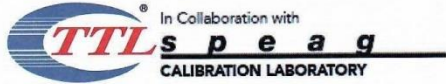


CALIBRATION DATA

PROBE CALIBRATION DATA



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Certificate No: Z23-60363

CALIBRATION CERTIFICATE

Object EX3DV4 - SN : 3953

Calibration Procedure(s) FF-Z11-004-02
Calibration Procedures for Dosimetric E-field Probes

Calibration date: August 05, 2023

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	101919	12-Jun-23(CTTL, No.J23X05435)	Jun-24
Power sensor NRP-Z91	101547	12-Jun-23(CTTL, No.J23X05435)	Jun-24
Power sensor NRP-Z91	101548	12-Jun-23(CTTL, No.J23X05435)	Jun-24
Reference 10dBAttenuator	18N50W-10dB	19-Jan-23(CTTL, No.J23X00212)	Jan-25
Reference 20dBAttenuator	18N50W-20dB	10-Jan-23(CTTL, No.J23X00211)	Jan-25
Reference Probe EX3DV4	SN 3846	31-May-23(SPEAG, No.EX3-3846_May23)	May-24
DAE4	SN 771	16-Jan-23(SPEAG, No.DAE4-771_Jan23)	Jan-24
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGenerator MG3700A	6201052605	12-Jun-23(CTTL, No.J23X05434)	Jun-24
Network Analyzer E5071C	MY46110673	10-Jan-23(CTTL, No.J23X00104)	Jan-24

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: September 18, 2024

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Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A,B,C,D	modulation dependent linearization parameters
Polarization Φ	Φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i $\theta=0$ is normal to probe axis

Connector Angle information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- IEC 62209-2, "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)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta=0$ ($f \leq 900\text{MHz}$ in TEM-cell; $f > 1800\text{MHz}$: waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z} * frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; VR_{x,y,z}; A,B,C** are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800\text{MHz}$) and inside waveguide using analytical field distributions based on power measurements for $f > 800\text{MHz}$. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from $\pm 50\text{MHz}$ to $\pm 100\text{MHz}$.
- Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3953

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.52	0.54	0.48	±10.0%
DCP(mV) ^B	101.2	104.2	102.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	180.2	±2.5%
		Y	0.0	0.0	1.0		189.5	
		Z	0.0	0.0	1.0		169.6	

The reported uncertainty of measurement is stated as the standard uncertainty of Measurement multiplied by the coverage factor $k=2$, which for a normal distribution Corresponds to a coverage probability of approximately 95%.

^A The uncertainties of Norm X, Y, Z do not affect the E²-field uncertainty inside TSL (see Page 4).

^B Numerical linearization parameter: uncertainty not required.

^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3953

Calibration Parameter Determined in Head Tissue Simulating Media

f [MHz] ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unct. (k=2)
750	41.9	0.89	10.62	10.62	10.62	0.16	1.23	±12.1%
835	41.5	0.90	10.23	10.23	10.23	0.12	1.38	±12.1%
900	41.5	0.97	10.18	10.18	10.18	0.22	1.18	±12.1%
1750	40.1	1.37	8.60	8.60	8.60	0.21	1.05	±12.1%
1810	40.0	1.40	8.40	8.40	8.40	0.22	0.98	±12.1%
1900	40.0	1.40	8.30	8.30	8.30	0.21	1.08	±12.1%
2000	40.0	1.40	8.45	8.45	8.45	0.15	1.23	±12.1%
2300	39.5	1.67	8.03	8.03	8.03	0.44	0.74	±12.1%
2450	39.2	1.80	7.80	7.80	7.80	0.46	0.74	±12.1%
2600	39.0	1.96	7.65	7.65	7.65	0.55	0.65	±12.1%

^C Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^F At frequency below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

