COMOSAR E-Field Probe Calibration Report

Ref : ACR.9.6.25.BES.B

Cancel and replace the report ACR.9.6.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR DOSIMETRIC E-FIELD PROBE

SERIAL NO.: 0125-EPGO-445

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 01/02/2025

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

Summary:

This document presents the method and results from an accredited COMOSAR Dosimetric 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).

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	1/9/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	1/9/2025	
Authorized by:	Geraldine Toutain	Quality Manager	2/13/2025	DocuSigned by: Geraldine TOUTAIN A1C9AC91CB5441A...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	1/9/2025	Initial release
B	Pedro Ruiz	2/12/2025	Change freq label 850 to 835

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1 DEVICE UNDER TEST

Device Under Test	
Device Type	COMOSAR DOSIMETRIC E FIELD PROBE
Manufacturer	MVG
Model	SSE2
Serial Number	0125-EPGO-445
Product Condition (new / used)	New
Frequency Range of Probe	0.15 GHz-7.5GHz
Resistance of Three Dipoles at Connector	Dipole 1: R1=0.206 MΩ Dipole 2: R2=0.208 MΩ Dipole 3: R3=0.226 MΩ

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 Probe*

Probe Length	330 mm
Length of Individual Dipoles	2 mm
Maximum external diameter	8 mm
Probe Tip External Diameter	2.5 mm
Distance between dipoles / probe extremity	1 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 effect. All calibrations / measurements performed meet the fore-mentioned standards.

3.1 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 for frequency range 600-7500MHz and using the calorimeter cell method (transfer method) as outlined in the standards for frequency 150-450 MHz.

3.2 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.

3.3 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°).

3.4 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:

$$\mathrm{SAR}_{\mathrm{uncertainty}}[\%] = \delta\mathrm{SAR}_{be}\,\frac{(d_{be}+d_{step})^2}{2d_{step}}\,\frac{\left(e^{-d_{be}/(\delta/2)}\right)}{\delta/2} \quad \text{for } (d_{be}+d_{step}) < 10\ \mathrm{mm}$$

where

$\mathrm{SAR}_{\mathrm{uncertainty}}$	is the uncertainty in percent of the probe boundary effect
d_{be}	is the distance between the surface and the closest *zoom-scan* 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., $\delta \approx 14$ mm at 3 GHz;
$\Delta\mathrm{SAR}_{be}$	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 SARuncertainty[%] for scanning distances larger than 4mm is 1.0% Limit ,2%).

3.5 PROBE MODULATION RESPONSE

MVG's probe were evaluated experimentally with various modulated signal and the deviation from CW response were found neglectable in the used power range of the probe. So the correction to taking into account the linearization parameters for different modulation is null, therefore the CW factor given in this report can be used whatever the measured modulation

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 a SAR probe calibration using the waveguide or calorimetric cell technique depending on the frequency.

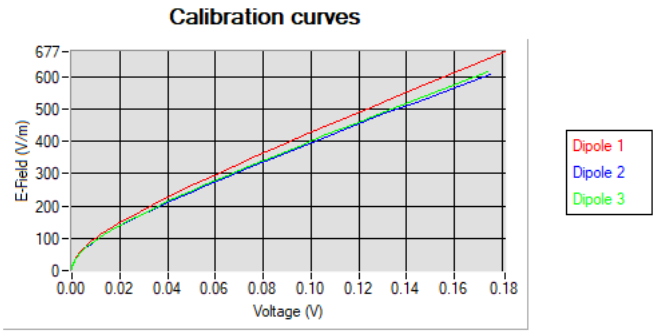
The estimated expanded uncertainty (k=2) in calibration for SAR (W/kg) is +/-11% for the frequency range 150-450MHz.
The estimated expanded uncertainty (k=2) in calibration for SAR (W/kg) is +/-14% for the frequency range 600-7500MHz.

5 CALIBRATION RESULTS

Ambient condition	
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

5.1 CALIBRATION IN AIR

The following curve represents the measurement in waveguide of the voltage picked up by the probe toward the E-field generated inside the waveguide.



From this curve, the sensitivity in air is calculated using the below formula.

$$E^2 = \sum_{i=1}^{3} \frac{V_i \left(1 + {}^{V_i}/_{DCP_i}\right)}{Norm_i}$$

where
Vi=voltage readings on the 3 channels of the probe
DCPi=diode compression point given below for the 3 channels of the probe
Normi=dipole sensitivity given below for the 3 channels of the probe

Normx dipole 1 (μV/(V/m)^2)	Normy dipole 2 (μV/(V/m)^2)	Normz dipole 3 (μV/(V/m)^2)
1.05	1.21	1.19

DCP dipole 1 (mV)	DCP dipole 2 (mV)	DCP dipole 3 (mV)
110	112	111

5.2 CALIBRATION IN LIQUID

The calorimeter cell or the waveguide is used to determine the calibration in liquid using the formula below.

$$ConvF = \frac{E_{liquid}^2}{E_{air}^2}$$

The E-field in the liquid is determined from the SAR measurement according to the below formula.

$$E_{liquid}^2 = \frac{\rho\, SAR}{\sigma}$$

where
σ=the conductivity of the liquid
ρ=the volumetric density of the liquid
SAR=the SAR measured from the formula that depends on the setup used. The SAR formulas are given below

For the calorimeter cell (150-450 MHz), the formula is:

$$SAR = c\frac{dT}{dt}$$

where
c=the specific heat for the liquid
dT/dt=the temperature rises over the time

For the waveguide setup (600-75000 MHz), the formula is:

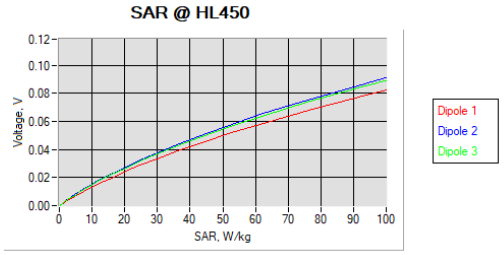
$$SAR = \frac{4Pw}{ab\delta} e^{\frac{-2z}{\delta}}$$

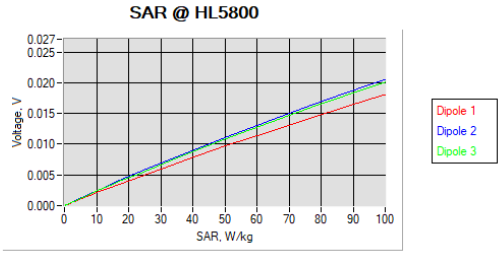
where
a=the larger cross-sectional of the waveguide
b=the smaller cross-sectional of the waveguide
δ=the skin depth for the liquid in the waveguide
Pw=the power delivered to the liquid

The below table summarize the ConvF for the calibrated liquid. The curves give examples for the measured SAR depending on the voltage in some liquid.

Liquid	Frequency (MHz*)	ConvF
HL450	450	1.19
HL750	750	1.24
HL835	835	1.15
HL1800	1800	1.20
HL1900	1900	1.31
HL2000	2000	1.35
HL2100	2100	1.31
HL2300	2300	1.38
HL2450	2450	1.40
HL2600	2600	1.27
HL3500	3500	1.17
HL3700	3700	1.11
HL3900	3900	1.14
HL4200	4200	1.29
HL4600	4600	1.28
HL4900	4900	1.19
HL5200	5200	1.18
HL5400	5400	1.14
HL5600	5600	1.12
HL5800	5800	1.11

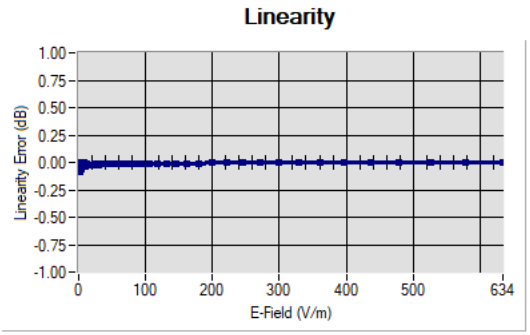
(*) Frequency validity is +/-50MHz below 600MHz, +/-100MHz from 600MHz to 6GHz and +/-700MHz above 6GHz



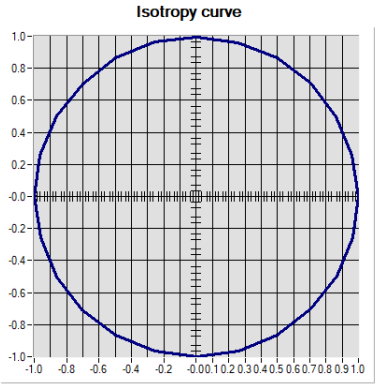


6 VERIFICATION RESULTS

The figures below represent the measured linearity and axial isotropy for this probe. The probe specification is +/-0.2 dB for linearity and +/-0.15 dB for axial isotropy.



Linearity:+/-2.00% (+/-0.09dB)



Isotropy:+/-0.25% (+/-0.01dB)

7 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
CALIPROBE Test Bench	Version 2	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2025
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	06/2026
USB Sensor	Keysight U2000A	SN: MY62340002	10/2024	10/2027
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Fluoroptic Thermometer	LumaSense Luxtron 812	94264	09/2022	09/2025
Coaxial cell	MVG	SN 32/16 COAXCELL_1	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG2_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_0G600_1	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG4_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_0G900_1	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG6_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_1G500_1	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG8_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_1G800B_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_1G800H_1	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG10_1	Validated. No cal required.	Validated. No cal required.

Liquid transition	MVG	SN 32/16 WGLIQ_3G500_1	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG12_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_5G000_1	Validated. No cal required.	Validated. No cal required.
Waveguide	MVG	SN 32/16 WG14_1	Validated. No cal required.	Validated. No cal required.
Liquid transition	MVG	SN 32/16 WGLIQ_7G000_1	Validated. No cal required.	Validated. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44235403	02/2024	02/2027

SAR Reference Dipole Calibration Report

Ref : ACR.148.5.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 750 MHZ

SERIAL NO.: 0722-DIP0G750-655

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 05/26/2025

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

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.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	6/2/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	6/2/2025	
Authorized by:	Kim Rutkowski	Quality Manager	6/4/2025	Signed by: Kimberley ROTKOWSKI 2B689547AD17461...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	6/2/2025	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	0722-DIP0G750-655
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, however, being built in accordance to relevant standards, it can be used in others SAR test benches as long as the final user take care that the prescribed S11 and SAR target value are met.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

4.1 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.

4.2 S11 PARAMETER REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a S11 of -20 dB or better. The S11 measurement shall be performed against a liquid filled flat phantom and using a prescribed spacer, 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.

4.3 SAR REQUIREMENTS

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.

5 MEASUREMENT UNCERTAINTY

5.1 MECHANICAL DIMENSIONS

For the measurement in the range 0-300mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.20 mm with respect to measurement conditions.

For the measurement in the range 300-450mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.44 mm with respect to measurement conditions.

5.2 S11 PARAMETER

The estimated expanded uncertainty (k=2) in calibration for the S11 parameter in linear is +/-0.08 with respect to measurement conditions.

5.3 SAR

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

The estimated expanded uncertainty (k=2) in calibration for the 1g and 10g SAR measurement in W/kg is +/-19% with respect to measurement conditions.

