

CALIBRATION DATA

PROBE CALIBRATION DATA



COMOSAR E-Field Probe Calibration Report

Ref : ACR.230.3.21.BES.A

ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

1-2/F, BUILDING 19, JUNFENG INDUSTRIAL PARK,
CHONGQING ROAD, HEPING COMMUNITY, FUHAI
STREET
BAO 'AN DISTRICT, SHENZHEN, GUANGDONG, CHINA
MVG COMOSAR DOSIMETRIC E-FIELD PROBE
SERIAL NO.: SN 24/20 EP336

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon
29280 PLOUZANE - FRANCE

Calibration date: 08/17/2021



Accreditations #2-6789
Scope available on www.cofrac.fr

Summary:

This document presents the method and results from an accredited COMOSAR E-Field Probe calibration performed at MVG, using the CALIPROBE test bench, for use with a MVG COMOSAR system only. The test results covered by accreditation are traceable to the International System of Units (SI).



	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
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2021.08.23

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	<i>Customer Name</i>
<i>Distribution :</i>	ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Jérôme Luc	8/18/2021	Initial release



TABLE OF CONTENTS

1	Device Under Test	4
2	Product Description	4
2.1	General Information	4
3	Measurement Method	4
3.1	Linearity	4
3.2	Sensitivity	4
3.3	Lower Detection Limit	5
3.4	Isotropy	5
3.1	Boundary Effect	5
4	Measurement Uncertainty	6
5	Calibration Measurement Results	6
5.1	Sensitivity in air	6
5.2	Linearity	7
5.3	Sensitivity in liquid	8
5.4	Isotropy	9
6	List of Equipment	10



1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR DOSIMETRIC E FIELD PROBE
Manufacturer	MVG
Model	SSE5
Serial Number	SN 24/20 EP336
Product Condition (new / used)	Used
Frequency Range of Probe	0.15 GHz-3GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.212 M Ω Dipole 2: R2=0.193 M Ω Dipole 3: R3=0.217 M Ω

2 PRODUCT DESCRIPTION

2.1 GENERAL INFORMATION

MVG's COMOSAR E field Probes are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards.



Figure 1 – MVG COMOSAR Dosimetric E field Dipole

Probe Length	330 mm
Length of Individual Dipoles	4.5 mm
Maximum external diameter	8 mm
Probe Tip External Diameter	5 mm
Distance between dipoles / probe extremity	2.7 mm

3 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide recommended practices for the probe calibrations, including the performance characteristics of interest and methods by which to assess their affect. All calibrations / measurements performed meet the fore mentioned standards.

3.1 LINEARITY

The evaluation of the linearity was done in free space using the waveguide, performing a power sweep to cover the SAR range 0.01W/kg to 100W/kg.

3.2 SENSITIVITY

The sensitivity factors of the three dipoles were determined using a two step calibration method (air and tissue simulating liquid) using waveguides as outlined in the standards.



3.3 LOWER DETECTION LIMIT

The lower detection limit was assessed using the same measurement set up as used for the linearity measurement. The required lower detection limit is 10 mW/kg.

3.4 ISOTROPY

The axial isotropy was evaluated by exposing the probe to a reference wave from a standard dipole with the dipole mounted under the flat phantom in the test configuration suggested for system validations and checks. The probe was rotated along its main axis from 0 to 360 degrees in 15-degree steps. The hemispherical isotropy is determined by inserting the probe in a thin plastic box filled with tissue-equivalent liquid, with the plastic box illuminated with the fields from a half wave dipole. The dipole is rotated about its axis (0°–180°) in 15° increments. At each step the probe is rotated about its axis (0°–360°).

3.1 BOUNDARY EFFECT

The boundary effect is defined as the deviation between the SAR measured data and the expected exponential decay in the liquid when the probe is oriented normal to the interface. To evaluate this effect, the liquid filled flat phantom is exposed to fields from either a reference dipole or waveguide. With the probe normal to the phantom surface, the peak spatial average SAR is measured and compared to the analytical value at the surface.

The boundary effect uncertainty can be estimated according to the following uncertainty approximation formula based on linear and exponential extrapolations between the surface and $d_{be} + d_{step}$ along lines that are approximately normal to the surface:

$$SAR_{uncertainty} [\%] = \Delta SAR_{be} \frac{(d_{be} + d_{step})^2}{2d_{step}} \frac{(e^{-d_{be}/\delta})}{\delta/2} \quad \text{for } (d_{be} + d_{step}) < 10 \text{ mm}$$

where

$SAR_{uncertainty}$	is the uncertainty in percent of the probe boundary effect
d_{be}	is the distance between the surface and the closest <i>zoom-scan</i> measurement point, in millimetre
Δ_{step}	is the separation distance between the first and second measurement points that are closest to the phantom surface, in millimetre, assuming the boundary effect at the second location is negligible
δ	is the minimum penetration depth in millimetres of the head tissue-equivalent liquids defined in this standard, i.e., $\delta \approx 14 \text{ mm}$ at 3 GHz
ΔSAR_{be}	in percent of SAR is the deviation between the measured SAR value, at the distance d_{be} from the boundary, and the analytical SAR value.

The measured worst case boundary effect $SAR_{uncertainty}[\%]$ for scanning distances larger than 4mm is 1.0% Limit, 2%).



4 MEASUREMENT UNCERTAINTY

The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty associated with an E-field probe calibration using the waveguide technique. All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of $k=2$, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

Uncertainty analysis of the probe calibration in waveguide					
ERROR SOURCES	Uncertainty value (%)	Probability Distribution	Divisor	d	Standard Uncertainty (%)
Expanded uncertainty 95 % confidence level $k = 2$					14 %

5 CALIBRATION MEASUREMENT RESULTS

Calibration Parameters	
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

5.1 SENSITIVITY IN AIR

Normx dipole 1 ($\mu\text{V}/(\text{V}/\text{m})^2$)	Normy dipole 2 ($\mu\text{V}/(\text{V}/\text{m})^2$)	Normz dipole 3 ($\mu\text{V}/(\text{V}/\text{m})^2$)
6.17	5.72	5.28

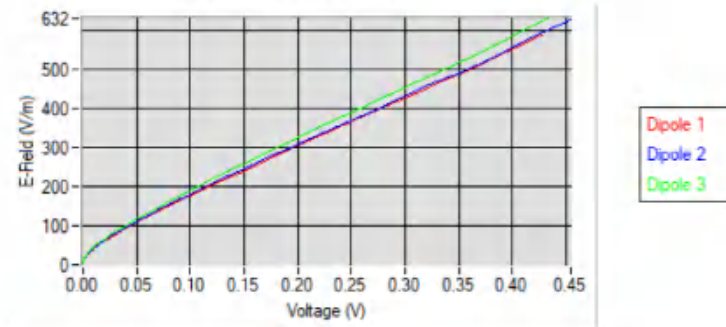
DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
107	115	112

Calibration curves $e_i=f(V)$ ($i=1,2,3$) allow to obtain E-field value using the formula:

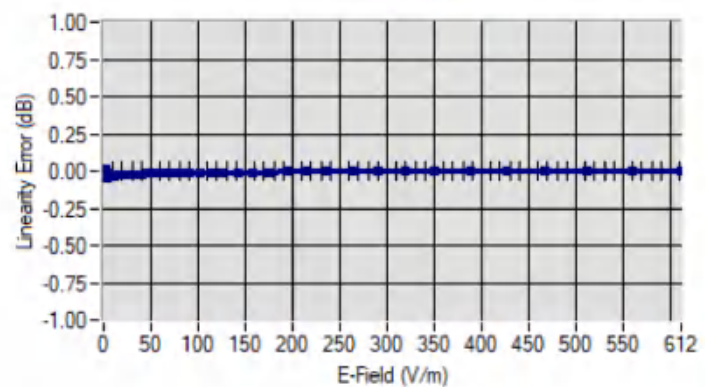
$$E = \sqrt{E_1^2 + E_2^2 + E_3^2}$$



Calibration curves

5.2 LINEARITY

Linearity

Linearity: $\pm 1.22\%$ ($\pm 0.05\text{dB}$)

5.3 SENSITIVITY IN LIQUID

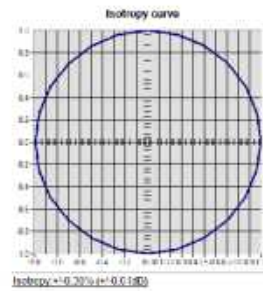
<u>Liquid</u>	<u>Frequency</u> <u>(MHz +/-</u> <u>100MHz)</u>	<u>ConvF</u>
HL700	700	5.46
HL750	750	5.35
HL850	835	5.21
HL900	900	5.53
HL1750	1750	4.94
HL1800	1800	4.57
HL1950	1950	4.41
HL2300	2300	4.48
HL2450	2450	4.02
HL2600	2600	3.89

LOWER DETECTION LIMIT: 6mW/kg



5.4 ISOTROPY

HL1800 MHz





6 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
Flat Phantom	MVG	SN-20/09-SAM71	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	05/2019	05/2022
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2019	05/2022
Multimeter	Keithley 2000	1160271	02/2020	02/2023
Signal Generator	Rohde & Schwarz SMB	106589	04/2019	04/2022
Amplifier	Aethercomm	SN 046	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	05/2019	05/2022
Directional Coupler	Narda 4216-20	01386	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Waveguide	Mega Industries	069Y7-158-13-712	Validated. No cal required.	Validated. No cal required.
Waveguide Transition	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Waveguide Termination	Mega Industries	069Y7-158-13-701	Validated. No cal required.	Validated. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44220687	05/2020	05/2023

DIPOLE CALIBRATION DATA



SAR Reference Dipole Calibration Report

Ref : ACR.118.16.22.BES.A

ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

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CHONGQING ROAD, HEPING COMMUNITY, FUHAI
STREET

BAO 'AN DISTRICT, SHENZHEN, GUANGDONG, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 835 MHZ

SERIAL NO.: SN 15/16 DIP0G835-399

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon
29280 PLOUZANE - FRANCE

Calibration date: 04/28/2022



Accreditations #2-6789 and #2-6814
Scope available on www.cofrac.fr

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Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Checked by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Approved by :</i>	Yann Toutain	Laboratory Director	4/28/2022	

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	<i>Customer Name</i>
<i>Distribution :</i>	ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Jérôme Luc	4/28/2022	Initial release



TABLE OF CONTENTS

1	Introduction.....	4
2	Device Under Test	4
3	Product Description	4
3.1	General Information	4
4	Measurement Method	5
4.1	Return Loss Requirements	5
4.2	Mechanical Requirements	5
5	Measurement Uncertainty	5
5.1	Return Loss	5
5.2	Dimension Measurement	5
5.3	Validation Measurement	5
6	Calibration Measurement Results	6
6.1	Return Loss and Impedance In Head Liquid	6
6.2	Return Loss and Impedance In Body Liquid	6
6.3	Mechanical Dimensions	7
7	Validation measurement	7
7.1	Head Liquid Measurement	8
7.2	SAR Measurement Result With Head Liquid	8
7.3	Body Liquid Measurement	11
7.4	SAR Measurement Result With Body Liquid	12
8	List of Equipment	13