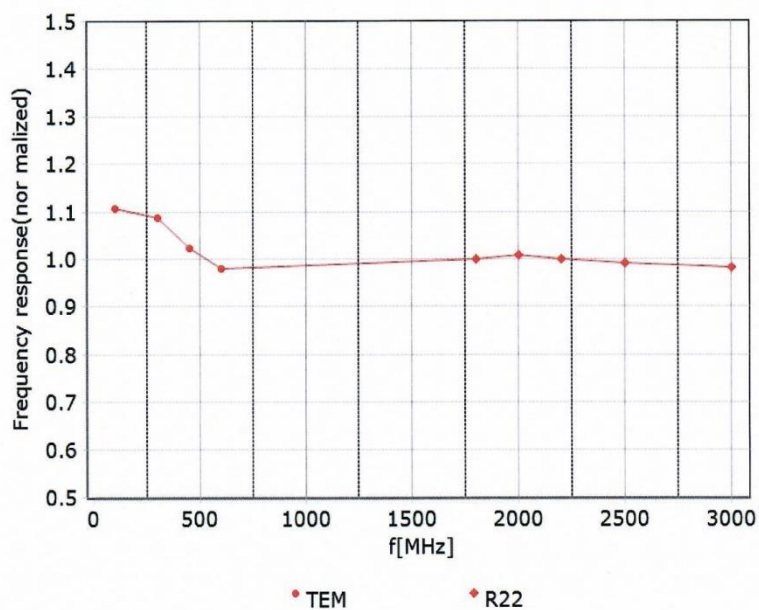


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Frequency Response of E-Field (TEM-Cell: ifi110 EXX, Waveguide: R22)

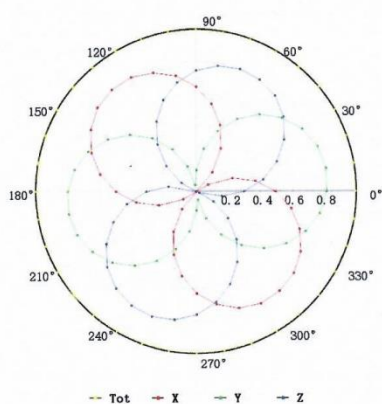


Uncertainty of Frequency Response of E-field: $\pm 7.4\%$ ($k=2$)

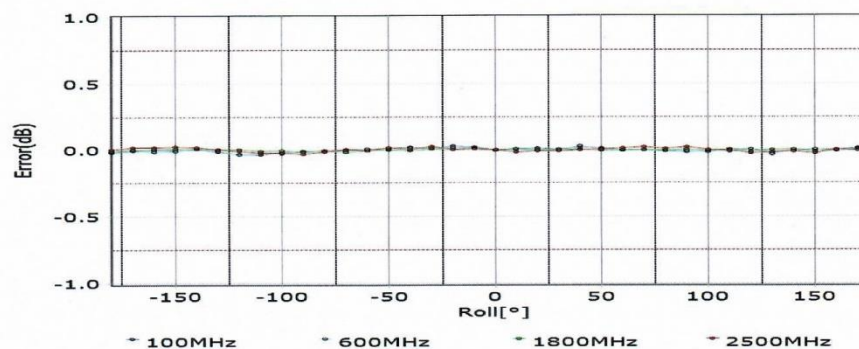
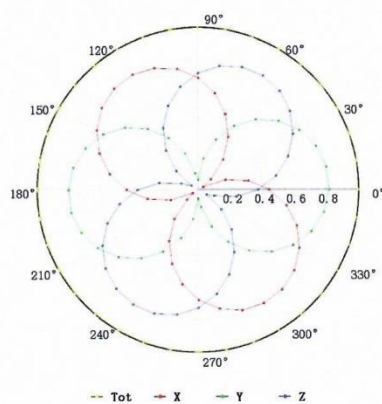
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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM