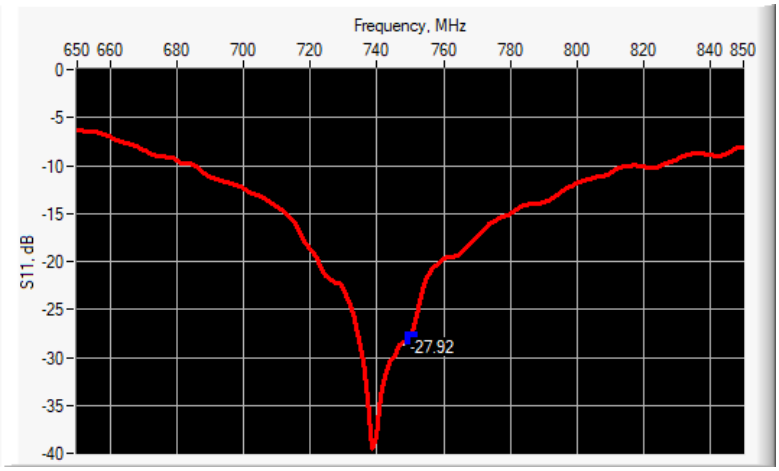
6 CALIBRATION RESULTS

6.1 MECHANICAL DIMENSIONS

L mm		h mm		d mm	
Measured	**Required**	**Measured**	**Required**	**Measured**	**Required**
-	176.00 +/- 2%	-	100.00 +/- 2%	-	6.35 +/- 2%

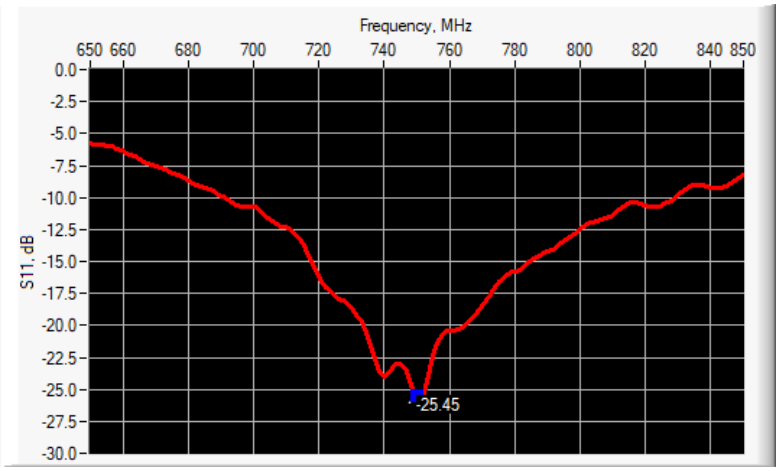
6.2 S11 PARAMETER

6.2.1 S11 parameter in Head Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
750	-27.92	-20	53.6Ω + 1.4jΩ

6.2.2 S11 parameter in Body Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
750	-25.45	-20	50.7Ω + 5.0jΩ

6.3 SAR

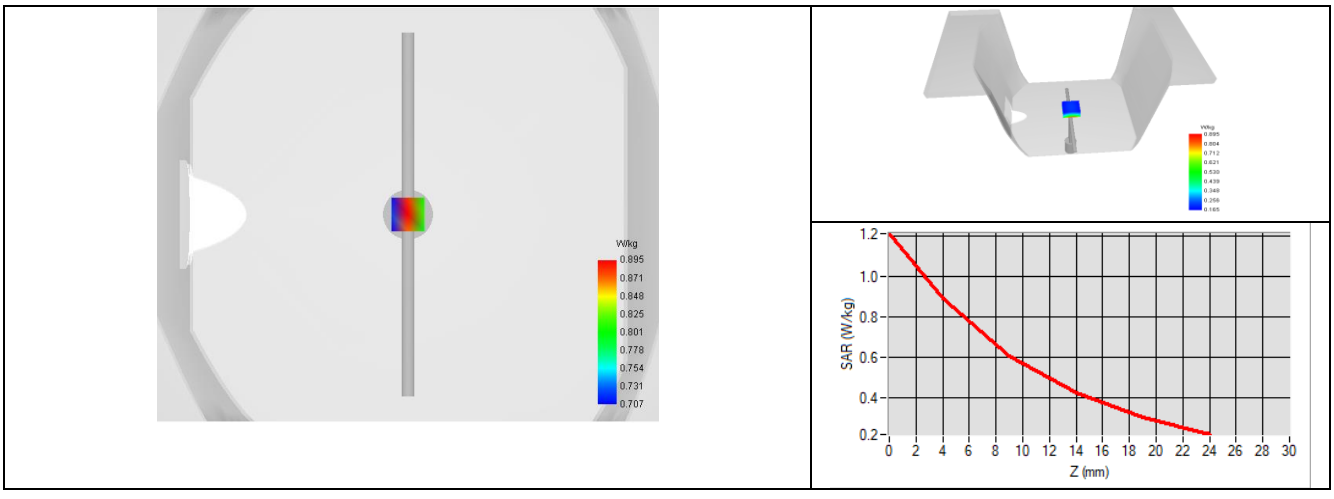
The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, 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 by using a prescribed spacer.

6.3.1 SAR 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.

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	4424-EPGO-443
Liquid	Head Liquid Values: eps' : 44.6 sigma : 0.88
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 %

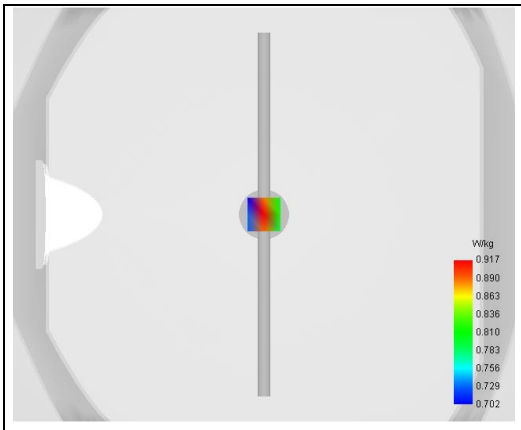
Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
750 MHz	0.84	8.41	8.49	0.55	5.55	5.55

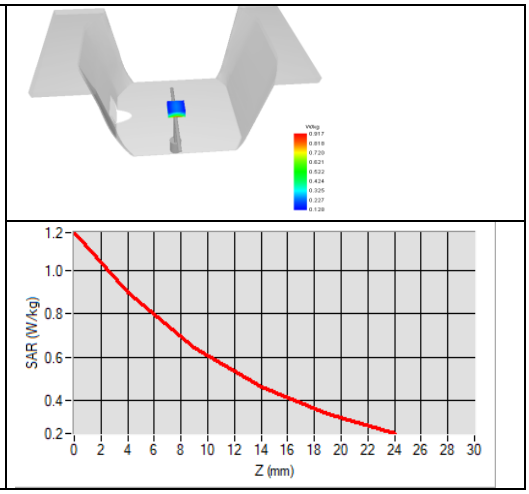


6.3.2 SAR with Body Liquid

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 4424-EPGO-443
Liquid	Body Liquid Values: eps' : 56.1 sigma : 0.93
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
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
750 MHz	0.85	8.48	8.60	0.57	5.68	5.70





7 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	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Calipers	Mitutoyo	SN 0009732	11/2022	11/2025
Reference Probe	MVG	4424-EPGO-443	05/2025	05/2026
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2026
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	06/2026
Power Meter	Keysight U2000A	SN: MY62340002	10/2024	10/2027
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	44235403	10/2024	10/2027

SAR Reference Dipole Calibration Report

Ref : ACR.148.6.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 835 MHZ

SERIAL NO.: 0722-DIP0G835-656

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 05/26/2025

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.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	6/2/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	6/2/2025	
Authorized by:	Kim Rutkowski	Quality Manager	6/4/2025	Signed by: Kimberley RUTKOWSKI 2B689547AD17461...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	6/2/2025	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	0722-DIP0G835-656
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, however, being built in accordance to relevant standards, it can be used in others SAR test benches as long as the final user take care that the prescribed S11 and SAR target value are met.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

4.1 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.

4.2 S11 PARAMETER REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a S11 of -20 dB or better. The S11 measurement shall be performed against a liquid filled flat phantom and using a prescribed spacer, 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.

4.3 SAR REQUIREMENTS

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.

5 MEASUREMENT UNCERTAINTY

5.1 MECHANICAL DIMENSIONS

For the measurement in the range 0-300mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.20 mm with respect to measurement conditions.

For the measurement in the range 300-450mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.44 mm with respect to measurement conditions.

5.2 S11 PARAMETER

The estimated expanded uncertainty (k=2) in calibration for the S11 parameter in linear is +/-0.08 with respect to measurement conditions.

5.3 SAR

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

The estimated expanded uncertainty (k=2) in calibration for the 1g and 10g SAR measurement in W/kg is +/-19% with respect to measurement conditions.

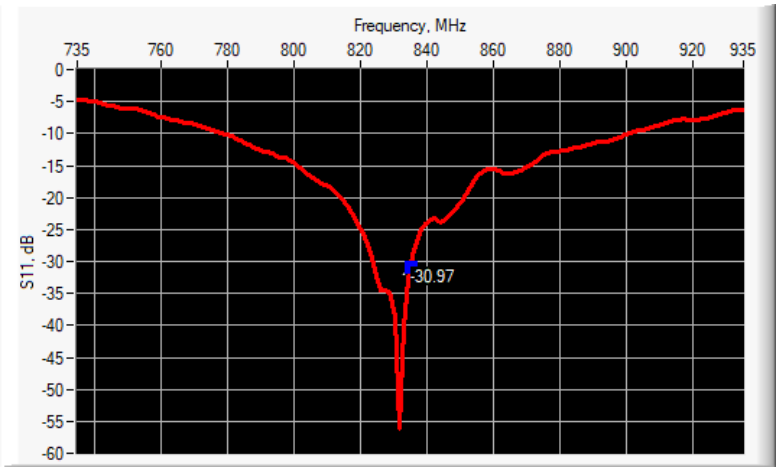
6 CALIBRATION RESULTS

6.1 MECHANICAL DIMENSIONS

L mm		h mm		d mm	
Measured	**Required**	**Measured**	**Required**	**Measured**	**Required**
-	161.00 +/- 2%	-	89.80 +/- 2%	-	3.60 +/- 2%

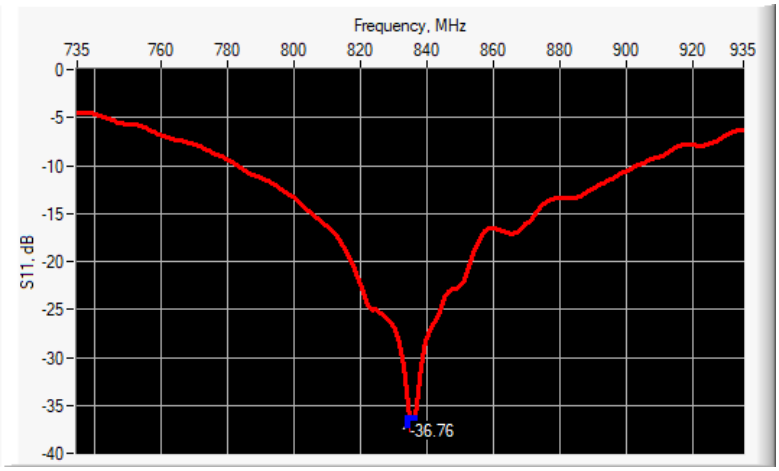
6.2 S11 PARAMETER

6.2.1 S11 parameter in Head Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
835	-30.97	-20	50.7Ω - 2.7jΩ

6.2.2 S11 parameter in Body Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
835	-36.76	-20	50.6Ω + 0.9jΩ

6.3 SAR

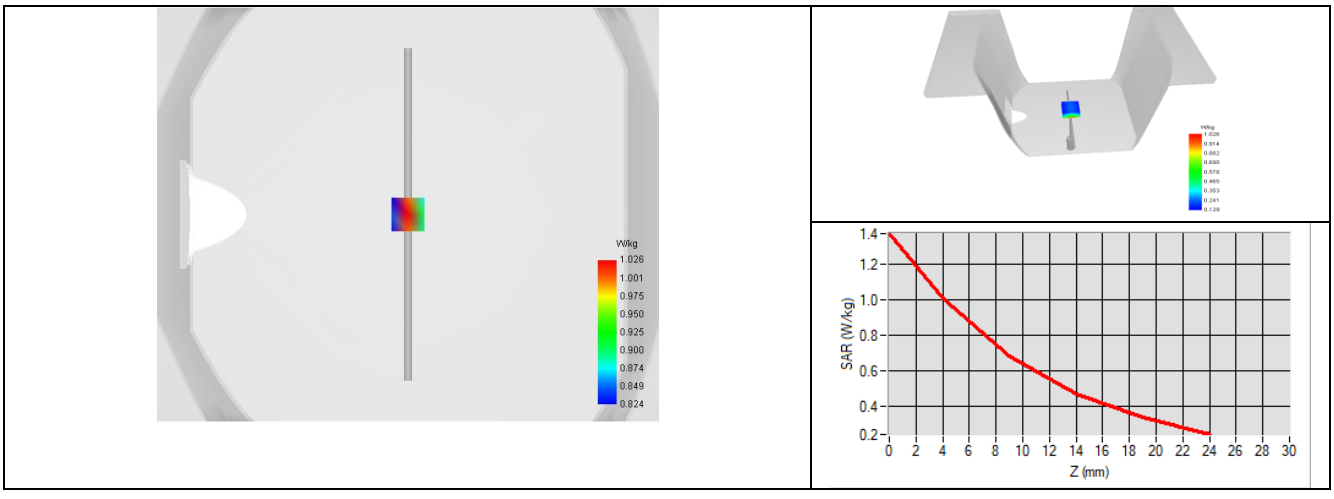
The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, 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 by using a prescribed spacer.