1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 835 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID835
Serial Number	SN 15/16 DIP0G835-399
Product Condition (new / used)	Used

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – MVG COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

4.2 MECHANICAL REQUIREMENTS

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards specify the mechanical components and dimensions of the validation dipoles, with the dimension's frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness. A direct method is used with a ISO17025 calibrated caliper.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.08 LIN

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
0 - 300	0.20 mm
300 - 450	0.44 mm

5.3 VALIDATION MEASUREMENT

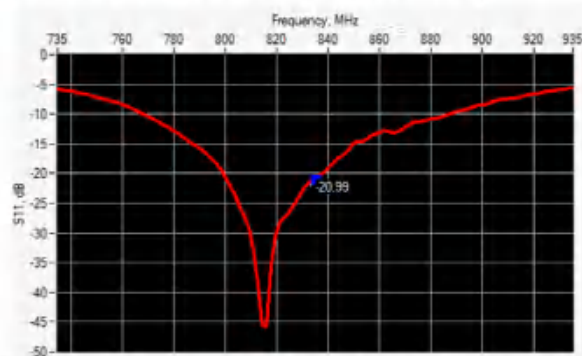
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



Scan Volume	Expanded Uncertainty
1 g	19 % (SAR)
10 g	19 % (SAR)

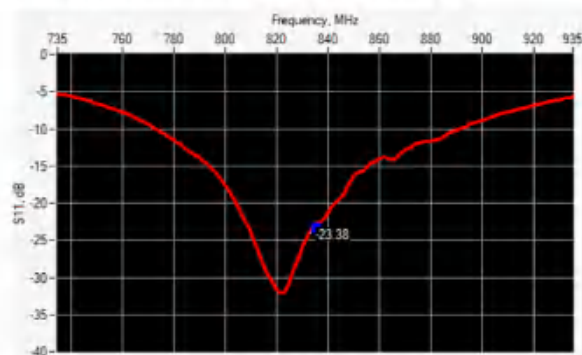
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
835	-20.99	-20	$59.4 \Omega - 0.8 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
835	-23.38	-20	$56.4 \Omega + 2.0 j\Omega$



6.3 MECHANICAL DIMENSIONS

Frequency/MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 $\pm 1\%$		250.0 $\pm 1\%$		6.35 $\pm 1\%$	
450	290.0 $\pm 1\%$		166.7 $\pm 1\%$		6.35 $\pm 1\%$	
750	176.0 $\pm 1\%$		100.0 $\pm 1\%$		6.35 $\pm 1\%$	
835	161.0 $\pm 1\%$		89.8 $\pm 1\%$		3.6 $\pm 1\%$	
900	149.0 $\pm 1\%$		83.3 $\pm 1\%$		3.6 $\pm 1\%$	
1450	89.1 $\pm 1\%$		51.7 $\pm 1\%$		3.6 $\pm 1\%$	
1500	86.2 $\pm 1\%$		50.0 $\pm 1\%$		3.6 $\pm 1\%$	
1640	79.0 $\pm 1\%$		45.7 $\pm 1\%$		3.6 $\pm 1\%$	
1750	75.2 $\pm 1\%$		42.9 $\pm 1\%$		3.6 $\pm 1\%$	
1800	72.0 $\pm 1\%$		41.7 $\pm 1\%$		3.6 $\pm 1\%$	
1900	68.0 $\pm 1\%$		39.5 $\pm 1\%$		3.6 $\pm 1\%$	
1950	66.3 $\pm 1\%$		38.5 $\pm 1\%$		3.6 $\pm 1\%$	
2000	64.5 $\pm 1\%$		37.5 $\pm 1\%$		3.6 $\pm 1\%$	
2100	61.0 $\pm 1\%$		35.7 $\pm 1\%$		3.6 $\pm 1\%$	
2300	55.5 $\pm 1\%$		32.6 $\pm 1\%$		3.6 $\pm 1\%$	
2450	51.5 $\pm 1\%$		30.4 $\pm 1\%$		3.6 $\pm 1\%$	
2600	48.5 $\pm 1\%$		28.8 $\pm 1\%$		3.6 $\pm 1\%$	
3000	41.5 $\pm 1\%$		25.0 $\pm 1\%$		3.6 $\pm 1\%$	
3300	-		-		-	
3500	37.0 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3700	34.7 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3900	-		-		-	
4200	-		-		-	
4600	-		-		-	
4900	-		-		-	

7 VALIDATION MEASUREMENT

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.



7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ϵ')		Conductivity (σ) S/m	
	required	measured	required	measured
300	45.3 ± 10 %		0.87 ± 10 %	
450	43.5 ± 10 %		0.87 ± 10 %	
750	41.9 ± 10 %		0.89 ± 10 %	
835	41.5 ± 10 %	39.9	0.90 ± 10 %	0.91
900	41.5 ± 10 %		0.97 ± 10 %	
1450	40.5 ± 10 %		1.20 ± 10 %	
1500	40.4 ± 10 %		1.23 ± 10 %	
1640	40.2 ± 10 %		1.31 ± 10 %	
1750	40.1 ± 10 %		1.37 ± 10 %	
1800	40.0 ± 10 %		1.40 ± 10 %	
1900	40.0 ± 10 %		1.40 ± 10 %	
1950	40.0 ± 10 %		1.40 ± 10 %	
2000	40.0 ± 10 %		1.40 ± 10 %	
2100	39.8 ± 10 %		1.49 ± 10 %	
2300	39.5 ± 10 %		1.67 ± 10 %	
2450	39.2 ± 10 %		1.80 ± 10 %	
2600	39.0 ± 10 %		1.96 ± 10 %	
3000	38.5 ± 10 %		2.40 ± 10 %	
3300	38.2 ± 10 %		2.71 ± 10 %	
3500	37.9 ± 10 %		2.91 ± 10 %	
3700	37.7 ± 10 %		3.12 ± 10 %	
3900	37.5 ± 10 %		3.32 ± 10 %	
4200	37.1 ± 10 %		3.63 ± 10 %	
4600	36.7 ± 10 %		4.04 ± 10 %	
4900	36.3 ± 10 %		4.35 ± 10 %	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

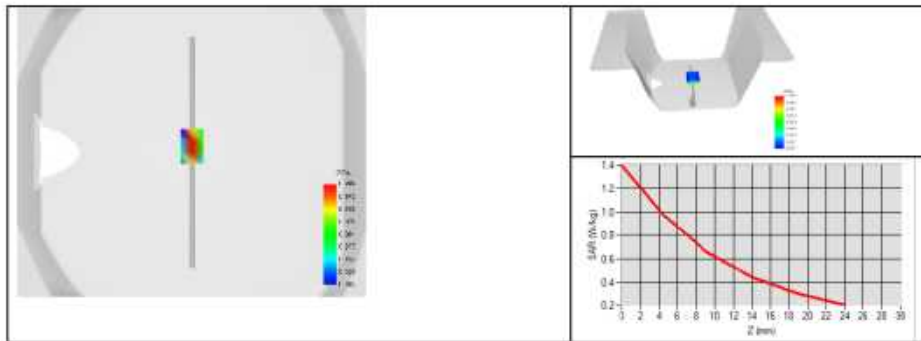


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.16.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Head Liquid Values: ϵ_p' : 39.9 σ : 0.91
Distance between dipole center and liquid	15.0 mm
Area scan resolution	$\Delta x=8\text{mm}/\Delta y=8\text{mm}$
Zoon Scan Resolution	$\Delta x=8\text{mm}/\Delta y=8\text{mm}/\Delta z=5\text{mm}$
Frequency	835 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56	9.67 (0.97)	6.22	6.14 (0.61)
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3		24.6	
3000	63.8		25.7	
3300	-		-	
3500	67.1		25	
3700	67.4		24.2	
3900	-		-	
4200	-		-	
4600	-		-	
4900	-		-	





7.3 BODY LIQUID MEASUREMENT

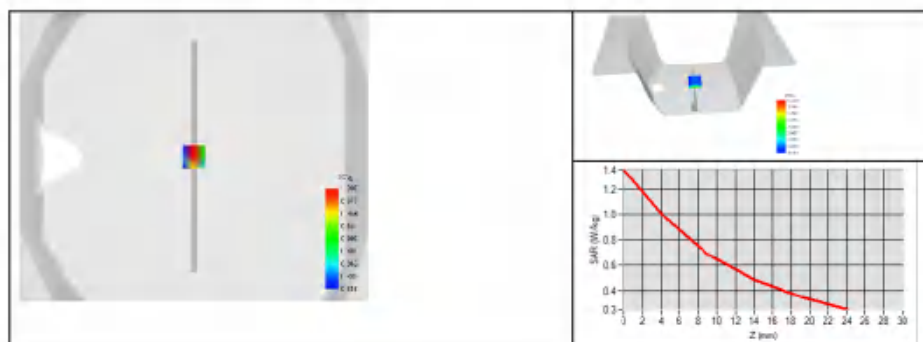
Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %		0.96 ± 10 %	
835	55.2 ± 10 %	52.3	0.97 ± 10 %	0.94
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 10 %		1.06 ± 10 %	
1450	54.0 ± 10 %		1.30 ± 10 %	
1610	53.8 ± 10 %		1.40 ± 10 %	
1800	53.3 ± 10 %		1.52 ± 10 %	
1900	53.3 ± 10 %		1.52 ± 10 %	
2000	53.3 ± 10 %		1.52 ± 10 %	
2100	53.2 ± 10 %		1.62 ± 10 %	
2300	52.9 ± 10 %		1.81 ± 10 %	
2450	52.7 ± 10 %		1.95 ± 10 %	
2600	52.5 ± 10 %		2.16 ± 10 %	
3000	52.0 ± 10 %		2.73 ± 10 %	
3300	51.6 ± 10 %		3.08 ± 10 %	
3500	51.3 ± 10 %		3.31 ± 10 %	
3700	51.0 ± 10 %		3.55 ± 10 %	
3900	50.8 ± 10 %		3.78 ± 10 %	
4200	50.4 ± 10 %		4.13 ± 10 %	
4600	49.8 ± 10 %		4.60 ± 10 %	
4900	49.4 ± 10 %		4.95 ± 10 %	
5200	49.0 ± 10 %		5.30 ± 10 %	
5300	48.9 ± 10 %		5.42 ± 10 %	
5400	48.7 ± 10 %		5.53 ± 10 %	
5500	48.6 ± 10 %		5.65 ± 10 %	
5600	48.5 ± 10 %		5.77 ± 10 %	
5800	48.2 ± 10 %		6.00 ± 10 %	



7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Body Liquid Values: ϵ_{ps}^* : 52.3 sigma : 0.94
Distance between dipole center and liquid	15.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=8mm/dy=8mm/dz=5mm$
Frequency	835 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
835	9.53 (0.95)	6.24 (0.62)