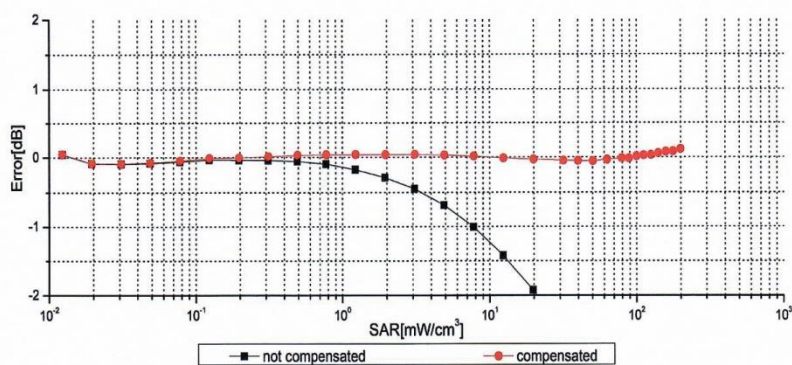
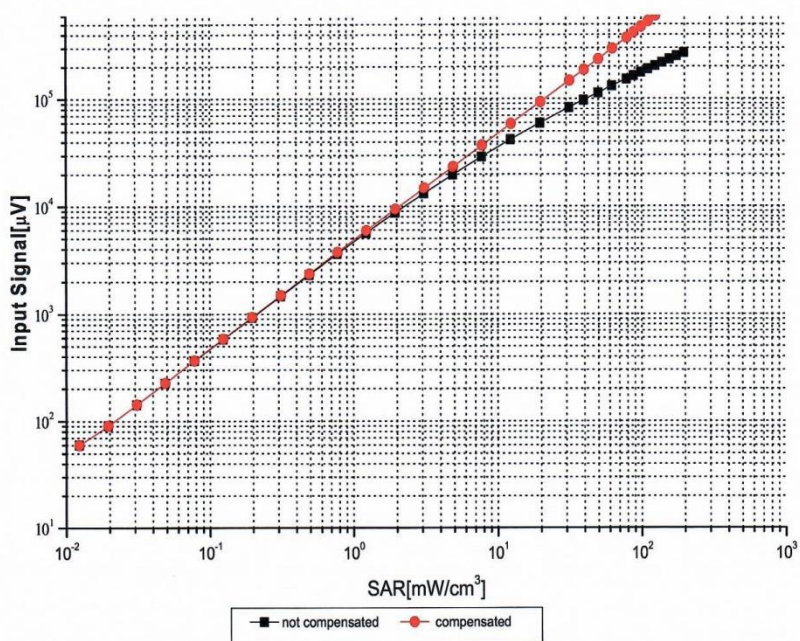


f=1800 MHz, R22



Uncertainty of Axial Isotropy Assessment: $\pm 1.2\%$ ($k=2$)

Dynamic Range $f(\text{SAR}_{\text{head}})$ (TEM cell, $f = 900 \text{ MHz}$)

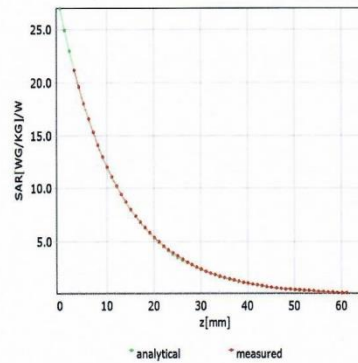
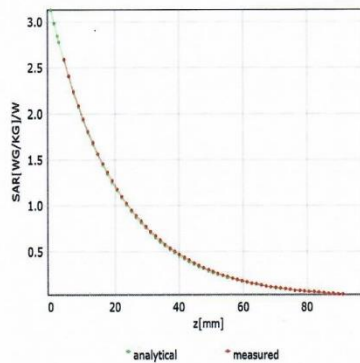


Uncertainty of Linearity Assessment: $\pm 0.9\%$ ($k=2$)