6.3.1 SAR 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.

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	4424-EPGO-443
Liquid	Head Liquid Values: eps' : 44.4 sigma : 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 %

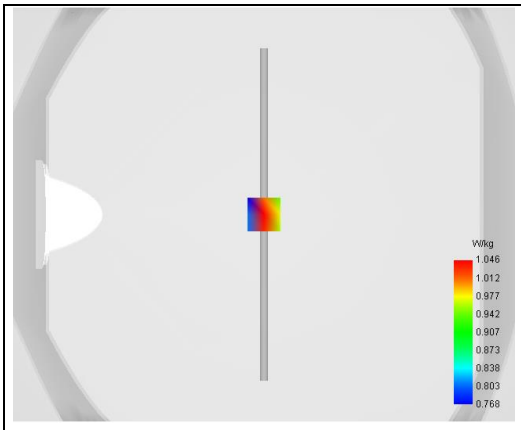
Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
835 MHz	0.95	9.46	9.56	0.61	6.12	6.22

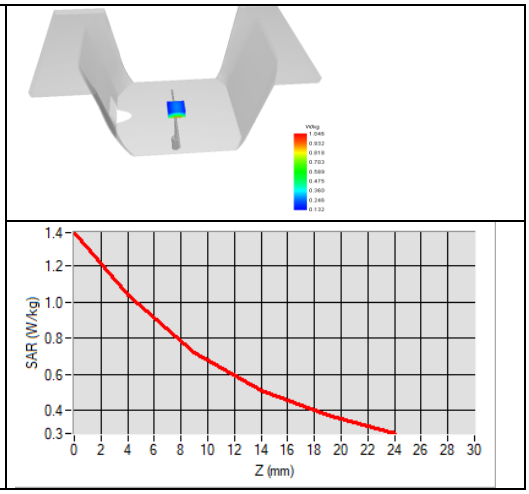


6.3.2 SAR with Body Liquid

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 4424-EPGO-443
Liquid	Body Liquid Values: eps' : 55.9 sigma : 0.96
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
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
835 MHz	0.98	9.78	9.71	0.65	6.47	6.38





7 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	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Calipers	Mitutoyo	SN 0009732	11/2022	11/2025
Reference Probe	MVG	4424-EPGO-443	05/2025	05/2026
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2026
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	06/2026
Power Meter	Keysight U2000A	SN: MY62340002	10/2024	10/2027
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	44235403	10/2024	10/2027

SAR Reference Dipole Calibration Report

Ref : ACR.148.7.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 1800 MHZ

SERIAL NO.: 0722-DIP1G800-657

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 05/26/2025

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

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.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	6/2/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	6/2/2025	
Authorized by:	Kim Rutkowski	Quality Manager	6/4/2025	Signed by: Kimberley RUTKOWSKI 2B689547AD17461...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	6/2/2025	Initial release

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5 Measurement Uncertainty 5
5.1 Mechanical dimensions 5
5.2 S11 Parameter 5
5.3 SAR 5
6 Calibration Results 6
6.1 Mechanical Dimensions 6
6.2 S11 parameter 6
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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 1800 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID1800
Serial Number	0722-DIP1G800-657
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, however, being built in accordance to relevant standards, it can be used in others SAR test benches as long as the final user take care that the prescribed S11 and SAR target value are met.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

4.1 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.

4.2 S11 PARAMETER REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a S11 of -20 dB or better. The S11 measurement shall be performed against a liquid filled flat phantom and using a prescribed spacer, 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.

4.3 SAR REQUIREMENTS

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.

5 MEASUREMENT UNCERTAINTY

5.1 MECHANICAL DIMENSIONS

For the measurement in the range 0-300mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.20 mm with respect to measurement conditions.

For the measurement in the range 300-450mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.44 mm with respect to measurement conditions.

5.2 S11 PARAMETER

The estimated expanded uncertainty (k=2) in calibration for the S11 parameter in linear is +/-0.08 with respect to measurement conditions.

5.3 SAR

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

The estimated expanded uncertainty (k=2) in calibration for the 1g and 10g SAR measurement in W/kg is +/-19% with respect to measurement conditions.

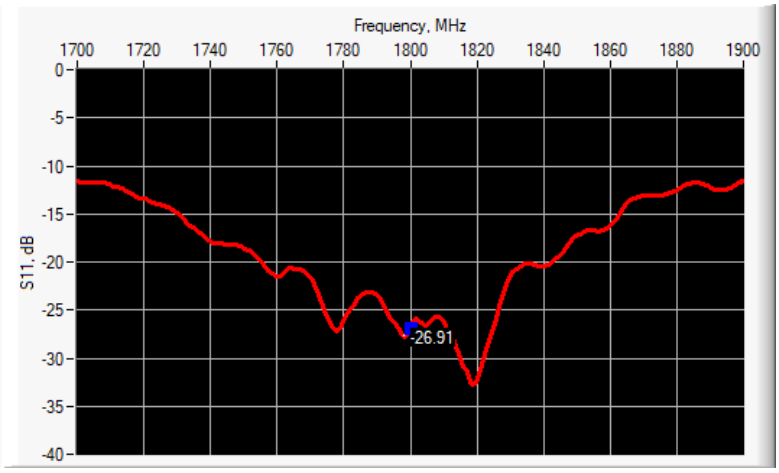
6 CALIBRATION RESULTS

6.1 MECHANICAL DIMENSIONS

L mm		h mm		d mm	
Measured	**Required**	**Measured**	**Required**	**Measured**	**Required**
-	72.00 +/- 2%	-	41.70 +/- 2%	-	3.60 +/- 2%

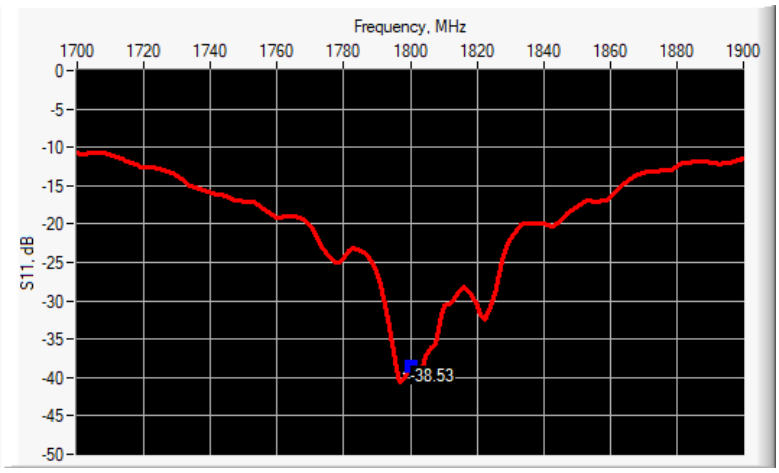
6.2 S11 PARAMETER

6.2.1 S11 parameter in Head Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
1800	-26.91	-20	50.8Ω + 4.3jΩ

6.2.2 S11 parameter in Body Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
1800	-38.53	-20	51.1Ω - 0.3jΩ

6.3 SAR

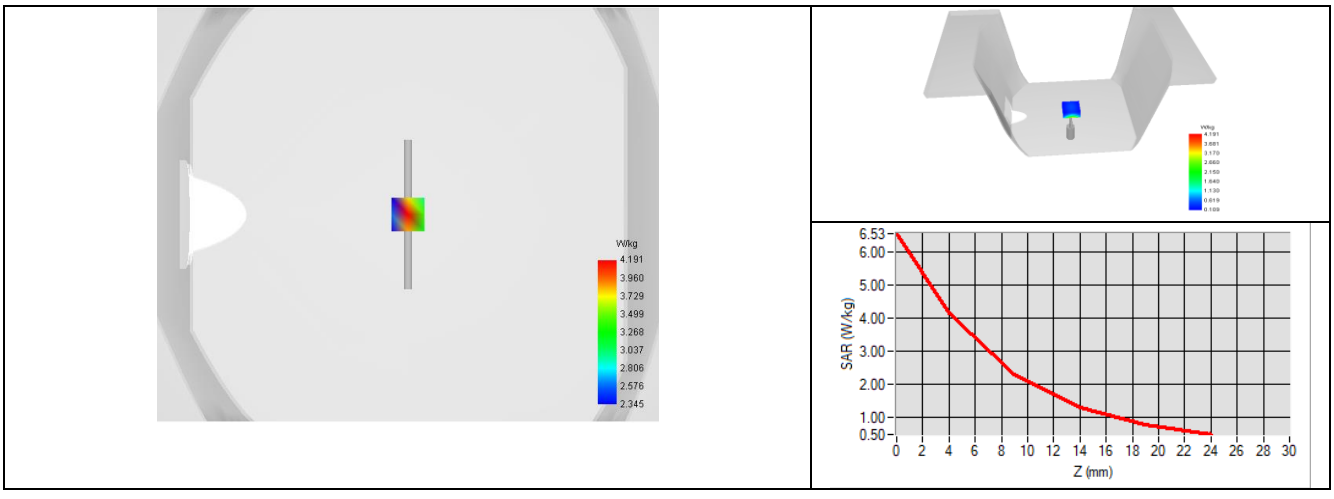
The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, 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 by using a prescribed spacer.

6.3.1 SAR 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.

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	4424-EPGO-443
Liquid	Head Liquid Values: eps' : 42.2 sigma : 1.39
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 %

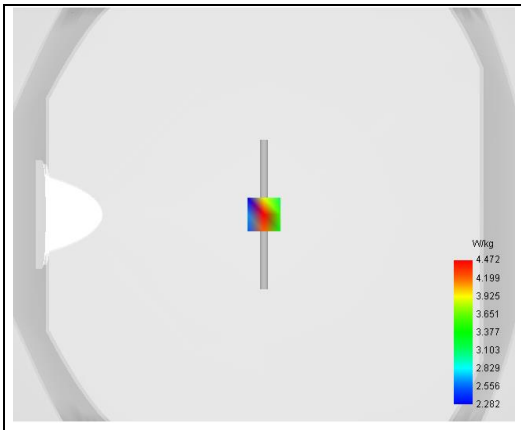
Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
1800 MHz	3.79	37.93	38.40	1.98	19.83	20.10

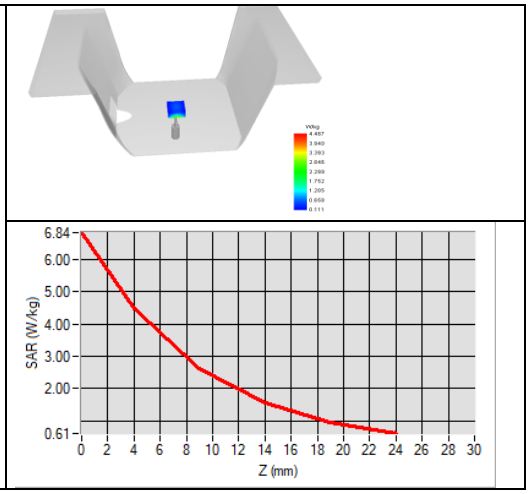


6.3.2 SAR with Body Liquid

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 4424-EPGO-443
Liquid	Body Liquid Values: eps' : 53.9 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
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
1800 MHz	4.07	40.68	38.50	2.15	21.48	20.30





7 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	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Calipers	Mitutoyo	SN 0009732	11/2022	11/2025
Reference Probe	MVG	4424-EPGO-443	05/2025	05/2026
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2026
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	06/2026
Power Meter	Keysight U2000A	SN: MY62340002	10/2024	10/2027
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	44235403	10/2024	10/2027

SAR Reference Dipole Calibration Report

Ref : ACR.148.8.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 1900 MHZ

SERIAL NO.: 4721-DIP1G900-658

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 05/26/2025

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

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.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	5/28/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	5/28/2025	
Authorized by:	Kim Rutkowski	Quality Manager	6/4/2025	Signed by: Kimberley RUTKOWSKI 2B689547AD17461...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	5/28/2025	Initial release

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6 Calibration Results 6
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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 1900 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID1900
Serial Number	4721-DIP1G900-658
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, however, being built in accordance to relevant standards, it can be used in others SAR test benches as long as the final user take care that the prescribed S11 and SAR target value are met.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

4.1 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.