8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
SAM Phantom	MVG	SN 13/09 SAM68	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2019	10/2022
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2019	05/2022
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Calipers	Mitutoyo	SN 0009732	10/2019	10/2022
Reference Probe	MVG	SN 41/18 EPGO333	10/2021	10/2022
Multimeter	Keithley 2000	1160271	02/2020	02/2023
Signal Generator	Rohde & Schwarz SMB	106589	03/2022	03/2025
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2021	06/2024
Power Meter	Rohde & Schwarz NRVD	832839-056	11/2019	11/2022
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024



SAR Reference Dipole Calibration Report

Ref : ACR.118.18.22.BES.A

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BAO 'AN DISTRICT, SHENZHEN, GUANGDONG, CHINA
MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 1800 MHZ

SERIAL NO.: SN 46/11 DIP1G800-186

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon
29280 PLOUZANE - FRANCE

Calibration date: 04/28/2022



Accreditations #2-6789 and #2-6814
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Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Checked by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Approved by :</i>	Yann Toutain	Laboratory Director	4/28/2022	

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	<i>Customer Name</i>
<i>Distribution :</i>	ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Jérôme Luc	4/28/2022	Initial release



TABLE OF CONTENTS

1	Introduction.....	4
2	Device Under Test	4
3	Product Description	4
3.1	General Information	4
4	Measurement Method	5
4.1	Return Loss Requirements	5
4.2	Mechanical Requirements	5
5	Measurement Uncertainty	5
5.1	Return Loss	5
5.2	Dimension Measurement	5
5.3	Validation Measurement	5
6	Calibration Measurement Results	6
6.1	Return Loss and Impedance In Head Liquid	6
6.2	Return Loss and Impedance In Body Liquid	6
6.3	Mechanical Dimensions	7
7	Validation measurement	7
7.1	Head Liquid Measurement	8
7.2	SAR Measurement Result With Head Liquid	8
7.3	Body Liquid Measurement	11
7.4	SAR Measurement Result With Body Liquid	12
8	List of Equipment	13



1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 1800 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID1800
Serial Number	SN 46/11 DIP1G800-186
Product Condition (new / used)	Used

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – MVG COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

4.2 MECHANICAL REQUIREMENTS

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards specify the mechanical components and dimensions of the validation dipoles, with the dimension's frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness. A direct method is used with a ISO17025 calibrated caliper.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.08 LIN

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
0 - 300	0.20 mm
300 - 450	0.44 mm

5.3 VALIDATION MEASUREMENT

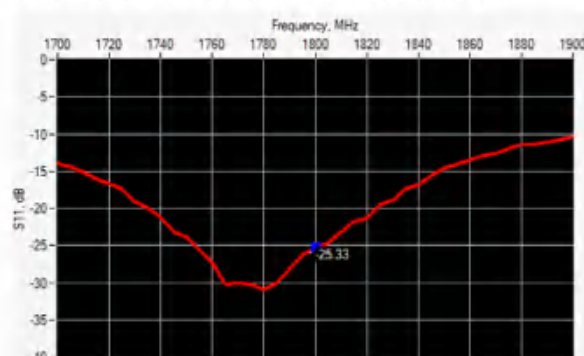
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



Scan Volume	Expanded Uncertainty
1 g	19 % (SAR)
10 g	19 % (SAR)

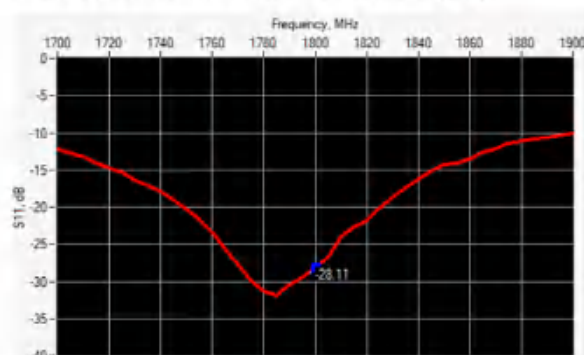
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1800	-25.33	-20	$47.2 \Omega + 4.6 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1800	-28.11	-20	$46.2 \Omega - 1.1 j\Omega$



6.3 MECHANICAL DIMENSIONS

Frequency/MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 $\pm 1\%$		250.0 $\pm 1\%$		6.35 $\pm 1\%$	
450	290.0 $\pm 1\%$		166.7 $\pm 1\%$		6.35 $\pm 1\%$	
750	176.0 $\pm 1\%$		100.0 $\pm 1\%$		6.35 $\pm 1\%$	
835	161.0 $\pm 1\%$		89.8 $\pm 1\%$		3.6 $\pm 1\%$	
900	149.0 $\pm 1\%$		83.3 $\pm 1\%$		3.6 $\pm 1\%$	
1450	89.1 $\pm 1\%$		51.7 $\pm 1\%$		3.6 $\pm 1\%$	
1500	86.2 $\pm 1\%$		50.0 $\pm 1\%$		3.6 $\pm 1\%$	
1640	79.0 $\pm 1\%$		45.7 $\pm 1\%$		3.6 $\pm 1\%$	
1750	75.2 $\pm 1\%$		42.9 $\pm 1\%$		3.6 $\pm 1\%$	
1800	72.0 $\pm 1\%$		41.7 $\pm 1\%$		3.6 $\pm 1\%$	
1900	68.0 $\pm 1\%$		39.5 $\pm 1\%$		3.6 $\pm 1\%$	
1950	66.3 $\pm 1\%$		38.5 $\pm 1\%$		3.6 $\pm 1\%$	
2000	64.5 $\pm 1\%$		37.5 $\pm 1\%$		3.6 $\pm 1\%$	
2100	61.0 $\pm 1\%$		35.7 $\pm 1\%$		3.6 $\pm 1\%$	
2300	55.5 $\pm 1\%$		32.6 $\pm 1\%$		3.6 $\pm 1\%$	
2450	51.5 $\pm 1\%$		30.4 $\pm 1\%$		3.6 $\pm 1\%$	
2600	48.5 $\pm 1\%$		28.8 $\pm 1\%$		3.6 $\pm 1\%$	
3000	41.5 $\pm 1\%$		25.0 $\pm 1\%$		3.6 $\pm 1\%$	
3300	-		-		-	
3500	37.0 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3700	34.7 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3900	-		-		-	
4200	-		-		-	
4600	-		-		-	
4900	-		-		-	

7 VALIDATION MEASUREMENT

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.



7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
300	45.3 ± 10 %		0.87 ± 10 %	
450	43.5 ± 10 %		0.87 ± 10 %	
750	41.9 ± 10 %		0.89 ± 10 %	
835	41.5 ± 10 %		0.90 ± 10 %	
900	41.5 ± 10 %		0.97 ± 10 %	
1450	40.5 ± 10 %		1.20 ± 10 %	
1500	40.4 ± 10 %		1.23 ± 10 %	
1640	40.2 ± 10 %		1.31 ± 10 %	
1750	40.1 ± 10 %		1.37 ± 10 %	
1800	40.0 ± 10 %	38.4	1.40 ± 10 %	1.36
1900	40.0 ± 10 %		1.40 ± 10 %	
1950	40.0 ± 10 %		1.40 ± 10 %	
2000	40.0 ± 10 %		1.40 ± 10 %	
2100	39.8 ± 10 %		1.49 ± 10 %	
2300	39.5 ± 10 %		1.67 ± 10 %	
2450	39.2 ± 10 %		1.80 ± 10 %	
2600	39.0 ± 10 %		1.96 ± 10 %	
3000	38.5 ± 10 %		2.40 ± 10 %	
3300	38.2 ± 10 %		2.71 ± 10 %	
3500	37.9 ± 10 %		2.91 ± 10 %	
3700	37.7 ± 10 %		3.12 ± 10 %	
3900	37.5 ± 10 %		3.32 ± 10 %	
4200	37.1 ± 10 %		3.63 ± 10 %	
4600	36.7 ± 10 %		4.04 ± 10 %	
4900	36.3 ± 10 %		4.35 ± 10 %	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

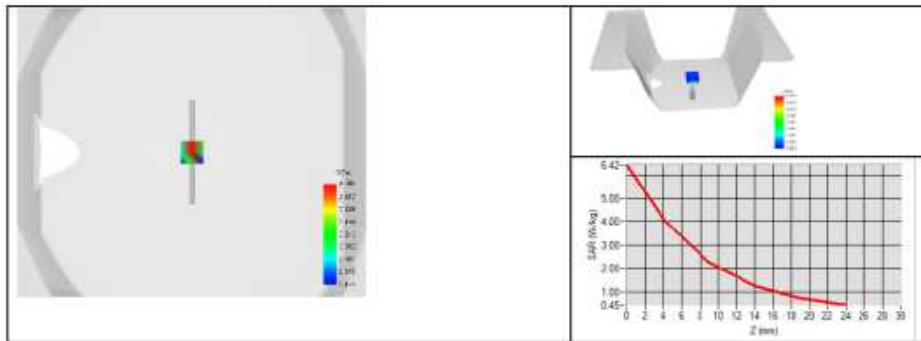


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.18.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Head Liquid Values: ϵ_{ps}' : 38.4 sigma : 1.36
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=8mm/dy=8mm/dz=5mm$
Frequency	1800 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4	37.76 (3.78)	20.1	19.60 (1.96)
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3		24.6	
3000	63.8		25.7	
3300	-		-	
3500	67.1		25	
3700	67.4		24.2	
3900	-		-	
4200	-		-	
4600	-		-	
4900	-		-	





7.3 BODY LIQUID MEASUREMENT

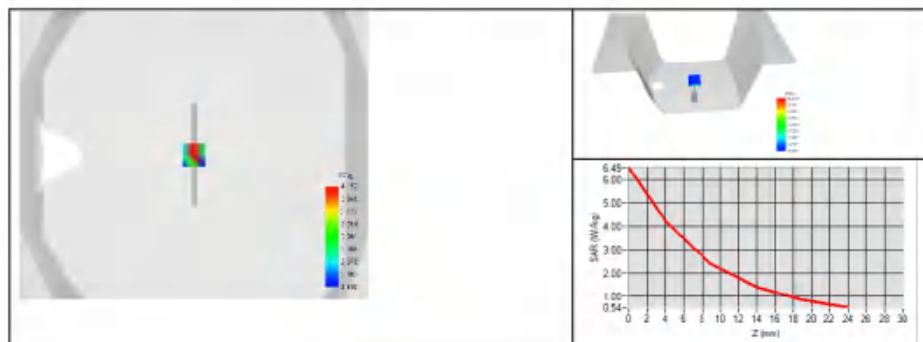
Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %		0.96 ± 10 %	
835	55.2 ± 10 %		0.97 ± 10 %	
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 10 %		1.06 ± 10 %	
1450	54.0 ± 10 %		1.30 ± 10 %	
1610	53.8 ± 10 %		1.40 ± 10 %	
1800	53.3 ± 10 %	55.3	1.52 ± 10 %	1.49
1900	53.3 ± 10 %		1.52 ± 10 %	
2000	53.3 ± 10 %		1.52 ± 10 %	
2100	53.2 ± 10 %		1.62 ± 10 %	
2300	52.9 ± 10 %		1.81 ± 10 %	
2450	52.7 ± 10 %		1.95 ± 10 %	
2600	52.5 ± 10 %		2.16 ± 10 %	
3000	52.0 ± 10 %		2.73 ± 10 %	
3300	51.6 ± 10 %		3.08 ± 10 %	
3500	51.3 ± 10 %		3.31 ± 10 %	
3700	51.0 ± 10 %		3.55 ± 10 %	
3900	50.8 ± 10 %		3.78 ± 10 %	
4200	50.4 ± 10 %		4.13 ± 10 %	
4600	49.8 ± 10 %		4.60 ± 10 %	
4900	49.4 ± 10 %		4.95 ± 10 %	
5200	49.0 ± 10 %		5.30 ± 10 %	
5300	48.9 ± 10 %		5.42 ± 10 %	
5400	48.7 ± 10 %		5.53 ± 10 %	
5500	48.6 ± 10 %		5.65 ± 10 %	
5600	48.5 ± 10 %		5.77 ± 10 %	
5800	48.2 ± 10 %		6.00 ± 10 %	



