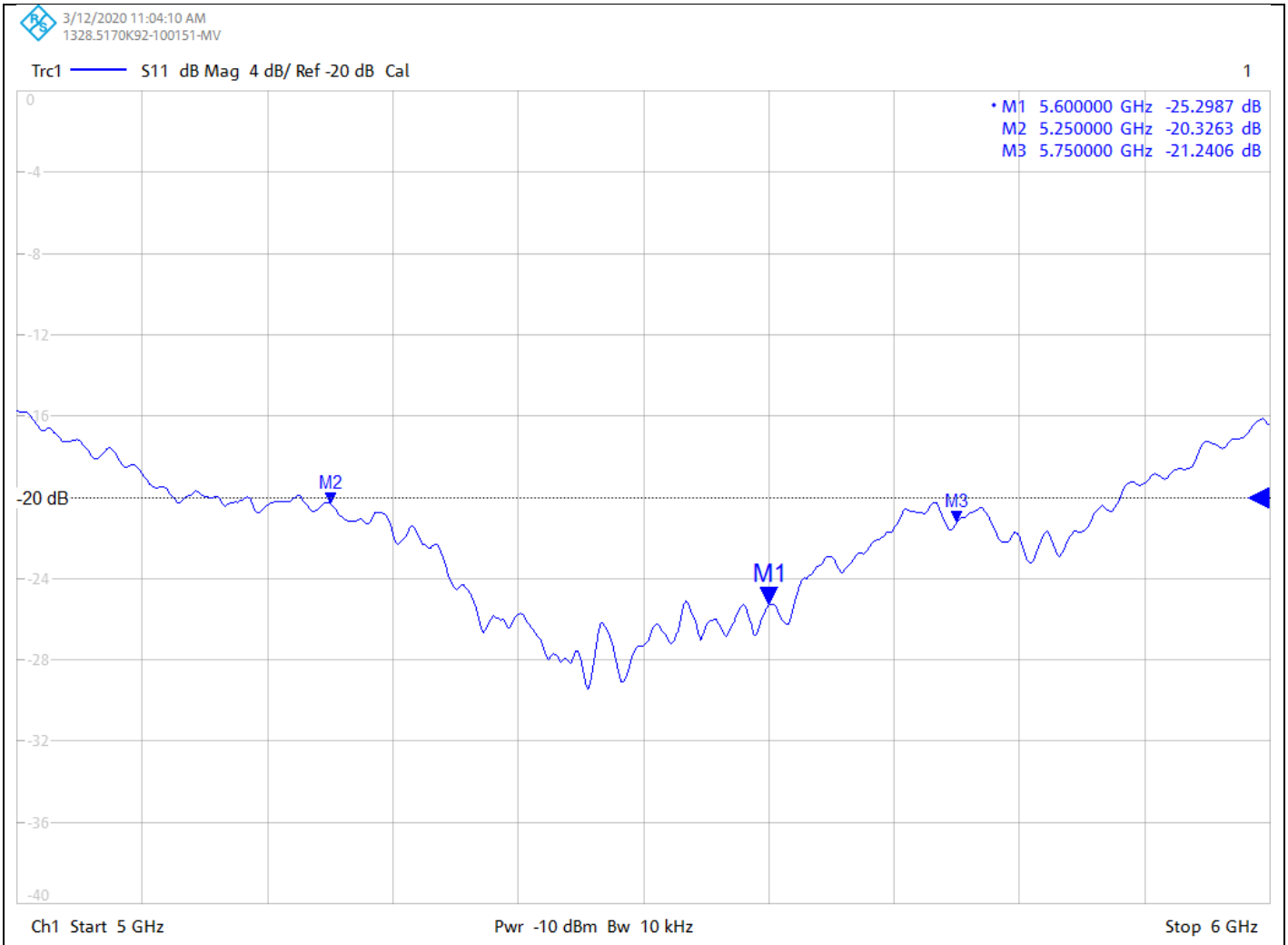
Communication System: UID 0, CW (0); Frequency: 5750 MHz;Duty Cycle: 1:1
Medium: MSL 10 03 20 - 5250, 5600, 5750 5% Medium parameters used: f = 5750 MHz; σ = 6.129 S/m; ε_r = 47.506; ρ = 1000 kg/m^3
Phantom section: Flat Section
DASY4 Configuration:
- Probe: EX3DV4 - SN3995; ConvF(4.5, 4.5, 4.5); Calibrated: 24/04/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1438; Calibrated: 11/04/2019
- Phantom: Twin SAM A (Site 65); Type: SAM 5.0; Serial: SN1818
- ; SEMCAD X Version 14.6.10 (7417)

5750/PMK d=10mm, Pin=100mW/Area Scan (81x81x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 20.1 W/kg
5750/PMK d=10mm, Pin=100mW/Zoom Scan (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.55 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 34.9 W/kg
SAR(1 g) = 7.48 W/kg; SAR(10 g) = 2.09 W/kg
Maximum value of SAR (measured) = 20.0 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: 13252596JD01C Instrument ID: 1003 Calibration Date: 12/Mar/2020 Calibration Due Date:

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