4.2 S11 PARAMETER REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a S11 of -20 dB or better. The S11 measurement shall be performed against a liquid filled flat phantom and using a prescribed spacer, 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.

4.3 SAR REQUIREMENTS

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.

5 MEASUREMENT UNCERTAINTY

5.1 MECHANICAL DIMENSIONS

For the measurement in the range 0-300mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.20 mm with respect to measurement conditions.

For the measurement in the range 300-450mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.44 mm with respect to measurement conditions.

5.2 S11 PARAMETER

The estimated expanded uncertainty (k=2) in calibration for the S11 parameter in linear is +/-0.08 with respect to measurement conditions.

5.3 SAR

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

The estimated expanded uncertainty (k=2) in calibration for the 1g and 10g SAR measurement in W/kg is +/-19% with respect to measurement conditions.

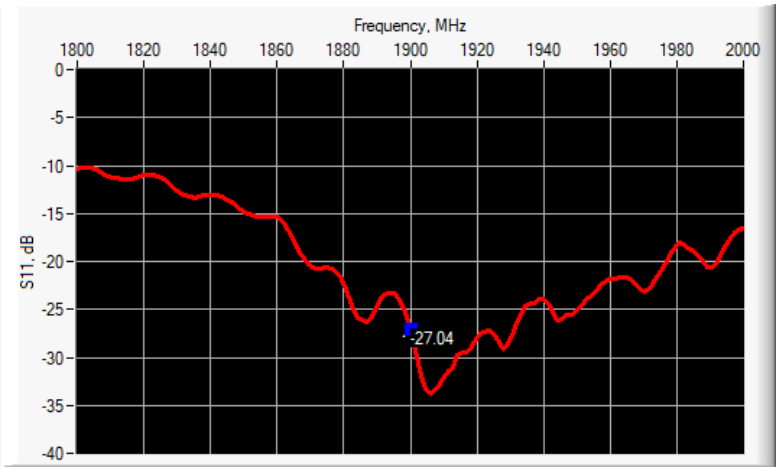
6 CALIBRATION RESULTS

6.1 MECHANICAL DIMENSIONS

L mm		h mm		d mm	
Measured	**Required**	**Measured**	**Required**	**Measured**	**Required**
-	68.00 +/- 2%	-	39.50 +/- 2%	-	3.60 +/- 2%

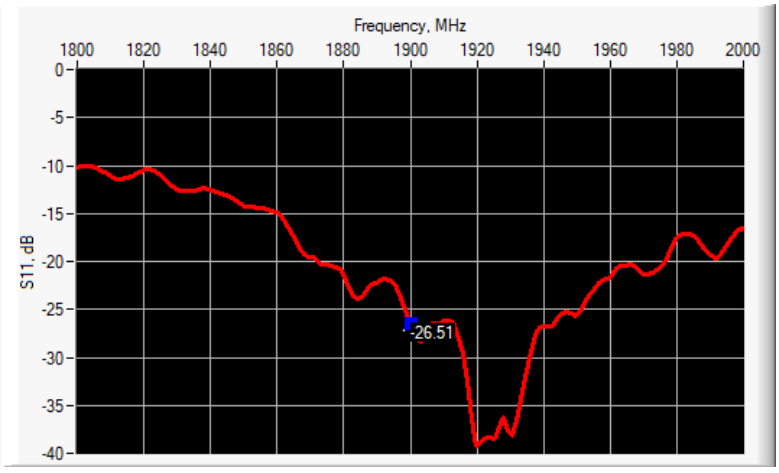
6.2 S11 PARAMETER

6.2.1 S11 parameter in Head Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
1900	-27.04	-20	50.8Ω - 4.3jΩ

6.2.2 S11 parameter in Body Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
1900	-26.51	-20	47.3Ω - 3.6jΩ

6.3 SAR

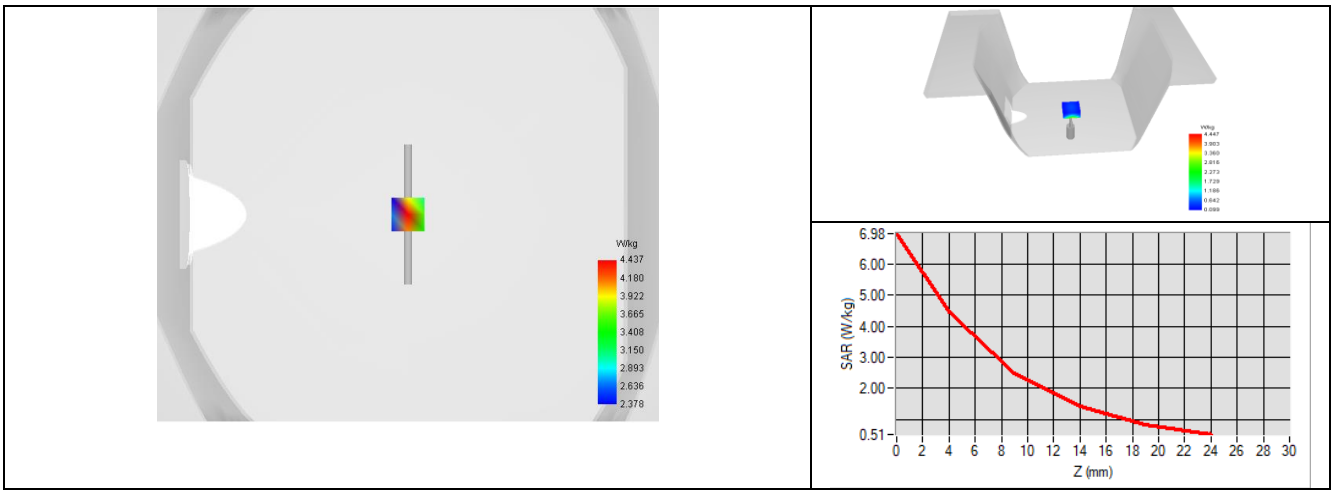
The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, 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 by using a prescribed spacer.

6.3.1 SAR 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.

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	4424-EPGO-443
Liquid	Head Liquid Values: eps' : 42.4 sigma : 1.39
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 %

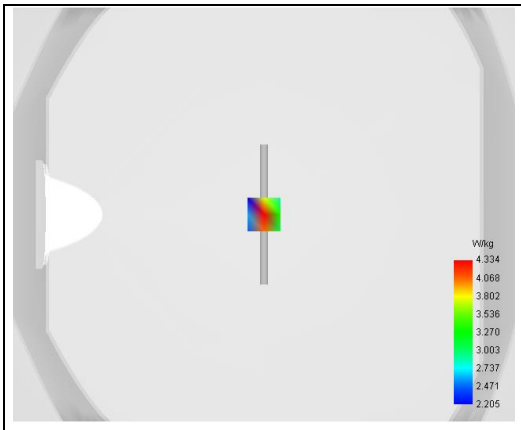
Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
1900 MHz	4.03	40.29	39.70	2.08	20.82	20.50

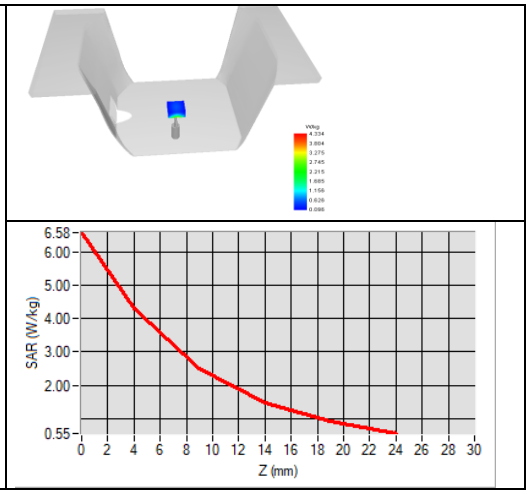


6.3.2 SAR with Body Liquid

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 4424-EPGO-443
Liquid	Body Liquid Values: eps' : 54.0 sigma : 1.50
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
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
1900 MHz	3.89	38.93	39.80	2.03	20.29	20.80





7 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	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Calipers	Mitutoyo	SN 0009732	11/2022	11/2025
Reference Probe	MVG	4424-EPGO-443	05/2025	05/2026
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2026
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	06/2026
Power Meter	Keysight U2000A	SN: MY62340002	10/2024	10/2027
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	44235403	10/2024	10/2027

SAR Reference Dipole Calibration Report

Ref : ACR.148.12.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 2450 MHZ

SERIAL NO.: 0722-DIP2G450-662

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 05/26/2025

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

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.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	5/28/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	5/28/2025	
Authorized by:	Kim Rutkowski	Quality Manager	6/4/2025	Signed by: Kimberley RUTKOWSKI 2B689547AD17461...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	5/28/2025	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 2450 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID2450
Serial Number	0722-DIP2G450-662
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, however, being built in accordance to relevant standards, it can be used in others SAR test benches as long as the final user take care that the prescribed S11 and SAR target value are met.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

4.1 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.

4.2 S11 PARAMETER REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a S11 of -20 dB or better. The S11 measurement shall be performed against a liquid filled flat phantom and using a prescribed spacer, 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.

4.3 SAR REQUIREMENTS

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.

5 MEASUREMENT UNCERTAINTY

5.1 MECHANICAL DIMENSIONS

For the measurement in the range 0-300mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.20 mm with respect to measurement conditions.

For the measurement in the range 300-450mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.44 mm with respect to measurement conditions.

5.2 S11 PARAMETER

The estimated expanded uncertainty (k=2) in calibration for the S11 parameter in linear is +/-0.08 with respect to measurement conditions.

5.3 SAR

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

The estimated expanded uncertainty (k=2) in calibration for the 1g and 10g SAR measurement in W/kg is +/-19% with respect to measurement conditions.

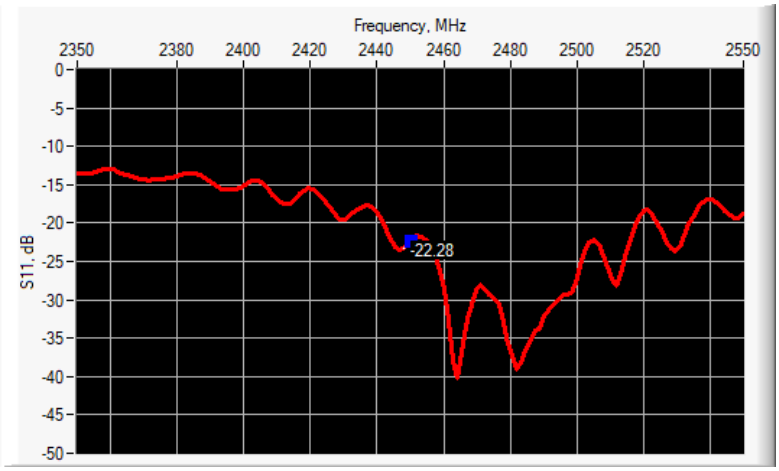
6 CALIBRATION RESULTS

6.1 MECHANICAL DIMENSIONS

L mm		h mm		d mm	
Measured	**Required**	**Measured**	**Required**	**Measured**	**Required**
-	51.50 +/- 2%	-	30.40 +/- 2%	-	3.60 +/- 2%