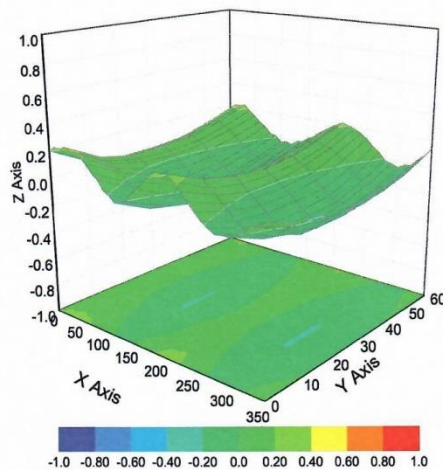
Conversion Factor Assessment

f=750 MHz,WGLS R9(H_convF)

f=1750 MHz,WGLS R22(H_convF)



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: $\pm 3.2\%$ ($k=2$)



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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3953

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	36.7
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disable
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	9mm
Tip Diameter	2.5mm
Probe Tip to Sensor X Calibration Point	1mm
Probe Tip to Sensor Y Calibration Point	1mm
Probe Tip to Sensor Z Calibration Point	1mm
Recommended Measurement Distance from Surface	1.4mm

DAE CALIBRATION DATA



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Certificate No: **J23Z60234**

CALIBRATION CERTIFICATE

Object **DAE4 - SN: 1398**

Calibration Procedure(s) **FF-Z11-002-01**
Calibration Procedure for the Data Acquisition Electronics (DAEx)

Calibration date: **May 17, 2023**

This calibration Certificate documents the traceability to national standards, which realize the physical units of measurements(SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature(22±3)°C and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Process Calibrator 753	1971018	14-Jun-22 (CTTL, No.J22X04180)	Jun-23

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Hao	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: May 18, 2023

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Glossary:

DAE data acquisition electronics
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters:

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The report provide only calibration results for DAE, it does not contain other performance test results.

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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 μ V, full range = -100...+300 mV

Low Range: 1LSB = 61nV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	404.225 $\pm$ 0.15% (k=2)	404.213 $\pm$ 0.15% (k=2)	403.666 $\pm$ 0.15% (k=2)
Low Range	3.97289 $\pm$ 0.7% (k=2)	3.99054 $\pm$ 0.7% (k=2)	3.96771 $\pm$ 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	47.5° $\pm$ 1 °
---	-----------------

DIPOLE CALIBRATION DATA



SAR Reference Dipole Calibration Report

Ref : ACR.118.15.22.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: 750 MHZ

SERIAL NO.: SN 22/16 DIP0G750-417

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.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.15.22.BES.A

	<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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16:58:54 +02'00'

	<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



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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 750 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID750
Serial Number	SN 22/16 DIP0G750-417
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

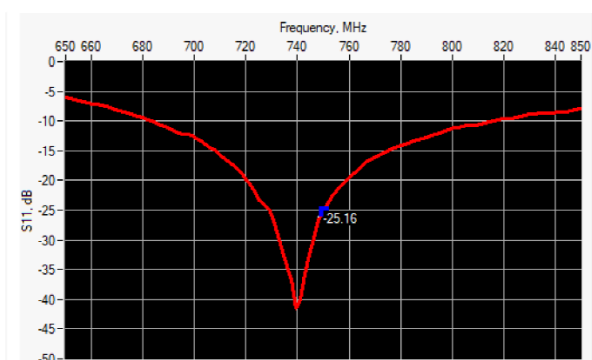
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



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

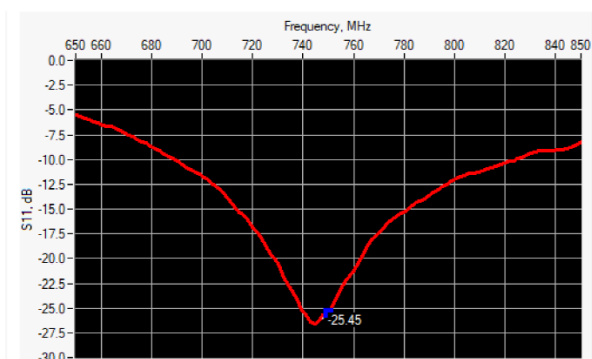
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
750	-25.16	-20	$55.4 \Omega - 1.2 j\Omega$