7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Body Liquid Values: ϵ_{ps}^* : 55.3 sigma : 1.49
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=8mm/dy=8mm/dz=5mm$
Frequency	1800 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
1800	38.20 (3.82)	20.38 (2.04)





8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
SAM Phantom	MVG	SN 13/09 SAM68	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2019	10/2022
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2019	05/2022
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Calipers	Mitutoyo	SN 0009732	10/2019	10/2022
Reference Probe	MVG	SN 41/18 EPGO333	10/2021	10/2022
Multimeter	Keithley 2000	1160271	02/2020	02/2023
Signal Generator	Rohde & Schwarz SMB	106589	03/2022	03/2025
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2021	06/2024
Power Meter	Rohde & Schwarz NRVD	832839-056	11/2019	11/2022
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024



SAR Reference Dipole Calibration Report

Ref : ACR.118.19.22.BES.A

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CHONGQING ROAD, HEPING COMMUNITY, FUHAI
STREET

BAO 'AN DISTRICT, SHENZHEN, GUANGDONG, CHINA
MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 1900 MHZ

SERIAL NO.: SN 29/15 DIP1G900-389

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon
29280 PLOUZANE - FRANCE

Calibration date: 04/28/2022



Accreditations #2-6789 and #2-6814
Scope available on www.cofrac.fr

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Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Checked by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Approved by :</i>	Yann Toutain	Laboratory Director	4/28/2022	

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	<i>Customer Name</i>
<i>Distribution :</i>	ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Jérôme Luc	4/28/2022	Initial release



TABLE OF CONTENTS

1	Introduction.....	4
2	Device Under Test	4
3	Product Description	4
3.1	General Information	4
4	Measurement Method	5
4.1	Return Loss Requirements	5
4.2	Mechanical Requirements	5
5	Measurement Uncertainty	5
5.1	Return Loss	5
5.2	Dimension Measurement	5
5.3	Validation Measurement	5
6	Calibration Measurement Results	6
6.1	Return Loss and Impedance In Head Liquid	6
6.2	Return Loss and Impedance In Body Liquid	6
6.3	Mechanical Dimensions	7
7	Validation measurement	7
7.1	Head Liquid Measurement	8
7.2	SAR Measurement Result With Head Liquid	8
7.3	Body Liquid Measurement	11
7.4	SAR Measurement Result With Body Liquid	12
8	List of Equipment	13



1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 1900 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID1900
Serial Number	SN 29/15 DIP1G900-389
Product Condition (new / used)	Used

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – MVG COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

4.2 MECHANICAL REQUIREMENTS

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards specify the mechanical components and dimensions of the validation dipoles, with the dimension's frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness. A direct method is used with a ISO17025 calibrated caliper.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.08 LIN

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
0 - 300	0.20 mm
300 - 450	0.44 mm

5.3 VALIDATION MEASUREMENT

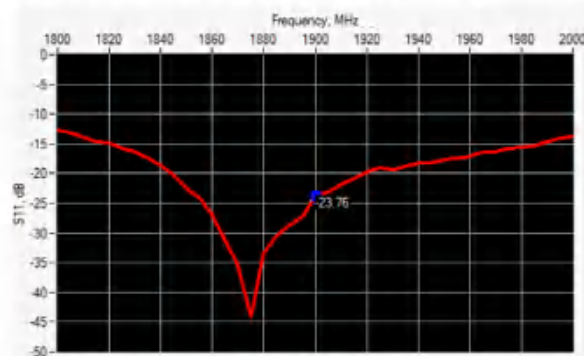
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



Scan Volume	Expanded Uncertainty
1 g	19 % (SAR)
10 g	19 % (SAR)

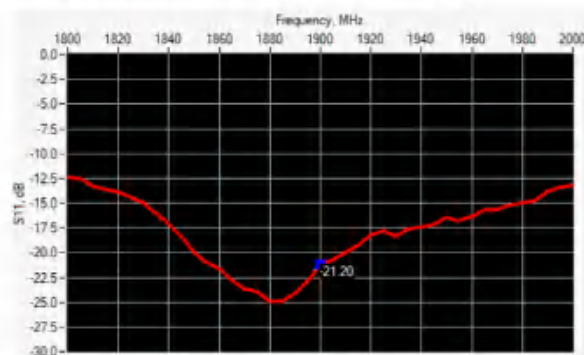
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1900	-23.76	-20	$52.2 \Omega + 6.1 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
1900	-21.20	-20	$45.5 \Omega + 7.4 j\Omega$



6.3 MECHANICAL DIMENSIONS

Frequency/MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 $\pm 1\%$		250.0 $\pm 1\%$		6.35 $\pm 1\%$	
450	290.0 $\pm 1\%$		166.7 $\pm 1\%$		6.35 $\pm 1\%$	
750	176.0 $\pm 1\%$		100.0 $\pm 1\%$		6.35 $\pm 1\%$	
835	161.0 $\pm 1\%$		89.8 $\pm 1\%$		3.6 $\pm 1\%$	
900	149.0 $\pm 1\%$		83.3 $\pm 1\%$		3.6 $\pm 1\%$	
1450	89.1 $\pm 1\%$		51.7 $\pm 1\%$		3.6 $\pm 1\%$	
1500	86.2 $\pm 1\%$		50.0 $\pm 1\%$		3.6 $\pm 1\%$	
1640	79.0 $\pm 1\%$		45.7 $\pm 1\%$		3.6 $\pm 1\%$	
1750	75.2 $\pm 1\%$		42.9 $\pm 1\%$		3.6 $\pm 1\%$	
1800	72.0 $\pm 1\%$		41.7 $\pm 1\%$		3.6 $\pm 1\%$	
1900	68.0 $\pm 1\%$		39.5 $\pm 1\%$		3.6 $\pm 1\%$	
1950	66.3 $\pm 1\%$		38.5 $\pm 1\%$		3.6 $\pm 1\%$	
2000	64.5 $\pm 1\%$		37.5 $\pm 1\%$		3.6 $\pm 1\%$	
2100	61.0 $\pm 1\%$		35.7 $\pm 1\%$		3.6 $\pm 1\%$	
2300	55.5 $\pm 1\%$		32.6 $\pm 1\%$		3.6 $\pm 1\%$	
2450	51.5 $\pm 1\%$		30.4 $\pm 1\%$		3.6 $\pm 1\%$	
2600	48.5 $\pm 1\%$		28.8 $\pm 1\%$		3.6 $\pm 1\%$	
3000	41.5 $\pm 1\%$		25.0 $\pm 1\%$		3.6 $\pm 1\%$	
3300	-		-		-	
3500	37.0 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3700	34.7 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3900	-		-		-	
4200	-		-		-	
4600	-		-		-	
4900	-		-		-	

7 VALIDATION MEASUREMENT

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.



7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
300	45.3 $\pm 10\%$		0.87 $\pm 10\%$	
450	43.5 $\pm 10\%$		0.87 $\pm 10\%$	
750	41.9 $\pm 10\%$		0.89 $\pm 10\%$	
835	41.5 $\pm 10\%$		0.90 $\pm 10\%$	
900	41.5 $\pm 10\%$		0.97 $\pm 10\%$	
1450	40.5 $\pm 10\%$		1.20 $\pm 10\%$	
1500	40.4 $\pm 10\%$		1.23 $\pm 10\%$	
1640	40.2 $\pm 10\%$		1.31 $\pm 10\%$	
1750	40.1 $\pm 10\%$		1.37 $\pm 10\%$	
1800	40.0 $\pm 10\%$		1.40 $\pm 10\%$	
1900	40.0 $\pm 10\%$	37.9	1.40 $\pm 10\%$	1.43
1950	40.0 $\pm 10\%$		1.40 $\pm 10\%$	
2000	40.0 $\pm 10\%$		1.40 $\pm 10\%$	
2100	39.8 $\pm 10\%$		1.49 $\pm 10\%$	
2300	39.5 $\pm 10\%$		1.67 $\pm 10\%$	
2450	39.2 $\pm 10\%$		1.80 $\pm 10\%$	
2600	39.0 $\pm 10\%$		1.96 $\pm 10\%$	
3000	38.5 $\pm 10\%$		2.40 $\pm 10\%$	
3300	38.2 $\pm 10\%$		2.71 $\pm 10\%$	
3500	37.9 $\pm 10\%$		2.91 $\pm 10\%$	
3700	37.7 $\pm 10\%$		3.12 $\pm 10\%$	
3900	37.5 $\pm 10\%$		3.32 $\pm 10\%$	
4200	37.1 $\pm 10\%$		3.63 $\pm 10\%$	
4600	36.7 $\pm 10\%$		4.04 $\pm 10\%$	
4900	36.3 $\pm 10\%$		4.35 $\pm 10\%$	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

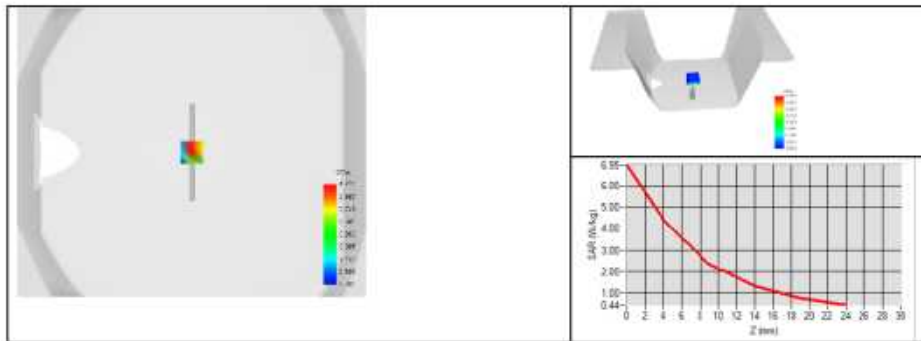


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.19.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Head Liquid Values: ϵ_p' : 37.9 σ : 1.43
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=8mm/dy=8mm/dz=5mm$
Frequency	1900 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7	41.26 (4.13)	20.5	20.86 (2.09)
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3		24.6	
3000	63.8		25.7	
3300	-		-	
3500	67.1		25	
3700	67.4		24.2	
3900	-		-	
4200	-		-	
4600	-		-	
4900	-		-	