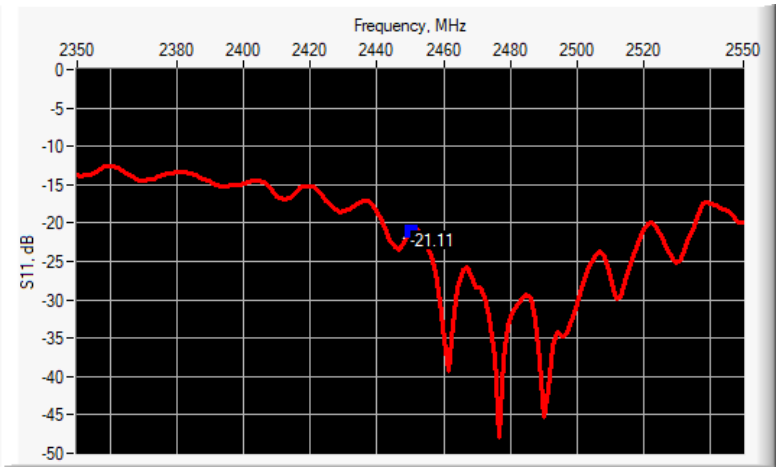
6.2 S11 PARAMETER

6.2.1 S11 parameter in Head Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
2450	-22.28	-20	49.2Ω + 7.4jΩ

6.2.2 S11 parameter in Body Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
2450	-21.11	-20	52.5Ω + 8.4jΩ

6.3 SAR

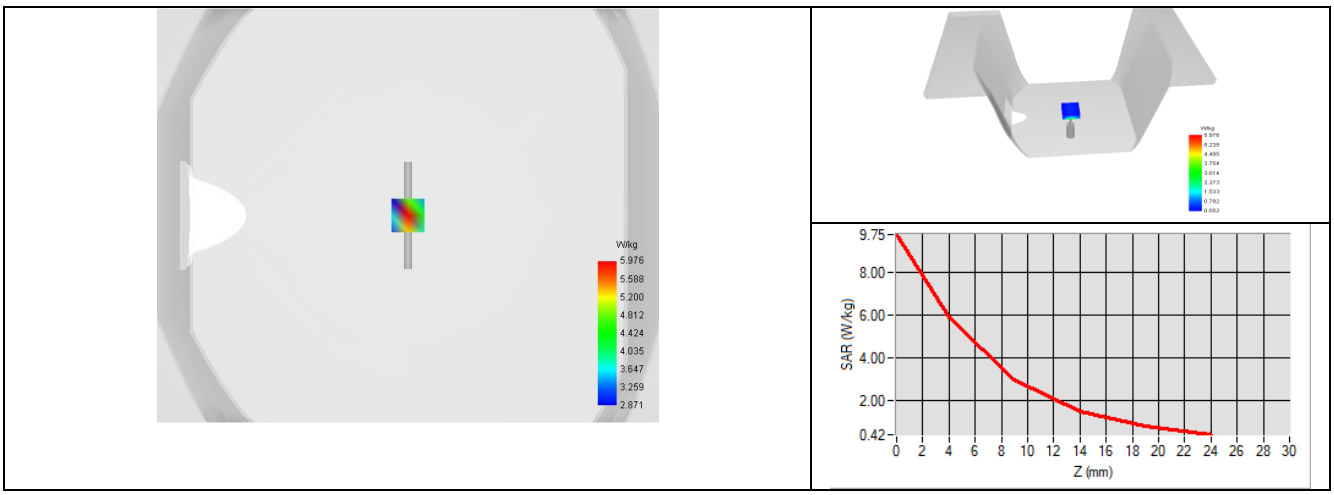
The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, 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 by using a prescribed spacer.

6.3.1 SAR 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.

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	4424-EPGO-443
Liquid	Head Liquid Values: eps' : 41.6 sigma : 1.88
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 %

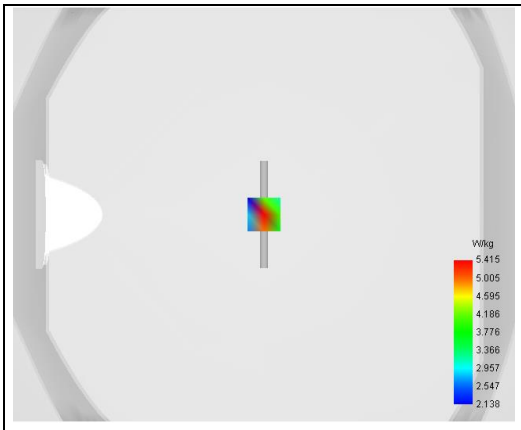
Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
2450 MHz	5.27	52.72	52.40	2.45	24.55	24.00

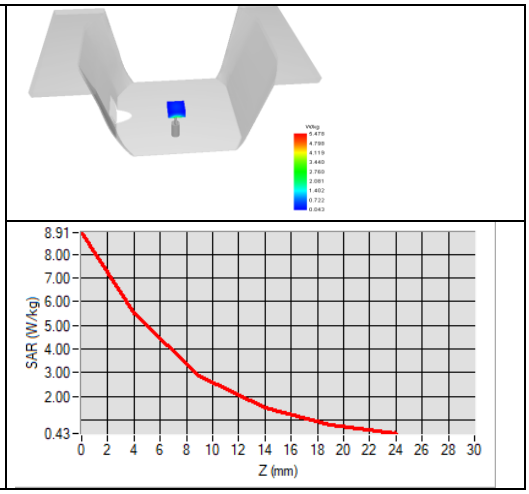


6.3.2 SAR with Body Liquid

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 4424-EPGO-443
Liquid	Body Liquid Values: eps' : 53.4 sigma : 2.08
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
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
2450 MHz	5.02	50.15	51.20	2.31	23.11	23.70





7 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	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Calipers	Mitutoyo	SN 0009732	11/2022	11/2025
Reference Probe	MVG	4424-EPGO-443	05/2025	05/2026
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2026
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	06/2026
Power Meter	Keysight U2000A	SN: MY62340002	10/2024	10/2027
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	44235403	10/2024	10/2027

SAR Reference Dipole Calibration Report

Ref : ACR.148.13.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 2600 MHZ

SERIAL NO.: 0722-DIP2G600-663

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 05/26/2025

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

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.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	5/28/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	5/28/2025	
Authorized by:	Kim Rutkowski	Quality Manager	6/4/2025	Signed by: Kimberley RUTKOWSKI 2B689547AD17461...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	5/28/2025	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 2600 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID2600
Serial Number	0722-DIP2G600-663
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, however, being built in accordance to relevant standards, it can be used in others SAR test benches as long as the final user take care that the prescribed S11 and SAR target value are met.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

4.1 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.

4.2 S11 PARAMETER REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a S11 of -20 dB or better. The S11 measurement shall be performed against a liquid filled flat phantom and using a prescribed spacer, 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.

4.3 SAR REQUIREMENTS

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.

5 MEASUREMENT UNCERTAINTY

5.1 MECHANICAL DIMENSIONS

For the measurement in the range 0-300mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.20 mm with respect to measurement conditions.

For the measurement in the range 300-450mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.44 mm with respect to measurement conditions.

5.2 S11 PARAMETER

The estimated expanded uncertainty (k=2) in calibration for the S11 parameter in linear is +/-0.08 with respect to measurement conditions.

5.3 SAR

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

The estimated expanded uncertainty (k=2) in calibration for the 1g and 10g SAR measurement in W/kg is +/-19% with respect to measurement conditions.

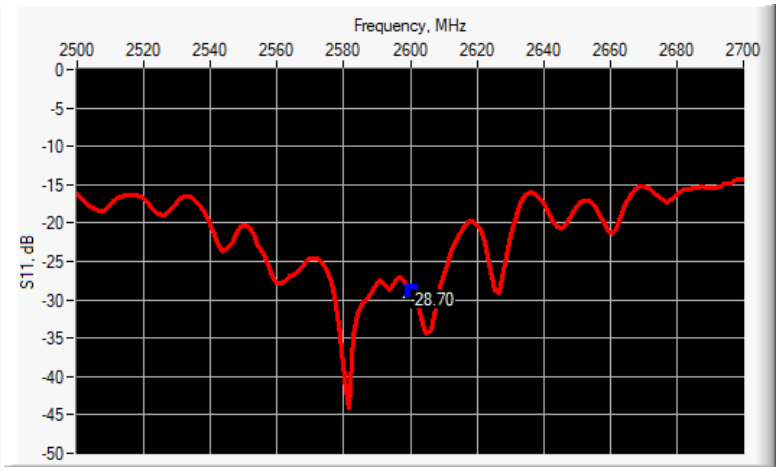
6 CALIBRATION RESULTS

6.1 MECHANICAL DIMENSIONS

L mm		h mm		d mm	
Measured	**Required**	**Measured**	**Required**	**Measured**	**Required**
-	48.50 +/- 2%	-	28.80 +/- 2%	-	3.60 +/- 2%

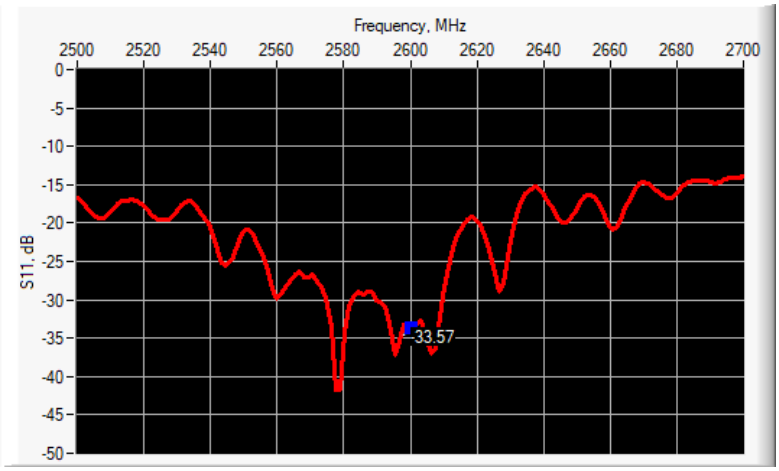
6.2 S11 PARAMETER

6.2.1 S11 parameter in Head Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
2600	-28.70	-20	50.0Ω + 3.7jΩ

6.2.2 S11 parameter in Body Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
2600	-33.57	-20	49.2Ω + 1.9jΩ

6.3 SAR

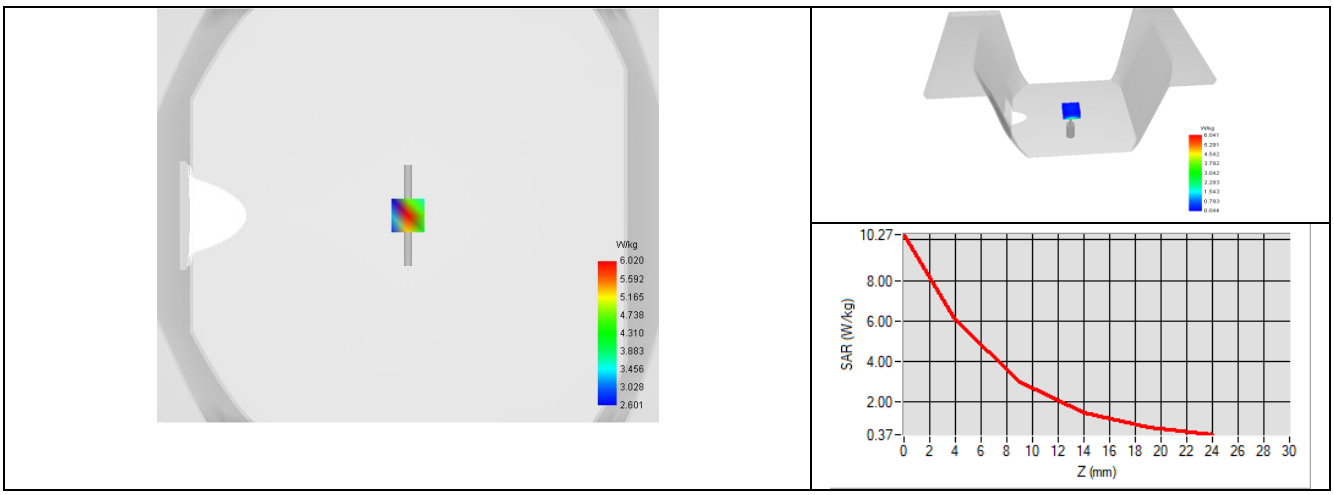
The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements must be performed using a reference dipole meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed against a liquid filled flat phantom, 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 by using a prescribed spacer.

