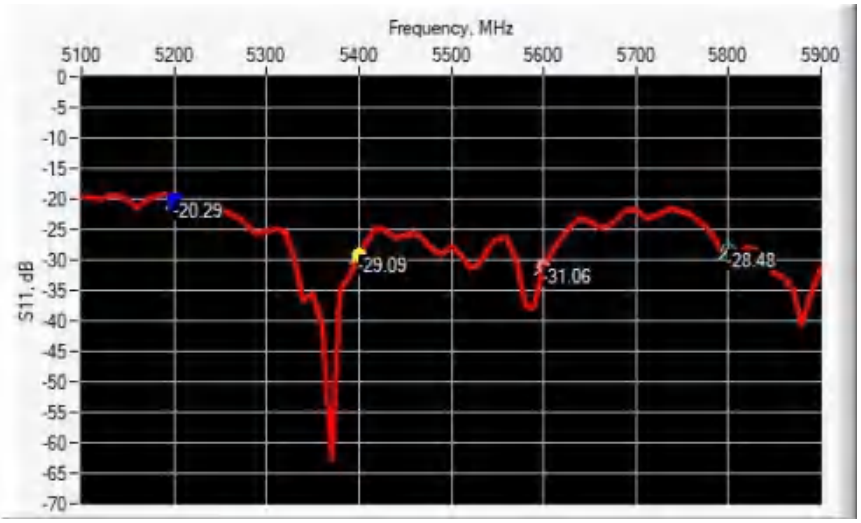
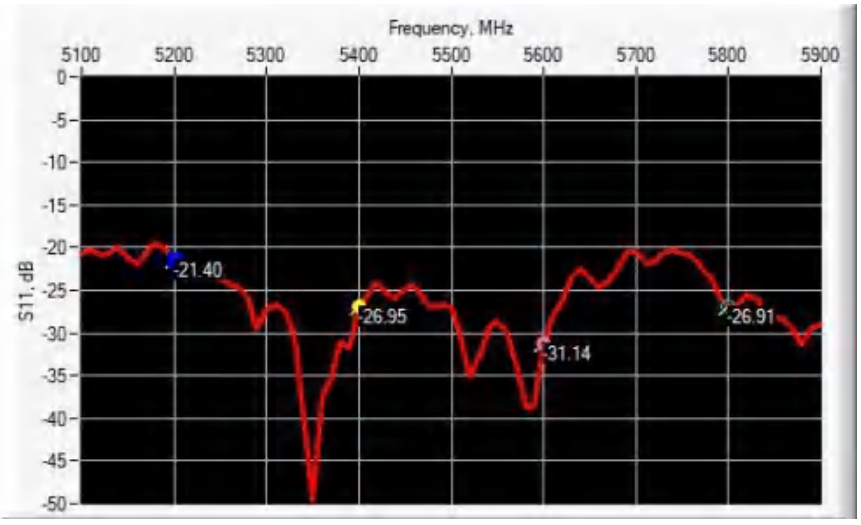
6 CALIBRATION MEASUREMENT RESULTS

6.1 RETURN LOSS IN HEAD LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
5200	-20.29	-20	58.76 Ω - 4.43 jΩ
5400	-29.09	-20	53.46 Ω + 0.61 jΩ
5600	-31.06	-20	52.76 Ω - 0.45 jΩ
5800	-28.48	-20	50.12 Ω - 3.76 jΩ

6.2 RETURN LOSS IN BODY LIQUID



Frequency (MHz)	Return Loss (dB)	Requirement (dB)	Impedance
5200	-21.40	-20	57.13 Ω - 4.54 jΩ
5400	-26.95	-20	54.47 Ω - 0.31 jΩ
5600	-31.14	-20	52.65 Ω + 0.81 jΩ
5800	-26.91	-20	49.92 Ω - 4.51 jΩ

6.3 MECHANICAL DIMENSIONS

Frequency MHz	**L** mm		**h** mm		**d** mm	
	required	**measured**	**required**	**measured**	**required**	**measured**
5000 to 6000	20.6±1 %.	20.78	40.3 ±1 %.	40.59	3.6 ±1 %.	3.59