6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
750	-25.45	-20	$53.9 \Omega + 3.7 j\Omega$



6.3 MECHANICAL DIMENSIONS

Frequency MHz	L mm		h mm		d mm	
	required	measured	required	measured	required	measured
300	420.0 ± 1 %.		250.0 ± 1 %.		6.35 ± 1 %.	
450	290.0 ± 1 %.		166.7 ± 1 %.		6.35 ± 1 %.	
750	176.0 ± 1 %.	-	100.0 ± 1 %.	-	6.35 ± 1 %.	-
835	161.0 ± 1 %.		89.8 ± 1 %.		3.6 ± 1 %.	
900	149.0 ± 1 %.		83.3 ± 1 %.		3.6 ± 1 %.	
1450	89.1 ± 1 %.		51.7 ± 1 %.		3.6 ± 1 %.	
1500	86.2 ± 1 %.		50.0 ± 1 %.		3.6 ± 1 %.	
1640	79.0 ± 1 %.		45.7 ± 1 %.		3.6 ± 1 %.	
1750	75.2 ± 1 %.		42.9 ± 1 %.		3.6 ± 1 %.	
1800	72.0 ± 1 %.		41.7 ± 1 %.		3.6 ± 1 %.	
1900	68.0 ± 1 %.		39.5 ± 1 %.		3.6 ± 1 %.	
1950	66.3 ± 1 %.		38.5 ± 1 %.		3.6 ± 1 %.	
2000	64.5 ± 1 %.		37.5 ± 1 %.		3.6 ± 1 %.	
2100	61.0 ± 1 %.		35.7 ± 1 %.		3.6 ± 1 %.	
2300	55.5 ± 1 %.		32.6 ± 1 %.		3.6 ± 1 %.	
2450	51.5 ± 1 %.		30.4 ± 1 %.		3.6 ± 1 %.	
2600	48.5 ± 1 %.		28.8 ± 1 %.		3.6 ± 1 %.	
3000	41.5 ± 1 %.		25.0 ± 1 %.		3.6 ± 1 %.	
3300	-		-		-	
3500	37.0 ± 1 %.		26.4 ± 1 %.		3.6 ± 1 %.	
3700	34.7 ± 1 %.		26.4 ± 1 %.		3.6 ± 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 %	41.0	0.89 ± 10 %	0.82
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 %		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.

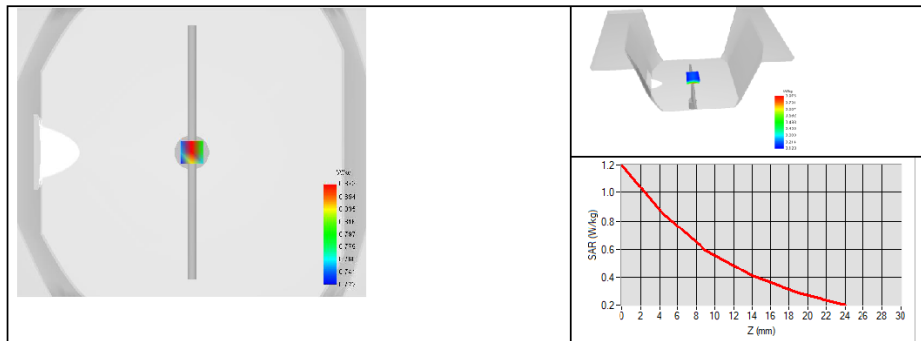


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.15.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Head Liquid Values: ϵ_s' : 41.0 σ : 0.82
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	750 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	8.33 (0.83)	5.55	5.44 (0.54)
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		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