6.3.1 SAR 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.

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	4424-EPGO-443
Liquid	Head Liquid Values: eps' : 41.2 sigma : 1.97
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 %

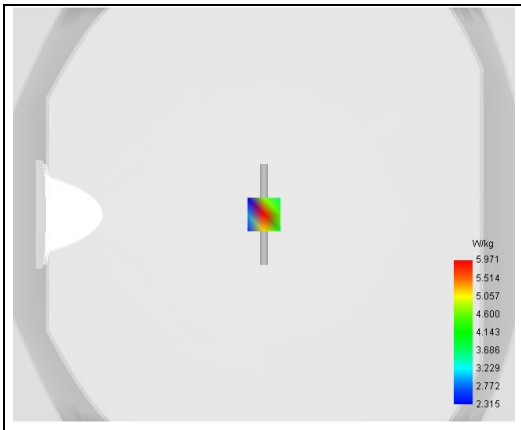
Frequency	1g SAR (W/kg)			10g SAR (W/kg)		
	Measured	Measured normalized to 1W	Target normalized to 1W	Measured	Measured normalized to 1W	Target normalized to 1W
2600 MHz	5.38	53.76	55.30	2.44	24.43	24.60

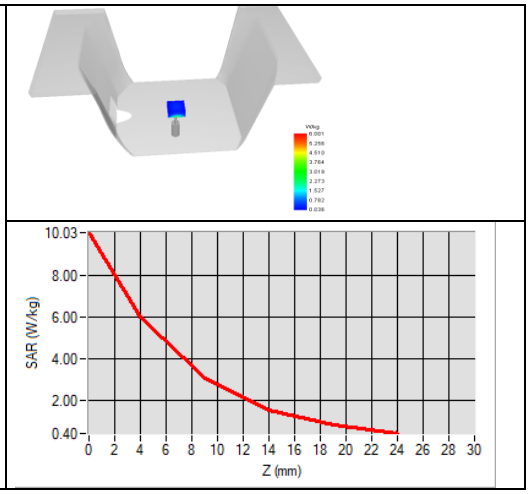


6.3.2 SAR with Body Liquid

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 4424-EPGO-443
Liquid	Body Liquid Values: eps' : 52.8 sigma : 2.17
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
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
2600 MHz	5.33	53.32	54.10	2.41	24.10	24.00





7 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	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Calipers	Mitutoyo	SN 0009732	11/2022	11/2025
Reference Probe	MVG	4424-EPGO-443	05/2025	05/2026
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2026
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	06/2026
Power Meter	Keysight U2000A	SN: MY62340002	10/2024	10/2027
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	44235403	10/2024	10/2027

SAR Reference Dipole Calibration Report

Ref : ACR.148.20.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 5200-5800 MHZ

SERIAL NO.: 0722-DIP5G000-670

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 05/26/2025

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

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.

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	5/30/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	5/30/2025	
Authorized by:	Kim Rutkowski	Quality Manager	6/4/2025	Signed by: Kimberley RUTKOWSKI 2B689547AD17461...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	5/30/2025	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 5200-5800 MHz REFERENCE DIPOLE
Manufacturer	MVG
Model	SID5000
Serial Number	0722-DIP5G000-670
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, however, being built in accordance to relevant standards, it can be used in others SAR test benches as long as the final user take care that the prescribed S11 and SAR target value are met.

Figure 1 – *MVG COMOSAR Validation Dipole*

4 MEASUREMENT METHOD

4.1 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.

4.2 S11 PARAMETER REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a S11 of -20 dB or better. The S11 measurement shall be performed against a liquid filled flat phantom and using a prescribed spacer, 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.

4.3 SAR REQUIREMENTS

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.

5 MEASUREMENT UNCERTAINTY

5.1 MECHANICAL DIMENSIONS

For the measurement in the range 0-300mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.20 mm with respect to measurement conditions.

For the measurement in the range 300-450mm, the estimated expanded uncertainty (k=2) in calibration for the dimension measurement in mm is +/-0.44 mm with respect to measurement conditions.

5.2 S11 PARAMETER

The estimated expanded uncertainty (k=2) in calibration for the S11 parameter in linear is +/-0.08 with respect to measurement conditions.

5.3 SAR

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

The estimated expanded uncertainty (k=2) in calibration for the 1g and 10g SAR measurement in W/kg is +/-19% with respect to measurement conditions.

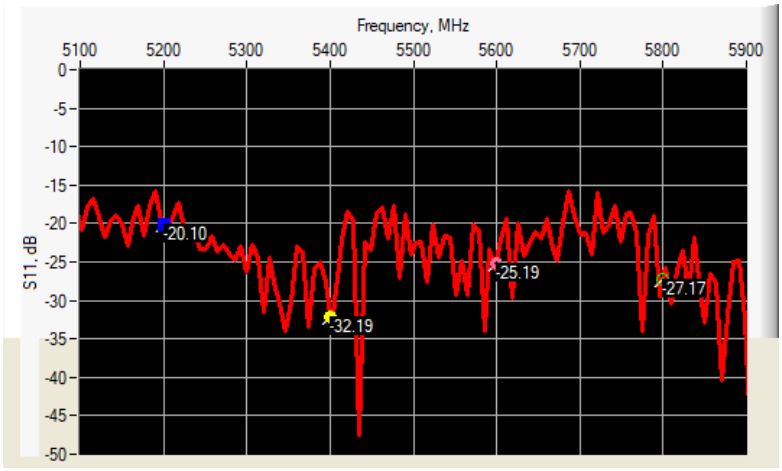
6 CALIBRATION RESULTS

6.1 MECHANICAL DIMENSIONS

L mm		h mm		d mm	
Measured	**Required**	**Measured**	**Required**	**Measured**	**Required**
-	20.60 +/- 2%	-	40.30 +/- 2%	-	3.60 +/- 2%

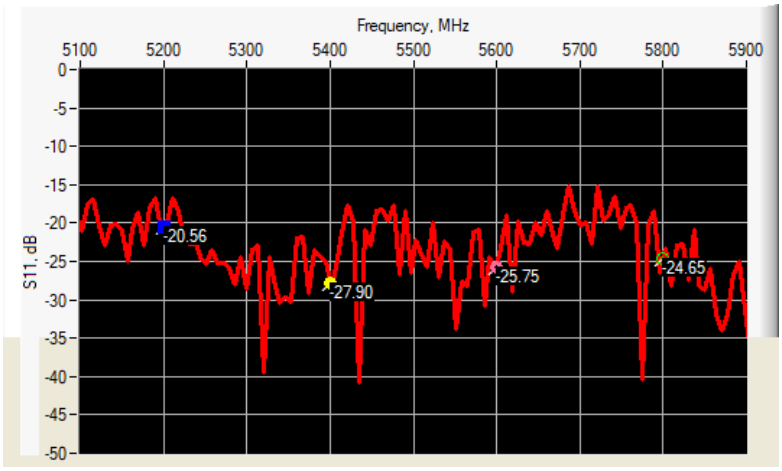
6.2 S11 PARAMETER

6.2.1 S11 parameter in Head Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
5200	-20.10	-20	49.9Ω + 2.4jΩ
5400	-32.19	-20	50.4Ω + 1.5jΩ
5600	-25.19	-20	48.4Ω + 1.8jΩ
5800	-27.17	-20	51.1Ω - 1.5jΩ

6.2.2 S11 parameter in Body Liquid



Frequency (MHz)	S11 parameter (dB)	Requirement (dB)	Impedance
5200	-20.56	-20	50.1Ω + 1.1jΩ
5400	-27.90	-20	51.6Ω + 1.8jΩ
5600	-25.75	-20	48.1Ω + 1.4jΩ
5800	-24.65	-20	50.9Ω - 2.2jΩ

6.3 SAR

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 by using a prescribed spacer.

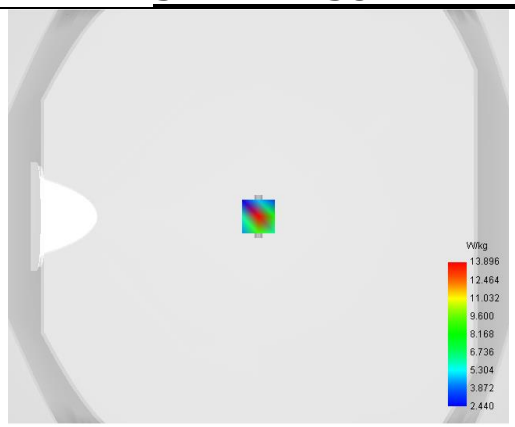
6.3.1 SAR with Head Liquid

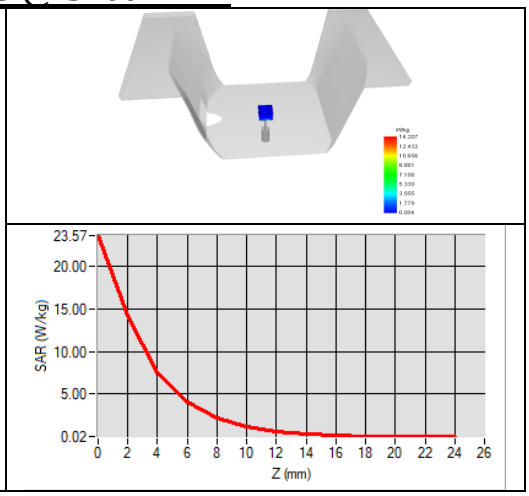
The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured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

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	4424-EPGO-443
Liquid	Head Liquid Values @ 5200 MHz: eps' : 34.2 sigma : 4.50 Head Liquid Values @ 5400 MHz: eps' : 33.7 sigma : 4.76 Head Liquid Values @ 5600 MHz: eps' : 33.2 sigma : 5.03 Head Liquid Values @ 5800 MHz: eps' : 32.8 sigma : 5.35
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=4mm/dy=4mm/dz=2mm
Frequency	5200 MHz 5400 MHz 5600 MHz 5800 MHz
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

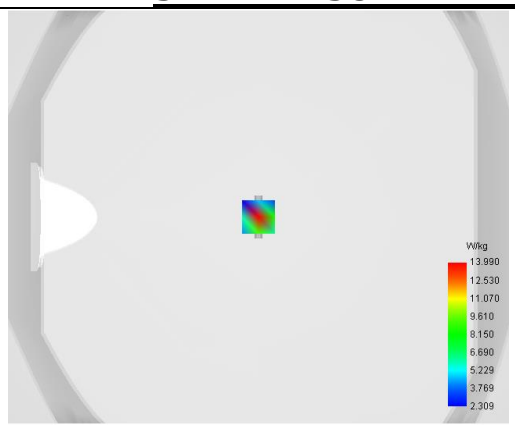
Frequency	1g SAR (W/kg)			10g SAR (W/kg)		
	Measured	Measured normalized to 1W	Target normalized to 1W	Measured	Measured normalized to 1W	Target normalized to 1W
5200 MHz	7.82	78.16	76.50	2.28	22.78	21.60
5400 MHz	7.86	78.64	79.60	2.25	22.55	23.40
5600 MHz	8.27	82.72	78.30	2.39	23.95	23.20
5800 MHz	7.83	78.32	78.00	2.27	22.71	21.90