7.3 BODY LIQUID MEASUREMENT

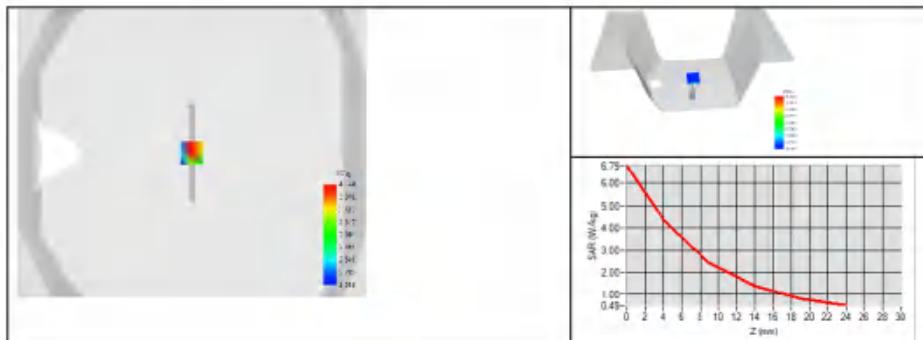
Frequency MHz	Relative permittivity (ϵ')		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %		0.96 ± 10 %	
835	55.2 ± 10 %		0.97 ± 10 %	
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 10 %		1.06 ± 10 %	
1450	54.0 ± 10 %		1.30 ± 10 %	
1610	53.8 ± 10 %		1.40 ± 10 %	
1800	53.3 ± 10 %		1.52 ± 10 %	
1900	53.3 ± 10 %	55.0	1.52 ± 10 %	1.57
2000	53.3 ± 10 %		1.52 ± 10 %	
2100	53.2 ± 10 %		1.62 ± 10 %	
2300	52.9 ± 10 %		1.81 ± 10 %	
2450	52.7 ± 10 %		1.95 ± 10 %	
2600	52.5 ± 10 %		2.16 ± 10 %	
3000	52.0 ± 10 %		2.73 ± 10 %	
3300	51.6 ± 10 %		3.08 ± 10 %	
3500	51.3 ± 10 %		3.31 ± 10 %	
3700	51.0 ± 10 %		3.55 ± 10 %	
3900	50.8 ± 10 %		3.78 ± 10 %	
4200	50.4 ± 10 %		4.13 ± 10 %	
4600	49.8 ± 10 %		4.60 ± 10 %	
4900	49.4 ± 10 %		4.95 ± 10 %	
5200	49.0 ± 10 %		5.30 ± 10 %	
5300	48.9 ± 10 %		5.42 ± 10 %	
5400	48.7 ± 10 %		5.53 ± 10 %	
5500	48.6 ± 10 %		5.65 ± 10 %	
5600	48.5 ± 10 %		5.77 ± 10 %	
5800	48.2 ± 10 %		6.00 ± 10 %	



7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Body Liquid Values: ϵ_{ps}^* : 55.0 sigma : 1.57
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=8mm/dy=8mm/dz=5mm$
Frequency	1900 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
1900	39.55 (3.96)	20.51 (2.05)





8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
SAM Phantom	MVG	SN 13/09 SAM68	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2019	10/2022
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2019	05/2022
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Calipers	Mitutoyo	SN 0009732	10/2019	10/2022
Reference Probe	MVG	SN 41/18 EPGO333	10/2021	10/2022
Multimeter	Keithley 2000	1160271	02/2020	02/2023
Signal Generator	Rohde & Schwarz SMB	106589	03/2022	03/2025
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2021	06/2024
Power Meter	Rohde & Schwarz NRVD	832839-056	11/2019	11/2022
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024



SAR Reference Dipole Calibration Report

Ref : ACR.118.20.22.BES.A

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BAO 'AN DISTRICT, SHENZHEN, GUANGDONG, CHINA
MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 2000 MHZ

SERIAL NO.: SN 29/15 DIP2G000-390

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon
29280 PLOUZANE - FRANCE

Calibration date: 04/28/2022



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Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Checked by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
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	<i>Customer Name</i>
<i>Distribution :</i>	ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Jérôme Luc	4/28/2022	Initial release



TABLE OF CONTENTS

1	Introduction.....	4
2	Device Under Test	4
3	Product Description	4
3.1	General Information	4
4	Measurement Method	5
4.1	Return Loss Requirements	5
4.2	Mechanical Requirements	5
5	Measurement Uncertainty	5
5.1	Return Loss	5
5.2	Dimension Measurement	5
5.3	Validation Measurement	5
6	Calibration Measurement Results	6
6.1	Return Loss and Impedance In Head Liquid	6
6.2	Return Loss and Impedance In Body Liquid	6
6.3	Mechanical Dimensions	7
7	Validation measurement	7
7.1	Head Liquid Measurement	8
7.2	SAR Measurement Result With Head Liquid	8
7.3	Body Liquid Measurement	11
7.4	SAR Measurement Result With Body Liquid	12
8	List of Equipment	13



1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 2000 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID2000
Serial Number	SN 29/15 DIP2G000-390
Product Condition (new / used)	Used

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – MVG COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

4.2 MECHANICAL REQUIREMENTS

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards specify the mechanical components and dimensions of the validation dipoles, with the dimension's frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness. A direct method is used with a ISO17025 calibrated caliper.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.08 LIN

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
0 - 300	0.20 mm
300 - 450	0.44 mm

5.3 VALIDATION MEASUREMENT

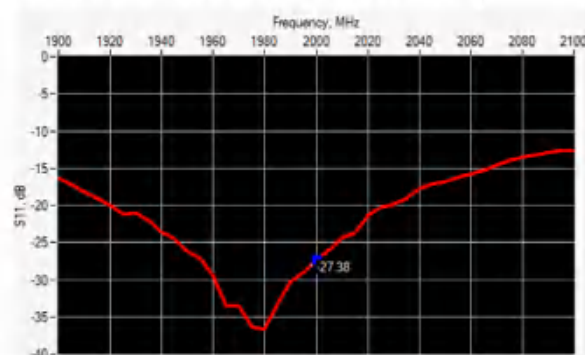
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



Scan Volume	Expanded Uncertainty
1 g	19 % (SAR)
10 g	19 % (SAR)

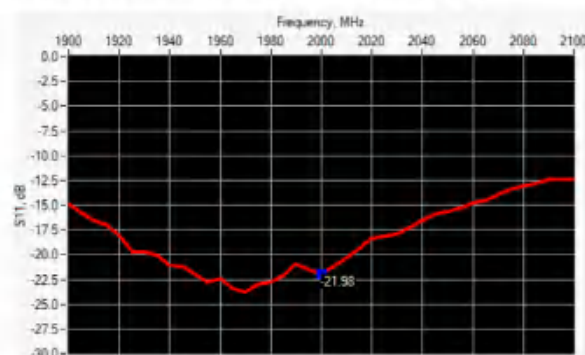
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2000	-27.38	-20	$54.3 \Omega - 0.4 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2000	-21.98	-20	$55.9 \Omega + 5.3 j\Omega$



6.3 MECHANICAL DIMENSIONS

Frequency/MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 $\pm 1\%$		250.0 $\pm 1\%$		6.35 $\pm 1\%$	
450	290.0 $\pm 1\%$		166.7 $\pm 1\%$		6.35 $\pm 1\%$	
750	176.0 $\pm 1\%$		100.0 $\pm 1\%$		6.35 $\pm 1\%$	
835	161.0 $\pm 1\%$		89.8 $\pm 1\%$		3.6 $\pm 1\%$	
900	149.0 $\pm 1\%$		83.3 $\pm 1\%$		3.6 $\pm 1\%$	
1450	89.1 $\pm 1\%$		51.7 $\pm 1\%$		3.6 $\pm 1\%$	
1500	86.2 $\pm 1\%$		50.0 $\pm 1\%$		3.6 $\pm 1\%$	
1640	79.0 $\pm 1\%$		45.7 $\pm 1\%$		3.6 $\pm 1\%$	
1750	75.2 $\pm 1\%$		42.9 $\pm 1\%$		3.6 $\pm 1\%$	
1800	72.0 $\pm 1\%$		41.7 $\pm 1\%$		3.6 $\pm 1\%$	
1900	68.0 $\pm 1\%$		39.5 $\pm 1\%$		3.6 $\pm 1\%$	
1950	66.3 $\pm 1\%$		38.5 $\pm 1\%$		3.6 $\pm 1\%$	
2000	64.5 $\pm 1\%$		37.5 $\pm 1\%$		3.6 $\pm 1\%$	
2100	61.0 $\pm 1\%$		35.7 $\pm 1\%$		3.6 $\pm 1\%$	
2300	55.5 $\pm 1\%$		32.6 $\pm 1\%$		3.6 $\pm 1\%$	
2450	51.5 $\pm 1\%$		30.4 $\pm 1\%$		3.6 $\pm 1\%$	
2600	48.5 $\pm 1\%$		28.8 $\pm 1\%$		3.6 $\pm 1\%$	
3000	41.5 $\pm 1\%$		25.0 $\pm 1\%$		3.6 $\pm 1\%$	
3300	-		-		-	
3500	37.0 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3700	34.7 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3900	-		-		-	
4200	-		-		-	
4600	-		-		-	
4900	-		-		-	

7 VALIDATION MEASUREMENT

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.



7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
300	45.3 ± 10 %		0.87 ± 10 %	
450	43.5 ± 10 %		0.87 ± 10 %	
750	41.9 ± 10 %		0.89 ± 10 %	
835	41.5 ± 10 %		0.90 ± 10 %	
900	41.5 ± 10 %		0.97 ± 10 %	
1450	40.5 ± 10 %		1.20 ± 10 %	
1500	40.4 ± 10 %		1.23 ± 10 %	
1640	40.2 ± 10 %		1.31 ± 10 %	
1750	40.1 ± 10 %		1.37 ± 10 %	
1800	40.0 ± 10 %		1.40 ± 10 %	
1900	40.0 ± 10 %		1.40 ± 10 %	
1950	40.0 ± 10 %		1.40 ± 10 %	
2000	40.0 ± 10 %	37.9	1.40 ± 10 %	1.49
2100	39.8 ± 10 %		1.49 ± 10 %	
2300	39.5 ± 10 %		1.67 ± 10 %	
2450	39.2 ± 10 %		1.80 ± 10 %	
2600	39.0 ± 10 %		1.96 ± 10 %	
3000	38.5 ± 10 %		2.40 ± 10 %	
3300	38.2 ± 10 %		2.71 ± 10 %	
3500	37.9 ± 10 %		2.91 ± 10 %	
3700	37.7 ± 10 %		3.12 ± 10 %	
3900	37.5 ± 10 %		3.32 ± 10 %	
4200	37.1 ± 10 %		3.63 ± 10 %	
4600	36.7 ± 10 %		4.04 ± 10 %	
4900	36.3 ± 10 %		4.35 ± 10 %	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