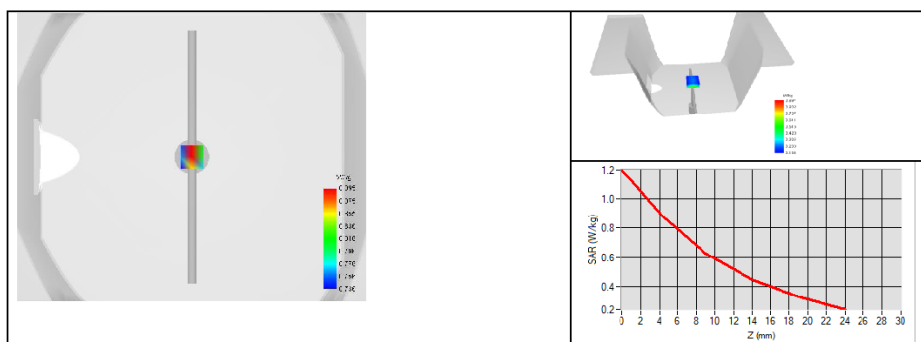
Frequency MHz	Relative permittivity (ϵ_r')		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %	52.9	0.96 ± 10 %	0.89
835	55.2 ± 10 %		0.97 ± 10 %	
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 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 %		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: $\epsilon_{ps}' : 52.9$ $\sigma : 0.89$
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	750 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
750	8.54 (0.85)	5.71 (0.57)





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.118.16.22.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 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
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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	

2022.04.28
17:00:21 +02'00'

	<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



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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

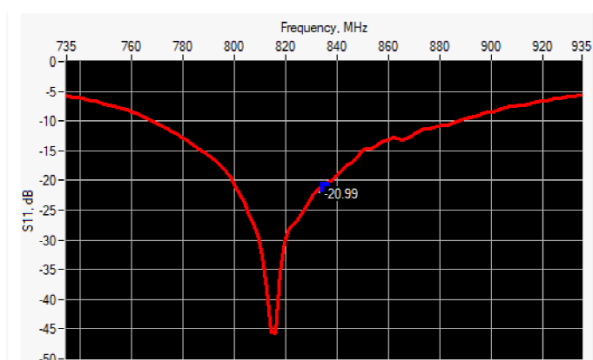
The guidelines outlined in the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards were followed to generate the measurement uncertainty for validation measurements.



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

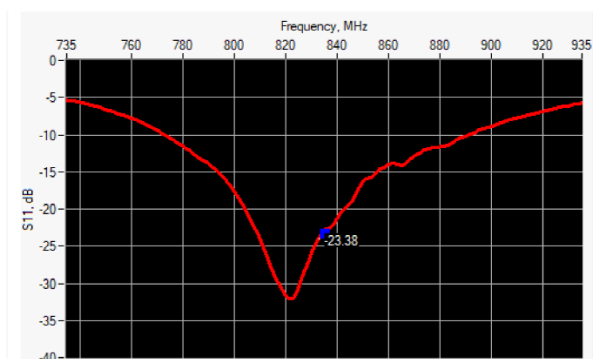
6 CALIBRATION MEASUREMENT RESULTS

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 ± 1 %.		250.0 ± 1 %.		6.35 ± 1 %.	
450	290.0 ± 1 %.		166.7 ± 1 %.		6.35 ± 1 %.	
750	176.0 ± 1 %.		100.0 ± 1 %.		6.35 ± 1 %.	
835	161.0 ± 1 %.	-	89.8 ± 1 %.	-	3.6 ± 1 %.	-
900	149.0 ± 1 %.		83.3 ± 1 %.		3.6 ± 1 %.	
1450	89.1 ± 1 %.		51.7 ± 1 %.		3.6 ± 1 %.	
1500	86.2 ± 1 %.		50.0 ± 1 %.		3.6 ± 1 %.	
1640	79.0 ± 1 %.		45.7 ± 1 %.		3.6 ± 1 %.	
1750	75.2 ± 1 %.		42.9 ± 1 %.		3.6 ± 1 %.	
1800	72.0 ± 1 %.		41.7 ± 1 %.		3.6 ± 1 %.	
1900	68.0 ± 1 %.		39.5 ± 1 %.		3.6 ± 1 %.	
1950	66.3 ± 1 %.		38.5 ± 1 %.		3.6 ± 1 %.	
2000	64.5 ± 1 %.		37.5 ± 1 %.		3.6 ± 1 %.	
2100	61.0 ± 1 %.		35.7 ± 1 %.		3.6 ± 1 %.	
2300	55.5 ± 1 %.		32.6 ± 1 %.		3.6 ± 1 %.	
2450	51.5 ± 1 %.		30.4 ± 1 %.		3.6 ± 1 %.	
2600	48.5 ± 1 %.		28.8 ± 1 %.		3.6 ± 1 %.	
3000	41.5 ± 1 %.		25.0 ± 1 %.		3.6 ± 1 %.	
3300	-		-		-	
3500	37.0 ± 1 %.		26.4 ± 1 %.		3.6 ± 1 %.	
3700	34.7 ± 1 %.		26.4 ± 1 %.		3.6 ± 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 %	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.