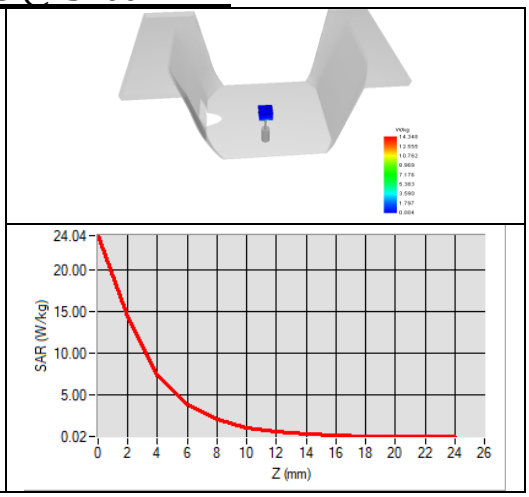
SAR MEASUREMENT PLOTS @ 5200 MHz



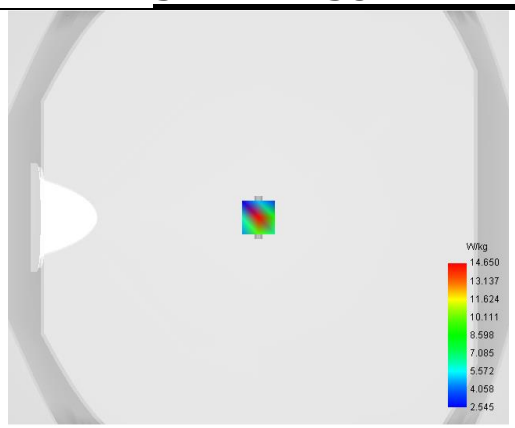


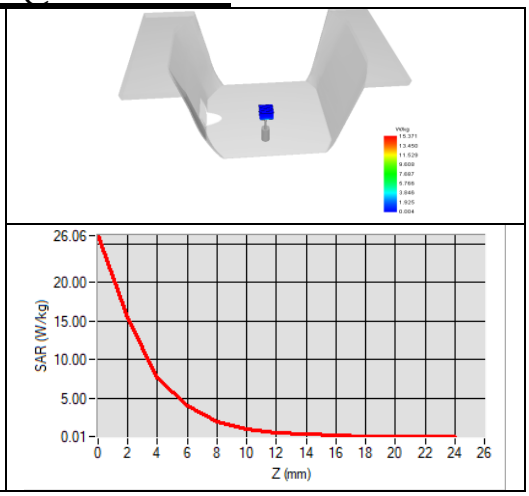
SAR MEASUREMENT PLOTS @ 5400 MHz



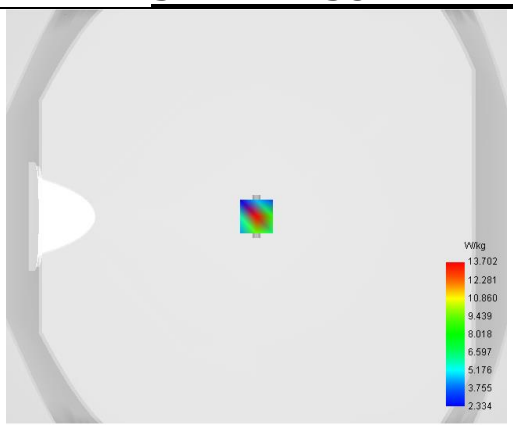


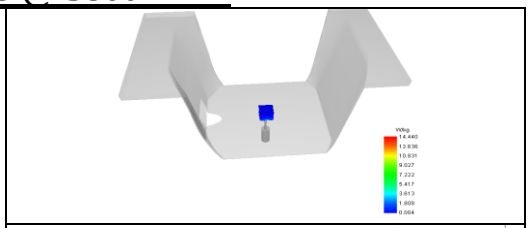
SAR MEASUREMENT PLOTS @ 5600 MHz

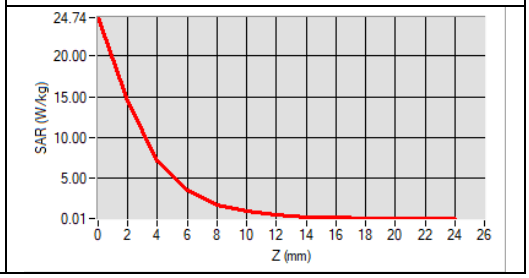




SAR MEASUREMENT PLOTS @ 5800 MHz





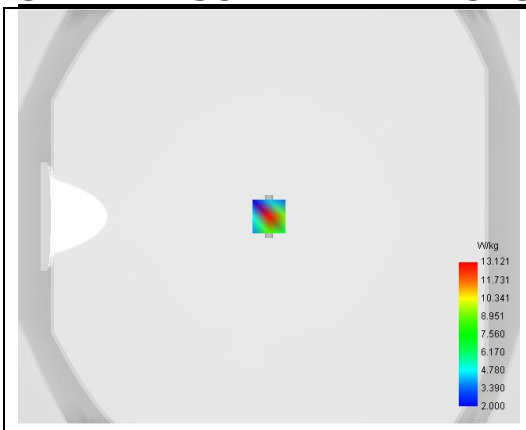


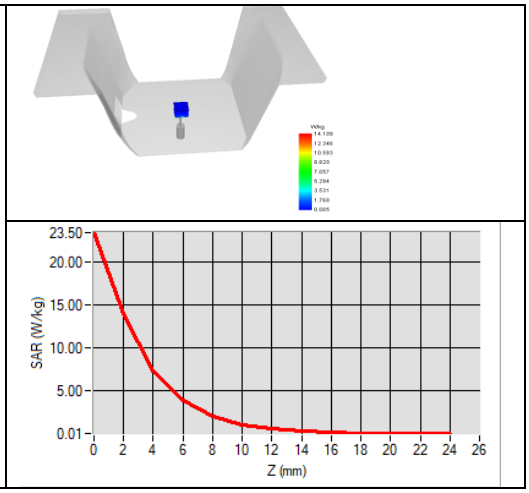
6.3.2 SAR with Body Liquid

Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 4424-EPGO-443
Liquid	Body Liquid Values @ 5200 MHz: eps' : 44.9 sigma : 5.53 Body Liquid Values @ 5400 MHz: eps' : 44.7 sigma : 5.83 Body Liquid Values @ 5600 MHz: eps' : 44.4 sigma : 6.15 Body Liquid Values @ 5800 MHz: eps' : 43.8 sigma : 6.47
Distance between dipole center and liquid	10.0 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=4mm/dy=4mm/dz=2mm
Frequency	5200 5400 5600 5800
Input power	20 dBm
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

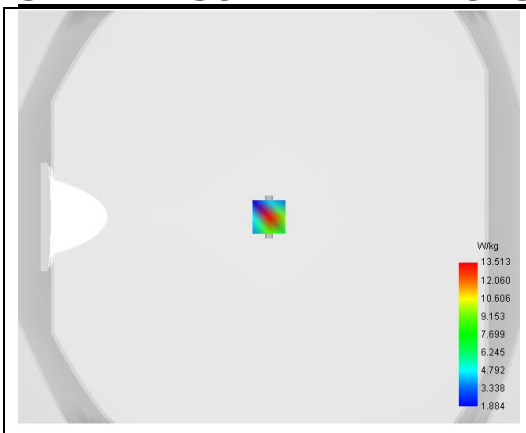
Frequency	**1g SAR (W/kg)**			**10g SAR (W/kg)**		
	Measured	**Measured normalized to 1W**	**Target normalized to 1W**	**Measured**	**Measured normalized to 1W**	**Target normalized to 1W**
5200 MHz	7.73	77.31	72.50	2.21	22.06	21.20
5400 MHz	7.96	79.60	79.10	2.25	22.52	22.80
5600 MHz	8.25	82.54	78.50	2.34	23.43	23.00
5800 MHz	7.90	79.03	72.20	2.24	22.38	21.10

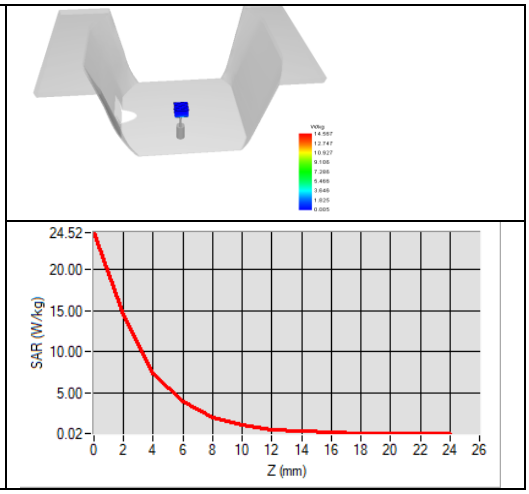
SAR MEASUREMENT PLOTS @ 5200 MHz



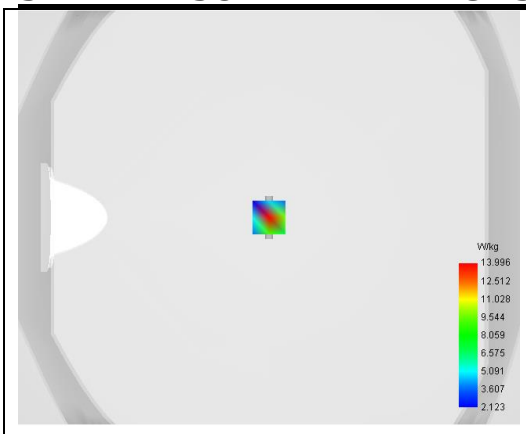


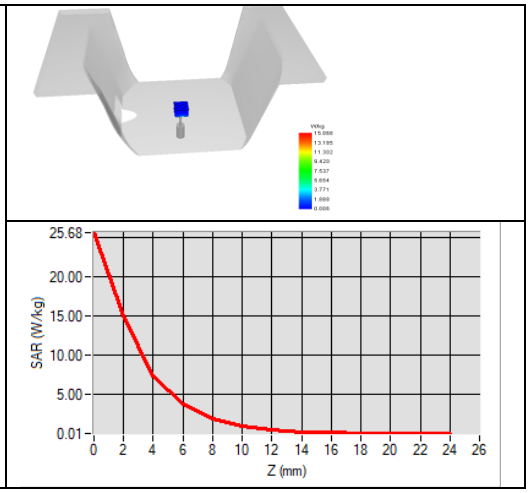
SAR MEASUREMENT PLOTS @ 5400 MHz



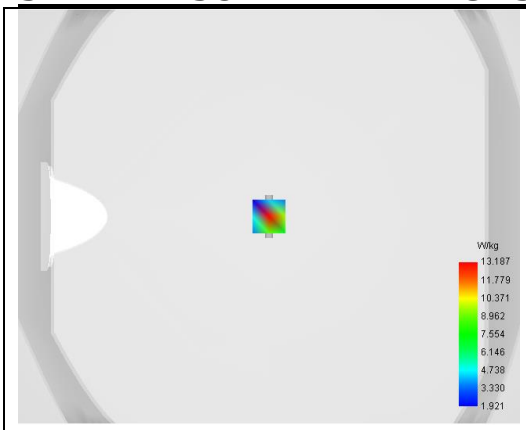


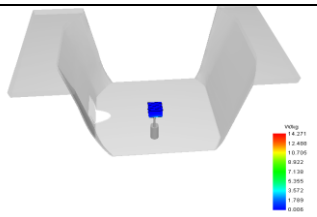
SAR MEASUREMENT PLOTS @ 5600 MHz

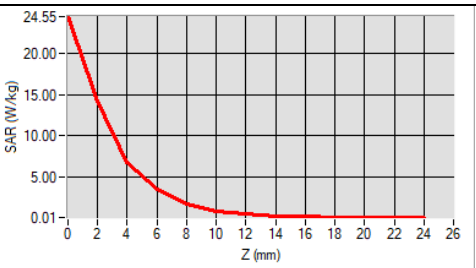




SAR MEASUREMENT PLOTS @ 5800 MHz







7 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	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Calipers	Mitutoyo	SN 0009732	11/2022	11/2025
Reference Probe	MVG	4424-EPGO-443	05/2025	05/2026
Multimeter	Keithley 2000	4013982	02/2023	02/2026
Signal Generator	Rohde & Schwarz SMB	183277	05/2022	05/2026
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	06/2026
Power Meter	Keysight U2000A	SN: MY62340002	10/2024	10/2027
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	44235403	10/2024	10/2027

Dielectric Probe Calibration Report

Ref : ACR.41.5.25.BES.A

BTF TESTING LAB (SHENZHEN) CO., LTD.

F101,201 AND 301, BUILDING 1, BLOCK 2, TANTOU INDUSTRIAL PARK, TANTOU COMMUNITY SONGGANG STREET, BAO'AN DISTRICT, SHENZHEN, CHINA

MVG LIMESAR DIELECTRIC PROBE

FREQUENCY: 0.15-7.5 GHZ

SERIAL NO.: SN 06/22 OCPG 88

Calibrated at MVG

Z.I. de la pointe du diable

Technopôle Brest Iroise – 295 avenue Alexis de Rochon

29280 PLOUZANE - FRANCE

Calibration date: 02/05/2025

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

Summary:

This document presents the method and results from an accredited Dielectric Probe calibration performed at MVG, using the LIMESAR test bench. The test results covered by accreditation are traceable to the International System of Units (SI).

	Name	*Function*	*Date*	*Signature*
Prepared by :	Pedro Ruiz	Technical Manager	2/10/2025	
Checked & approved by:	Pedro Ruiz	Technical Manager	2/10/2025	
Authorized by:	Geraldine Toutain	Quality Manager	2/10/2025	DocuSigned by: Géraldine TOUTAIN A1C9AC91CB5441A...

	Customer Name
Distribution :	BTF Testing Lab (Shenzhen) Co., Ltd.