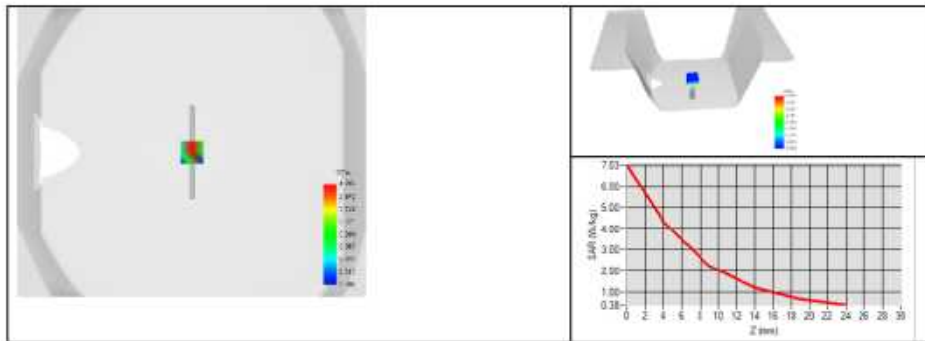


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.20.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Head Liquid Values: ϵ_p' : 37.9 σ : 1.49
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=5mm/dy=5mm/dz=5mm$
Frequency	2000 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1	41.06 (4.11)	21.1	20.41 (2.04)
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3		24.6	
3000	63.8		25.7	
3300	-		-	
3500	67.1		25	
3700	67.4		24.2	
3900	-		-	
4200	-		-	
4600	-		-	
4900	-		-	





7.3 BODY LIQUID MEASUREMENT

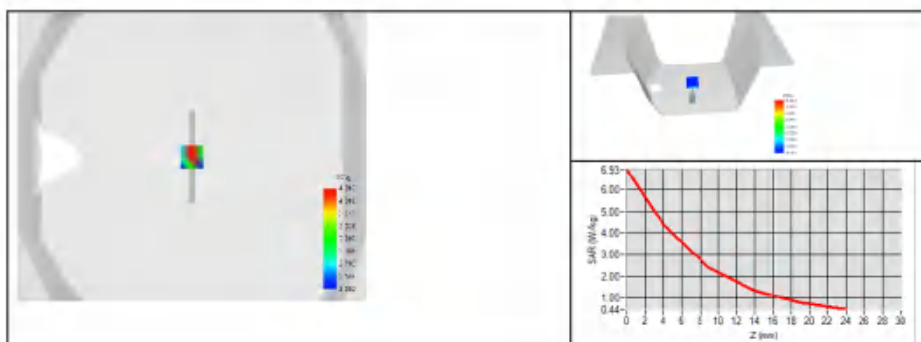
Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %		0.96 ± 10 %	
835	55.2 ± 10 %		0.97 ± 10 %	
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 10 %		1.06 ± 10 %	
1450	54.0 ± 10 %		1.30 ± 10 %	
1610	53.8 ± 10 %		1.40 ± 10 %	
1800	53.3 ± 10 %		1.52 ± 10 %	
1900	53.3 ± 10 %		1.52 ± 10 %	
2000	53.3 ± 10 %	55.2	1.52 ± 10 %	1.65
2100	53.2 ± 10 %		1.62 ± 10 %	
2300	52.9 ± 10 %		1.81 ± 10 %	
2450	52.7 ± 10 %		1.95 ± 10 %	
2600	52.5 ± 10 %		2.16 ± 10 %	
3000	52.0 ± 10 %		2.73 ± 10 %	
3300	51.6 ± 10 %		3.08 ± 10 %	
3500	51.3 ± 10 %		3.31 ± 10 %	
3700	51.0 ± 10 %		3.55 ± 10 %	
3900	50.8 ± 10 %		3.78 ± 10 %	
4200	50.4 ± 10 %		4.13 ± 10 %	
4600	49.8 ± 10 %		4.60 ± 10 %	
4900	49.4 ± 10 %		4.95 ± 10 %	
5200	49.0 ± 10 %		5.30 ± 10 %	
5300	48.9 ± 10 %		5.42 ± 10 %	
5400	48.7 ± 10 %		5.53 ± 10 %	
5500	48.6 ± 10 %		5.65 ± 10 %	
5600	48.5 ± 10 %		5.77 ± 10 %	
5800	48.2 ± 10 %		6.00 ± 10 %	



7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Body Liquid Values: ϵ_{ps}^* : 55.2 sigma : 1.65
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=5mm/dy=5mm/dz=5mm$
Frequency	2000 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
2000	40.73 (4.07)	20.41 (2.04)





8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
SAM Phantom	MVG	SN 13/09 SAM68	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2019	10/2022
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2019	05/2022
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Calipers	Mitutoyo	SN 0009732	10/2019	10/2022
Reference Probe	MVG	SN 41/18 EPGO333	10/2021	10/2022
Multimeter	Keithley 2000	1160271	02/2020	02/2023
Signal Generator	Rohde & Schwarz SMB	106589	03/2022	03/2025
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2021	06/2024
Power Meter	Rohde & Schwarz NRVD	832839-056	11/2019	11/2022
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024



SAR Reference Dipole Calibration Report

Ref : ACR.118.22.22.BES.A

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CHONGQING ROAD, HEPING COMMUNITY, FUHAI
STREET

BAO 'AN DISTRICT, SHENZHEN, GUANGDONG, CHINA
MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 2450 MHZ

SERIAL NO.: SN 29/15 DIP2G450-393

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon
29280 PLOUZANE - FRANCE

Calibration date: 04/28/2022



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Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Checked by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Approved by :</i>	Yann Toutain	Laboratory Director	4/28/2022	

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	<i>Customer Name</i>
<i>Distribution :</i>	ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Jérôme Luc	4/28/2022	Initial release



TABLE OF CONTENTS

1	Introduction.....	4
2	Device Under Test	4
3	Product Description	4
3.1	General Information	4
4	Measurement Method	5
4.1	Return Loss Requirements	5
4.2	Mechanical Requirements	5
5	Measurement Uncertainty	5
5.1	Return Loss	5
5.2	Dimension Measurement	5
5.3	Validation Measurement	5
6	Calibration Measurement Results	6
6.1	Return Loss and Impedance In Head Liquid	6
6.2	Return Loss and Impedance In Body Liquid	6
6.3	Mechanical Dimensions	7
7	Validation measurement	7
7.1	Head Liquid Measurement	8
7.2	SAR Measurement Result With Head Liquid	8
7.3	Body Liquid Measurement	11
7.4	SAR Measurement Result With Body Liquid	12
8	List of Equipment	13



1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 2450 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID2450
Serial Number	SN 29/15 DIP2G450-393
Product Condition (new / used)	Used

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – MVG COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

4.2 MECHANICAL REQUIREMENTS

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards specify the mechanical components and dimensions of the validation dipoles, with the dimension's frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness. A direct method is used with a ISO17025 calibrated caliper.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.08 LIN

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
0 - 300	0.20 mm
300 - 450	0.44 mm

5.3 VALIDATION MEASUREMENT

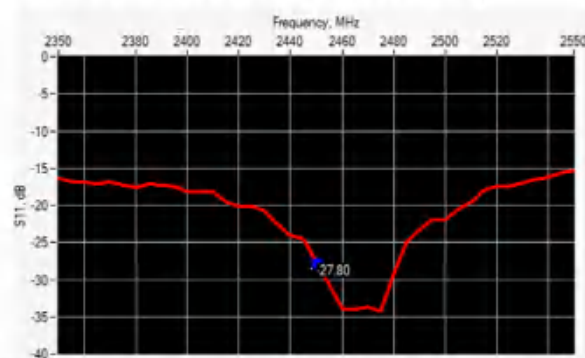
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



Scan Volume	Expanded Uncertainty
1 g	19 % (SAR)
10 g	19 % (SAR)

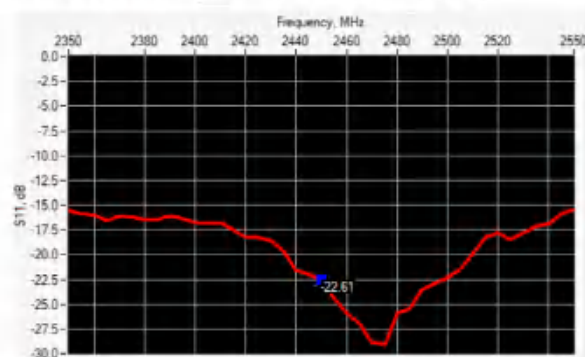
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2450	-27.80	-20	$52.3 \Omega + 3.4 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2450	-22.61	-20	$57.3 \Omega + 1.1 j\Omega$



6.3 MECHANICAL DIMENSIONS

Frequency/MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 $\pm 1\%$		250.0 $\pm 1\%$		6.35 $\pm 1\%$	
450	290.0 $\pm 1\%$		166.7 $\pm 1\%$		6.35 $\pm 1\%$	
750	176.0 $\pm 1\%$		100.0 $\pm 1\%$		6.35 $\pm 1\%$	
835	161.0 $\pm 1\%$		89.8 $\pm 1\%$		3.6 $\pm 1\%$	
900	149.0 $\pm 1\%$		83.3 $\pm 1\%$		3.6 $\pm 1\%$	
1450	89.1 $\pm 1\%$		51.7 $\pm 1\%$		3.6 $\pm 1\%$	
1500	86.2 $\pm 1\%$		50.0 $\pm 1\%$		3.6 $\pm 1\%$	
1640	79.0 $\pm 1\%$		45.7 $\pm 1\%$		3.6 $\pm 1\%$	
1750	75.2 $\pm 1\%$		42.9 $\pm 1\%$		3.6 $\pm 1\%$	
1800	72.0 $\pm 1\%$		41.7 $\pm 1\%$		3.6 $\pm 1\%$	
1900	68.0 $\pm 1\%$		39.5 $\pm 1\%$		3.6 $\pm 1\%$	
1950	66.3 $\pm 1\%$		38.5 $\pm 1\%$		3.6 $\pm 1\%$	
2000	64.5 $\pm 1\%$		37.5 $\pm 1\%$		3.6 $\pm 1\%$	
2100	61.0 $\pm 1\%$		35.7 $\pm 1\%$		3.6 $\pm 1\%$	
2300	55.5 $\pm 1\%$		32.6 $\pm 1\%$		3.6 $\pm 1\%$	
2450	51.5 $\pm 1\%$		30.4 $\pm 1\%$		3.6 $\pm 1\%$	
2600	48.5 $\pm 1\%$		28.8 $\pm 1\%$		3.6 $\pm 1\%$	
3000	41.5 $\pm 1\%$		25.0 $\pm 1\%$		3.6 $\pm 1\%$	
3300	-		-		-	
3500	37.0 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3700	34.7 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3900	-		-		-	
4200	-		-		-	
4600	-		-		-	
4900	-		-		-	

7 VALIDATION MEASUREMENT

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.