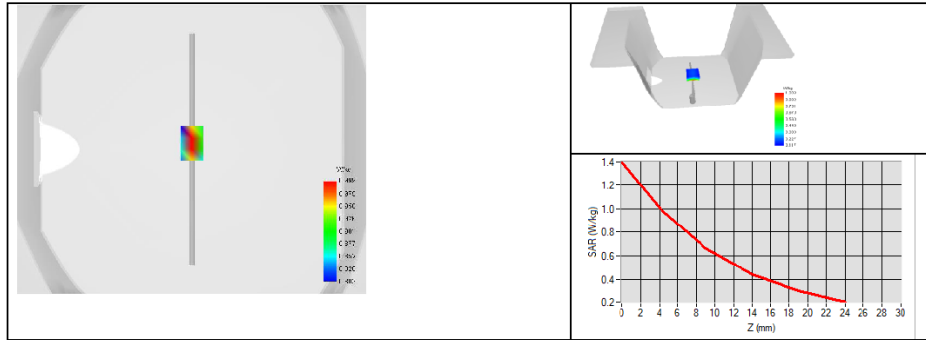


SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.16.22.BES.A

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Head Liquid Values: ϵ_s' : 39.9 σ : 0.91
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)	
	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

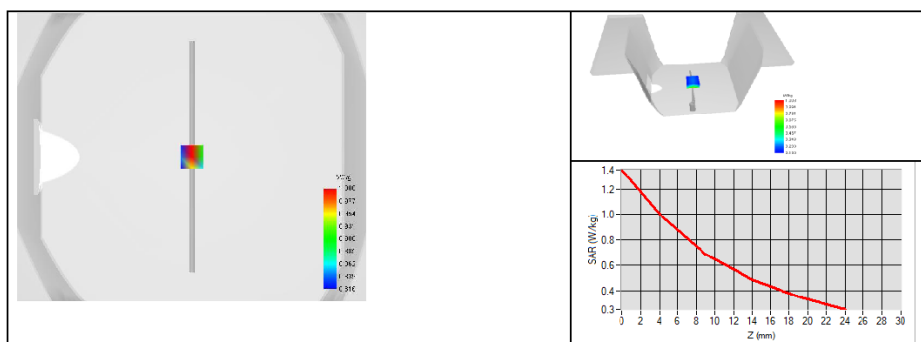
Frequency MHz	Relative permittivity (ϵ_r')		Conductivity (σ) S/m	
	required	measured	required	measured
150	61.9 ± 10 %		0.80 ± 10 %	
300	58.2 ± 10 %		0.92 ± 10 %	
450	56.7 ± 10 %		0.94 ± 10 %	
750	55.5 ± 10 %		0.96 ± 10 %	
835	55.2 ± 10 %	52.3	0.97 ± 10 %	0.94
900	55.0 ± 10 %		1.05 ± 10 %	
915	55.0 ± 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

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 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
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.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.118.18.22.BES.A

	<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



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