Issue	*Name*	*Date*	*Modifications*
A	Pedro Ruiz	2/10/2025	Initial release

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6.1 Liquid complex Permittivity Measurement 5

7 List of Equipment 7

1 INTRODUCTION

This document contains a summary of the suggested methods and requirements set forth by the IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards for liquid permittivity measurements 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	LIMESAR DIELECTRIC PROBE
Manufacturer	MVG
Model	SCLMP
Serial Number	SN 06/22 OCPG 88
Product Condition (new / used)	Used

3 PRODUCT DESCRIPTION

3.1 GENERAL INFORMATION

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

Figure 1 – *MVG LIMESAR Dielectric Probe*

4 MEASUREMENT METHOD

The IEC/IEEE 62209-1528 and FCC KDB865664 D01 standards outline techniques for dielectric property measurements. The LIMESAR test bench employs one of the methods outlined in the standards, using a contact probe or open-ended coaxial transmission-line probe and vector network analyzer. The standards recommend the measurement of two reference materials that have well established and stable dielectric properties to validate the system, one for the calibration and one for checking the calibration. The LIMESAR test bench uses De-ionized water as the reference for the calibration and either Ethanediol or Methanol as the reference for checking the calibration. The following measurements were performed to verify that the product complies with the fore-mentioned standards.

4.1 LIQUID COMPLEX PERMITTIVITY MEASUREMENTS

The complex permittivity of a liquid with known dielectric properties was measured and the measurement results compared to the values provided in the fore mentioned standards.

5 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 a SAR probe calibration using the waveguide or calorimetric cell technique depending on the frequency.

The estimated expanded uncertainty (k=2) in calibration for relative permittivity is +/-10% with respect to measurement conditions.
The estimated expanded uncertainty (k=2) in calibration for conductivity (S/m) is +/-8.2% with respect to measurement conditions.

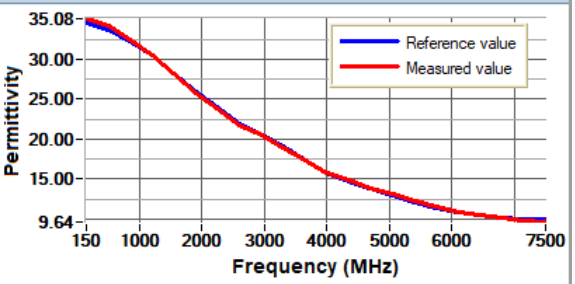
6 CALIBRATION RESULTS

Measurement Condition

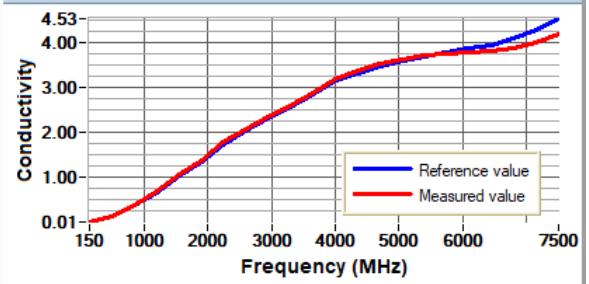
Software	LIMESAR
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

6.1 LIQUID COMPLEX PERMITTIVITY MEASUREMENT

A liquid of known characteristics (methanol or ethanediol) is measured with the probe and the results (complex permittivity ε'+jε") are compared with the reference values for this liquid.



Frequency (MHz)	Methanol Permittivity (Reference)	Methanol Permittivity (Measure)	Difference (%)	Limit (+/- %)
150	34.52	35.08	-1.6	10.0
500	33.73	34.18	-1.3	10.0
850	32.20	32.49	-0.9	10.0
1200	30.57	30.52	0.2	10.0
1550	28.17	28.17	0.0	10.0
1900	25.91	25.81	0.4	10.0
2250	24.02	23.86	0.7	10.0
2600	22.00	21.79	0.9	10.0
2950	20.53	20.43	0.5	10.0
3300	19.03	18.95	0.4	10.0
3650	17.44	17.44	-0.0	10.0
4000	15.76	15.84	-0.5	10.0
4350	14.75	14.84	-0.5	10.0
4700	13.82	13.92	-0.7	10.0
5050	12.97	13.08	-0.9	10.0
5400	12.18	12.27	-0.8	10.0
5750	11.44	11.51	-0.6	10.0
6100	10.88	10.90	-0.2	10.0
6450	10.52	10.47	0.4	10.0
6800	10.23	10.11	1.3	10.0
7150	10.06	9.81	2.5	10.0
7500	10.01	9.64	3.7	10.0



Frequency (MHz)	Methanol Conductivity (Reference)	Methanol Conductivity (Measure)	Difference (%)	Limit (+/- %)
150	0.01	0.01	-5.5	8.2
500	0.14	0.15	-7.0	8.2
850	0.37	0.39	-5.7	8.2
1200	0.67	0.69	-3.4	8.2
1550	1.04	1.08	-4.2	8.2
1900	1.36	1.40	-2.9	8.2
2250	1.74	1.79	-2.9	8.2
2600	2.04	2.07	-1.7	8.2
2950	2.32	2.35	-1.3	8.2
3300	2.57	2.61	-1.5	8.2
3650	2.84	2.88	-1.4	8.2
4000	3.15	3.20	-1.6	8.2
4350	3.33	3.38	-1.7	8.2
4700	3.48	3.52	-1.2	8.2
5050	3.60	3.63	-0.8	8.2
5400	3.70	3.71	-0.2	8.2
5750	3.78	3.74	1.0	8.2
6100	3.87	3.78	2.2	8.2
6450	3.95	3.81	3.6	8.2
6800	4.09	3.88	5.0	8.2
7150	4.29	4.01	6.5	8.2
7500	4.53	4.19	7.6	8.2

7 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
LIMESAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Liquid measurement probe	MVG	SN 35/10 OCPG37	01/2025	02/2026
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2026
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	07/2022	07/2027
Temperature / Humidity Sensor	Testo 184 H1	44235403	10/2024	10/2027

中 国 检 验 认 证 集 团
CHINA CERTIFICATION & INSPECTION GROUP
中检（深圳）计量测试服务有限公司
CCIC (Shenzhen) Metrology & Testing Service Co.,Ltd

中国认可
国际互认
校准
CALIBRATION
CNAS L3103

校 准 证 书
CALIBRATION CERTIFICATE

证书编号：S424079462
Certificate No.

客户信息 Customer Information

客户名称: Name	信恒检测技术（深圳）有限公司
客户地址: Address	深圳市宝安区松岗街道潭头社区潭头工业城二区1栋厂房101.201.301

被校测量器具信息 Information of Instrument under Calibration

仪器名称: Description	Coaxial mechanical calibration parts同轴机械校准件
型号规格: Model/Type	50Ω 35mm 9G
制造厂商: Manufacturer	南京普纳科技设备有限公司
出厂编号: Serial No.	/
管理编号: Asset No.	BTF-EM-068
接收日期: Received Date	2024 / 10 / 25
接收状态: As Received	正常/Normal
结 论: Conclusion	参照检测/校准结果使用。 The test or calibration results are referred to evaluate the validity of instrument measurement.

证书专用章
Issued by

扫一扫查真伪

证书有效性声明：
1、证书首页盖有证书章
2、证书须有唯一防伪码
3、扫描信息与证书一致

校准日期: 2024 / 10 / 25
Cal.Date

签发日期: 2024 / 10 / 30
Issue Date

建议复校日期: 2025 / 10 / 24
Next Cal. Date

校准: 刘金辉
Calibrated by

核验: 何聪
Inspected by

签发: 杨帆 （总经理助理）
Approved by

地址：深圳市光明区玉塘街道田寮社区同仁路盛荟红星创智广场
Addr：ShengHui Hongxing Chuangzhi Square, Tongren Road, Tianliao Community, Yutang Street, Guangming District, Shenzhen
邮政编码(Post No.)：518107
网址(Web)：http://www.ccic-mts.com
电话(Tel)：0755-86139118
传真(Fax)：0755-86139110
邮箱(e-mail): Calibration@sz.ccic.com

校 准 说 明

CALIBRATION DIRECTIONS

证书编号：S424079462
Certificate No.

1. 本公司实验室经中国合格评定国家认可委员会审核，符合ISO/IEC17025《检测和校准实验室能力的通用要求》的要求，认可证书号：No.L3103。
   This laboratory is accredited to ISO/IEC 17025《Requirements for the competence of Testing and Calibration Laboratories》,CNAS Accreditation Certificate No.L3103.
2. 本证书中的校准结果均可溯源至国际单位制（SI）单位。
   The calibration results in this certificate are traceable to International System of Units(SI)
3. 对本次校准若有异议，委托方应于收到被校件之日起十五日内向本公司提出。
   If there is any objection concerning the calibration, the Client should inform the issuing company within 15 days from the date of the device under test return to the client.
4. 未经本公司许可，不得部分复印、摘用或篡改本证书的内容。
   This report may not be reproduced, except in full, without the written approval of CCIC (ShenZhen) Metrology & Testing Service Co.,Ltd.
5. 本证书校准结果只与被校准仪器有关，带'*'号的校准项目或参数不在本公司实验室认可范围内。
   The results reported here in apply only to the calibrated equipment，Calibration items or parameter with '* ' is beyond the scope of our laboratory acc reditation.
6. 本次校准的技术依据:
   Procedures for the Calibration:

参照 JJF 1495-2014《矢量网络分析仪校准规范》 C.S. for Vector network analyzer
JJF(军工)76-2014《微波二端口器件校准规范》 C.S. for Two-port Microwave Devices

7. 本次校准所使用的主要标准器具:
   Standards Used in the Calibration:

器具名称/型号规格 Instrument Description/Model	编 号 Asset No.	证书编号 Certificate No.	有效期 Due Date	计量特性 Metrological Characteristic	溯源机构 Traceability institutions
网络分析仪/Vector Network Analyzer E5071C	CCIC-WX-1024	JL2402278931	2025/02/05	Sij模值:U=0.12dB;Sij相位:U=0.9°;VSWR:U=0.030;(k=2)	深圳计量院
N型校准套件/Type-N Calibration Kit 85054B	CCIC-WX-1006	GFJGJL1002220078220	2025/04/28	Reflection:U=0.02(k=2);Phase:U=1°(k=2);	二○三所

8. 校准地点和环境条件:
   Place and environmental conditions:

地 点：客户现场 实验室 Place of Calibration
温 度：（22.5 ~ 23）℃ Temperature
相对湿度：（55 ~ 60）% Relative Humidity

校 准 结 果
CALIBRATION RESULT

证书编号：S424079462
Certificate No.

1、 外观及正常性检查： 正常

Check on Appearance and Function： Pass

2、 50Ω负载驻波比

50Ω load VSWR

频率 Frequency (MHz)	实测值 Measured /
10	1.004
50	1.005
100	1.007
200	1.006
500	1.007
1000	1.011
2000	1.012
3000	1.018
4000	1.021
5000	1.023
6000	1.023
7000	1.019
8000	1.016
9000	1.017

3、 开路反射

Open circuit reflex

频率 Frequency (MHz)	实测值 Measured /
10	1.000
50	1.000
100	1.000
200	1.000

校 准 结 果
CALIBRATION RESULT

500	1.000
1000	1.000
2000	0.999
3000	0.998
4000	0.995
5000	0.993
6000	0.991
7000	0.989
8000	0.987
9000	0.987

4、 开路相位

Open phase

频率 Frequency (MHz)	实测值 Measured (°)
10	-0.22
50	-1.12
100	-2.23
200	-4.42
500	-11.10
1000	-22.27
2000	-44.37
3000	-67.00
4000	-89.40
5000	-111.91
6000	-134.79
7000	-157.98
8000	179.05
9000	155.91

5、 短路反射

校 准 结 果
CALIBRATION RESULT

Short circuit reflex

频率 Frequency (MHz)	实测值 Measured /
10	0.999
50	0.998
100	0.997
200	0.996
500	0.994
1000	0.990
2000	0.988
3000	0.988
4000	0.988
5000	0.988
6000	0.990
7000	0.992
8000	0.990
9000	0.992

6、 短路相位

Short phase

频率 Frequency (MHz)	实测值 Measured (°)
10	179.74
50	178.69
100	177.44
200	175.02
500	167.80
1000	155.90
2000	132.22

校 准 结 果

CALIBRATION RESULT

3000	108.77
4000	89.80
5000	62.70
6000	40.54
7000	18.00
8000	-4.05
9000	-26.09

说明(Notes)

1、本次校准的测量不确定度

Measurement Uncertainty in Calibration

1.1 依据JJF 1059.1-2012 测量不确定度评定与表示

Conform JJF 1059.1-2012 *Evaluation and Expression of Uncertainty in Measurement.*

1.2 本次测量结果的扩展不确定度（k=2）

The Expanded Uncertainty of the Measurement Results

—— 反射系数相位(Reflective Phase) U = 1.7°

—— 反射系数模值 (Reflective Properties) U = 0.029

以下空白

End of Report