7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
300	45.3 $\pm 10\%$		0.87 $\pm 10\%$	
450	43.5 $\pm 10\%$		0.87 $\pm 10\%$	
750	41.9 $\pm 10\%$		0.89 $\pm 10\%$	
835	41.5 $\pm 10\%$		0.90 $\pm 10\%$	
900	41.5 $\pm 10\%$		0.97 $\pm 10\%$	
1450	40.5 $\pm 10\%$		1.20 $\pm 10\%$	
1500	40.4 $\pm 10\%$		1.23 $\pm 10\%$	
1640	40.2 $\pm 10\%$		1.31 $\pm 10\%$	
1750	40.1 $\pm 10\%$		1.37 $\pm 10\%$	
1800	40.0 $\pm 10\%$		1.40 $\pm 10\%$	
1900	40.0 $\pm 10\%$		1.40 $\pm 10\%$	
1950	40.0 $\pm 10\%$		1.40 $\pm 10\%$	
2000	40.0 $\pm 10\%$		1.40 $\pm 10\%$	
2100	39.8 $\pm 10\%$		1.49 $\pm 10\%$	
2300	39.5 $\pm 10\%$		1.67 $\pm 10\%$	
2450	39.2 $\pm 10\%$	36.4	1.80 $\pm 10\%$	1.98
2600	39.0 $\pm 10\%$		1.96 $\pm 10\%$	
3000	38.5 $\pm 10\%$		2.40 $\pm 10\%$	
3300	38.2 $\pm 10\%$		2.71 $\pm 10\%$	
3500	37.9 $\pm 10\%$		2.91 $\pm 10\%$	
3700	37.7 $\pm 10\%$		3.12 $\pm 10\%$	
3900	37.5 $\pm 10\%$		3.32 $\pm 10\%$	
4200	37.1 $\pm 10\%$		3.63 $\pm 10\%$	
4600	36.7 $\pm 10\%$		4.04 $\pm 10\%$	
4900	36.3 $\pm 10\%$		4.35 $\pm 10\%$	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

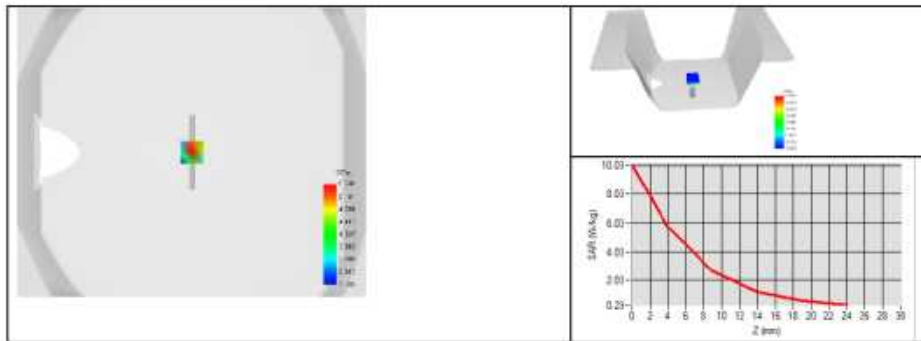


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.22.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Head Liquid Values: ϵ_p' : 36.4 σ : 1.98
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$\Delta x=8\text{mm}/\Delta y=8\text{mm}$
Zoon Scan Resolution	$\Delta x=5\text{mm}/\Delta y=5\text{mm}/\Delta z=5\text{mm}$
Frequency	2450 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4	54.32 (5.43)	24	24.25 (2.42)
2600	55.3		24.6	
3000	63.8		25.7	
3300	-		-	
3500	67.1		25	
3700	67.4		24.2	
3900	-		-	
4200	-		-	
4600	-		-	
4900	-		-	





7.3 BODY LIQUID MEASUREMENT

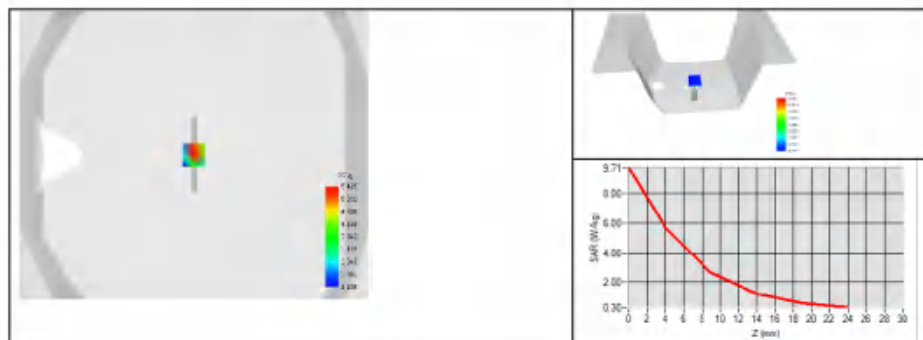
Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %		0.96 ± 10 %	
835	55.2 ± 10 %		0.97 ± 10 %	
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 10 %		1.06 ± 10 %	
1450	54.0 ± 10 %		1.30 ± 10 %	
1610	53.8 ± 10 %		1.40 ± 10 %	
1800	53.3 ± 10 %		1.52 ± 10 %	
1900	53.3 ± 10 %		1.52 ± 10 %	
2000	53.3 ± 10 %		1.52 ± 10 %	
2100	53.2 ± 10 %		1.62 ± 10 %	
2300	52.9 ± 10 %		1.81 ± 10 %	
2450	52.7 ± 10 %	53.4	1.95 ± 10 %	2.14
2600	52.5 ± 10 %		2.16 ± 10 %	
3000	52.0 ± 10 %		2.73 ± 10 %	
3300	51.6 ± 10 %		3.08 ± 10 %	
3500	51.3 ± 10 %		3.31 ± 10 %	
3700	51.0 ± 10 %		3.55 ± 10 %	
3900	50.8 ± 10 %		3.78 ± 10 %	
4200	50.4 ± 10 %		4.13 ± 10 %	
4600	49.8 ± 10 %		4.60 ± 10 %	
4900	49.4 ± 10 %		4.95 ± 10 %	
5200	49.0 ± 10 %		5.30 ± 10 %	
5300	48.9 ± 10 %		5.42 ± 10 %	
5400	48.7 ± 10 %		5.53 ± 10 %	
5500	48.6 ± 10 %		5.65 ± 10 %	
5600	48.5 ± 10 %		5.77 ± 10 %	
5800	48.2 ± 10 %		6.00 ± 10 %	



7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Body Liquid Values: ϵ_{ps}^* : 53.4 sigma : 2.14
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=5mm/dy=5mm/dz=5mm$
Frequency	2450 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
2450	53.59 (5.36)	23.63 (2.36)





8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
SAM Phantom	MVG	SN 13/09 SAM68	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2019	10/2022
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2019	05/2022
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Calipers	Mitutoyo	SN 0009732	10/2019	10/2022
Reference Probe	MVG	SN 41/18 EPGO333	10/2021	10/2022
Multimeter	Keithley 2000	1160271	02/2020	02/2023
Signal Generator	Rohde & Schwarz SMB	106589	03/2022	03/2025
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2021	06/2024
Power Meter	Rohde & Schwarz NRVD	832839-056	11/2019	11/2022
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024



SAR Reference Dipole Calibration Report

Ref : ACR.118.23.22.BES.A

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CHONGQING ROAD, HEPING COMMUNITY, FUHAI
STREET

BAO 'AN DISTRICT, SHENZHEN, GUANGDONG, CHINA
MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 2600 MHZ

SERIAL NO.: SN 22/16 DIP2G600-407

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon
29280 PLOUZANE - FRANCE

Calibration date: 04/28/2022



Accreditations #2-6789 and #2-6814
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Summary:

This document presents the method and results from an accredited SAR reference dipole calibration performed in MVG using the COMOSAR test bench. All calibration results are traceable to national metrology institutions.



	<i>Name</i>	<i>Function</i>	<i>Date</i>	<i>Signature</i>
<i>Prepared by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Checked by :</i>	Jérôme Luc	Technical Manager	4/28/2022	
<i>Approved by :</i>	Yann Toutain	Laboratory Director	4/28/2022	

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	<i>Customer Name</i>
<i>Distribution :</i>	ATTESTATION OF GLOBAL COMPLIANCE CO. LTD.

<i>Issue</i>	<i>Name</i>	<i>Date</i>	<i>Modifications</i>
A	Jérôme Luc	4/28/2022	Initial release



TABLE OF CONTENTS

1	Introduction.....	4
2	Device Under Test	4
3	Product Description	4
3.1	General Information	4
4	Measurement Method	5
4.1	Return Loss Requirements	5
4.2	Mechanical Requirements	5
5	Measurement Uncertainty	5
5.1	Return Loss	5
5.2	Dimension Measurement	5
5.3	Validation Measurement	5
6	Calibration Measurement Results	6
6.1	Return Loss and Impedance In Head Liquid	6
6.2	Return Loss and Impedance In Body Liquid	6
6.3	Mechanical Dimensions	7
7	Validation measurement	7
7.1	Head Liquid Measurement	8
7.2	SAR Measurement Result With Head Liquid	8
7.3	Body Liquid Measurement	11
7.4	SAR Measurement Result With Body Liquid	12
8	List of Equipment	13



1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards for reference dipoles used for SAR measurement system validations and the measurements that were performed to verify that the product complies with the fore mentioned standards.

2 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR 2600 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID2600
Serial Number	SN 22/16 DIP2G600-407
Product Condition (new / used)	Used

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Dipoles are built in accordance to the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards. The product is designed for use with the COMOSAR test bench only.



Figure 1 – MVG COMOSAR Validation Dipole



4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards provide requirements for reference dipoles used for system validation measurements. The following measurements were performed to verify that the product complies with the fore mentioned standards.

4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. A direct method is used with a network analyser and its calibration kit, both with a valid ISO17025 calibration.

4.2 MECHANICAL REQUIREMENTS

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards specify the mechanical components and dimensions of the validation dipoles, with the dimension's frequency and phantom shell thickness dependent. The COMOSAR test bench employs a 2 mm phantom shell thickness therefore the dipoles sold for use with the COMOSAR test bench comply with the requirements set forth for a 2 mm phantom shell thickness. A direct method is used with a ISO17025 calibrated caliper.

5 MEASUREMENT UNCERTAINTY

All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

Frequency band	Expanded Uncertainty on Return Loss
400-6000MHz	0.08 LIN

5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

Length (mm)	Expanded Uncertainty on Length
0 - 300	0.20 mm
300 - 450	0.44 mm

5.3 VALIDATION MEASUREMENT

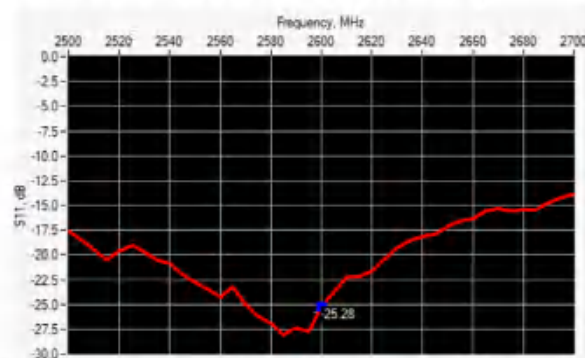
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



Scan Volume	Expanded Uncertainty
1 g	19 % (SAR)
10 g	19 % (SAR)

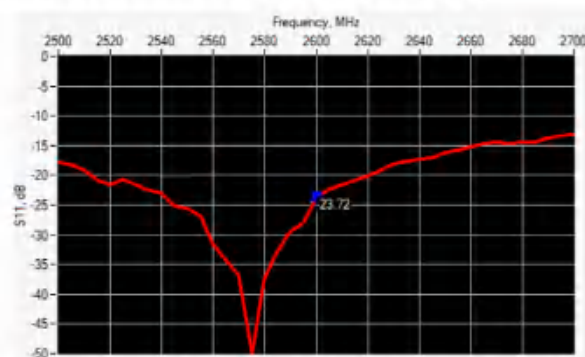
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2600	-25.28	-20	$51.0 \Omega + 5.3 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
2600	-23.72	-20	$45.4 \Omega + 4.6 j\Omega$



6.3 MECHANICAL DIMENSIONS

Frequency/MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 $\pm 1\%$		250.0 $\pm 1\%$		6.35 $\pm 1\%$	
450	290.0 $\pm 1\%$		166.7 $\pm 1\%$		6.35 $\pm 1\%$	
750	176.0 $\pm 1\%$		100.0 $\pm 1\%$		6.35 $\pm 1\%$	
835	161.0 $\pm 1\%$		89.8 $\pm 1\%$		3.6 $\pm 1\%$	
900	149.0 $\pm 1\%$		83.3 $\pm 1\%$		3.6 $\pm 1\%$	
1450	89.1 $\pm 1\%$		51.7 $\pm 1\%$		3.6 $\pm 1\%$	
1500	86.2 $\pm 1\%$		50.0 $\pm 1\%$		3.6 $\pm 1\%$	
1640	79.0 $\pm 1\%$		45.7 $\pm 1\%$		3.6 $\pm 1\%$	
1750	75.2 $\pm 1\%$		42.9 $\pm 1\%$		3.6 $\pm 1\%$	
1800	72.0 $\pm 1\%$		41.7 $\pm 1\%$		3.6 $\pm 1\%$	
1900	68.0 $\pm 1\%$		39.5 $\pm 1\%$		3.6 $\pm 1\%$	
1950	66.3 $\pm 1\%$		38.5 $\pm 1\%$		3.6 $\pm 1\%$	
2000	64.5 $\pm 1\%$		37.5 $\pm 1\%$		3.6 $\pm 1\%$	
2100	61.0 $\pm 1\%$		35.7 $\pm 1\%$		3.6 $\pm 1\%$	
2300	55.5 $\pm 1\%$		32.6 $\pm 1\%$		3.6 $\pm 1\%$	
2450	51.5 $\pm 1\%$		30.4 $\pm 1\%$		3.6 $\pm 1\%$	
2600	48.5 $\pm 1\%$		28.8 $\pm 1\%$		3.6 $\pm 1\%$	
3000	41.5 $\pm 1\%$		25.0 $\pm 1\%$		3.6 $\pm 1\%$	
3300	-		-		-	
3500	37.0 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3700	34.7 $\pm 1\%$		26.4 $\pm 1\%$		3.6 $\pm 1\%$	
3900	-		-		-	
4200	-		-		-	
4600	-		-		-	
4900	-		-		-	

7 VALIDATION MEASUREMENT

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards. Per the standards, the dipole shall be positioned below the bottom of the phantom, with the dipole length centered and parallel to the longest dimension of the flat phantom, with the top surface of the dipole at the described distance from the bottom surface of the phantom.



7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
300	45.3 ± 10 %		0.87 ± 10 %	
450	43.5 ± 10 %		0.87 ± 10 %	
750	41.9 ± 10 %		0.89 ± 10 %	
835	41.5 ± 10 %		0.90 ± 10 %	
900	41.5 ± 10 %		0.97 ± 10 %	
1450	40.5 ± 10 %		1.20 ± 10 %	
1500	40.4 ± 10 %		1.23 ± 10 %	
1640	40.2 ± 10 %		1.31 ± 10 %	
1750	40.1 ± 10 %		1.37 ± 10 %	
1800	40.0 ± 10 %		1.40 ± 10 %	
1900	40.0 ± 10 %		1.40 ± 10 %	
1950	40.0 ± 10 %		1.40 ± 10 %	
2000	40.0 ± 10 %		1.40 ± 10 %	
2100	39.8 ± 10 %		1.49 ± 10 %	
2300	39.5 ± 10 %		1.67 ± 10 %	
2450	39.2 ± 10 %		1.80 ± 10 %	
2600	39.0 ± 10 %	35.7	1.96 ± 10 %	2.12
3000	38.5 ± 10 %		2.40 ± 10 %	
3300	38.2 ± 10 %		2.71 ± 10 %	
3500	37.9 ± 10 %		2.91 ± 10 %	
3700	37.7 ± 10 %		3.12 ± 10 %	
3900	37.5 ± 10 %		3.32 ± 10 %	
4200	37.1 ± 10 %		3.63 ± 10 %	
4600	36.7 ± 10 %		4.04 ± 10 %	
4900	36.3 ± 10 %		4.35 ± 10 %	

7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is given with the used input power.

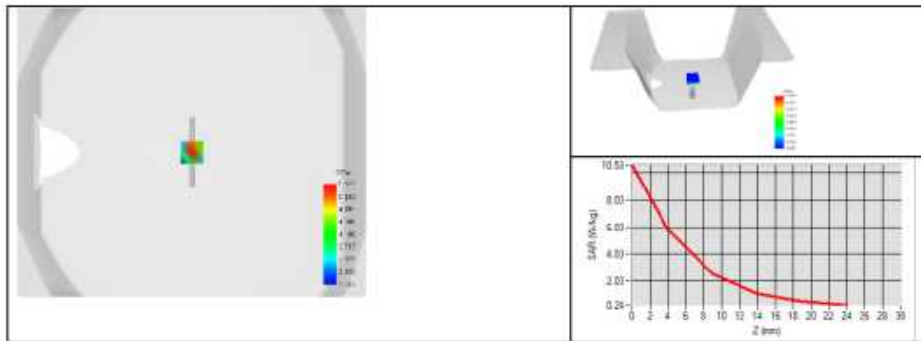


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.23.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPG0333
Liquid	Head Liquid Values: ϵ_{ps}' : 35.7 sigma : 2.12
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=5mm/dy=5mm/dz=5mm$
Frequency	2600 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)		10 g SAR (W/kg/W)	
	required	measured	required	measured
300	2.85		1.94	
450	4.58		3.06	
750	8.49		5.55	
835	9.56		6.22	
900	10.9		6.99	
1450	29		16	
1500	30.5		16.8	
1640	34.2		18.4	
1750	36.4		19.3	
1800	38.4		20.1	
1900	39.7		20.5	
1950	40.5		20.9	
2000	41.1		21.1	
2100	43.6		21.9	
2300	48.7		23.3	
2450	52.4		24	
2600	55.3	54.94 (5.49)	24.6	23.77 (2.38)
3000	63.8		25.7	
3300	-		-	
3500	67.1		25	
3700	67.4		24.2	
3900	-		-	
4200	-		-	
4600	-		-	
4900	-		-	





7.3 BODY LIQUID MEASUREMENT

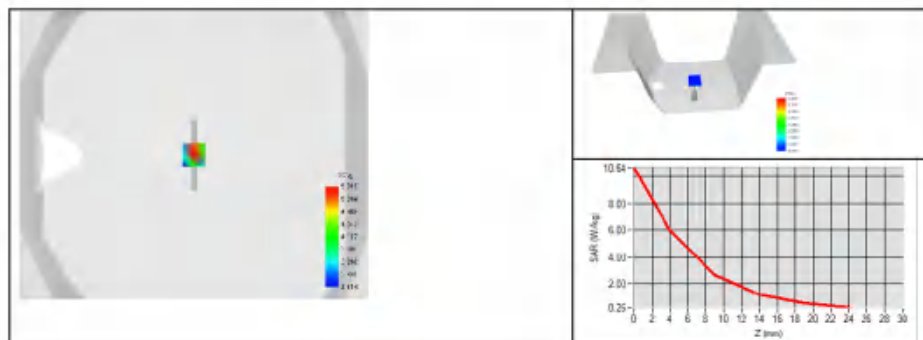
Frequency MHz	Relative permittivity (ϵ_r)		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %		0.96 ± 10 %	
835	55.2 ± 10 %		0.97 ± 10 %	
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 10 %		1.06 ± 10 %	
1450	54.0 ± 10 %		1.30 ± 10 %	
1610	53.8 ± 10 %		1.40 ± 10 %	
1800	53.3 ± 10 %		1.52 ± 10 %	
1900	53.3 ± 10 %		1.52 ± 10 %	
2000	53.3 ± 10 %		1.52 ± 10 %	
2100	53.2 ± 10 %		1.62 ± 10 %	
2300	52.9 ± 10 %		1.81 ± 10 %	
2450	52.7 ± 10 %		1.95 ± 10 %	
2600	52.5 ± 10 %	52.7	2.16 ± 10 %	2.36
3000	52.0 ± 10 %		2.73 ± 10 %	
3300	51.6 ± 10 %		3.08 ± 10 %	
3500	51.3 ± 10 %		3.31 ± 10 %	
3700	51.0 ± 10 %		3.55 ± 10 %	
3900	50.8 ± 10 %		3.78 ± 10 %	
4200	50.4 ± 10 %		4.13 ± 10 %	
4600	49.8 ± 10 %		4.60 ± 10 %	
4900	49.4 ± 10 %		4.95 ± 10 %	
5200	49.0 ± 10 %		5.30 ± 10 %	
5300	48.9 ± 10 %		5.42 ± 10 %	
5400	48.7 ± 10 %		5.53 ± 10 %	
5500	48.6 ± 10 %		5.65 ± 10 %	
5600	48.5 ± 10 %		5.77 ± 10 %	
5800	48.2 ± 10 %		6.00 ± 10 %	



7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Body Liquid Values: ϵ_{ps}^* : 52.7 sigma : 2.36
Distance between dipole center and liquid	10.0 mm
Area scan resolution	$dx=8mm/dy=8mm$
Zoon Scan Resolution	$dx=5mm/dy=5mm/dz=5mm$
Frequency	2600 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency MHz	1 g SAR (W/kg/W)	10 g SAR (W/kg/W)
	measured	measured
2600	55.82 {5.58}	23.94 {2.39}





8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	Manufacturer / Model	Identification No.	Current Calibration Date	Next Calibration Date
SAM Phantom	MVG	SN 13/09 SAM68	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2019	10/2022
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2019	05/2022
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Calipers	Mitutoyo	SN 0009732	10/2019	10/2022
Reference Probe	MVG	SN 41/18 EPGO333	10/2021	10/2022
Multimeter	Keithley 2000	1160271	02/2020	02/2023
Signal Generator	Rohde & Schwarz SMB	106589	03/2022	03/2025
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2021	06/2024
Power Meter	Rohde & Schwarz NRVD	832839-056	11/2019	11/2022
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024