7 VALIDATION MEASUREMENT

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

7.1 HEAD LIQUID MEASUREMENT

Frequency MHz	**Relative permittivity (ε_r')**		**Conductivity (σ) S/m**	
	required	**measured**	**required**	**measured**
5000	36.2 ±10 %		4.45 ±10 %	
5100	36.1 ±10 %		4.56 ±10 %	
5200	36.0 ±10 %	34.44	4.66 ±10 %	4.64
5300	35.9 ±10 %		4.76 ±10 %	
5400	35.8 ±10 %	33.63	4.86 ±10 %	4.88
5500	35.6 ±10 %		4.97 ±10 %	
5600	35.5 ±10 %	32.80	5.07 ±10 %	5.12
5700	35.4 ±10 %		5.17 ±10 %	
5800	35.3 ±10 %	32.63	5.27 ±10 %	5.31
5900	35.2 ±10 %		5.38 ±10 %	
6000	35.1 ±10 %		5.48 ±10 %	

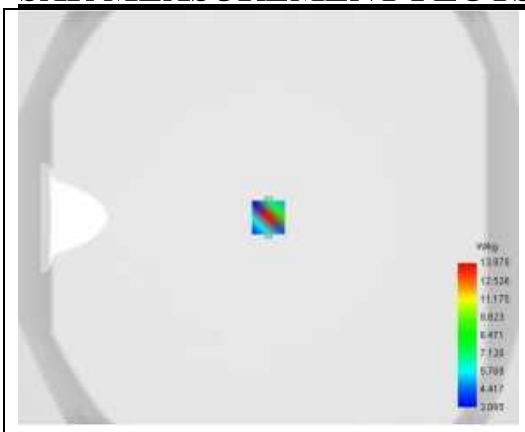
7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

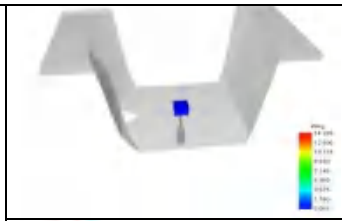
At those frequencies, the target SAR value can not be generic. Hereunder is the target SAR value defined by MVG, within the uncertainty for the system validation. All SAR values are normalized to 1 W net power. In bracket, the measured SAR is given with the used input power.

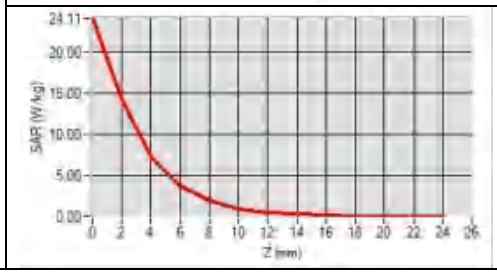
Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Head Liquid Values 5200 MHz: eps' :34.44 sigma : 4.64 Head Liquid Values 5400 MHz: eps' :33.63 sigma : 4.88 Head Liquid Values 5600 MHz: eps' :32.80 sigma : 5.12 Head Liquid Values 5800 MHz: eps' :32.63 sigma : 5.31
Distance between dipole and liquid	10 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=4mm/dy=4m/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 (MHz)	1 g SAR (W/kg)		10 g SAR (W/kg)	
	required	measured	required	measured
5200	76.50	73.88 (7.39)	21.60	21.29 (2.13)
5400	-	81.47 (8.15)	-	23.23 (2.32)
5600	-	78.71 (7.87)	-	22.64 (2.26)
5800	78.00	74.21 (7.42)	21.90	21.50 (2.15)

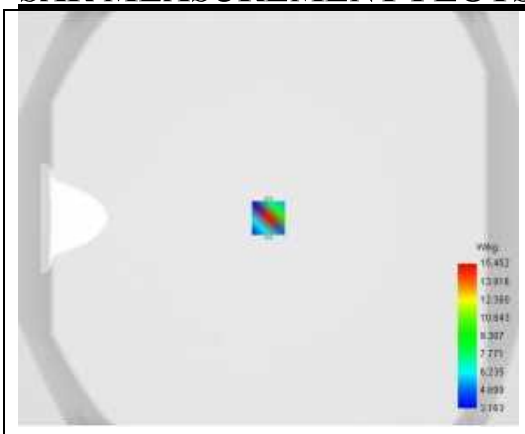
SAR MEASUREMENT PLOTS @ 5200 MHz

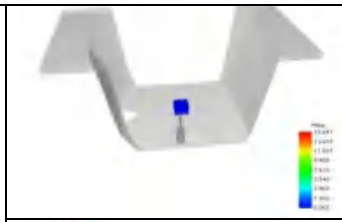


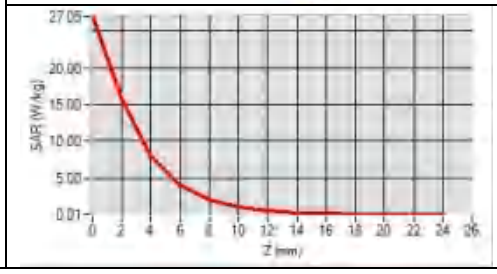




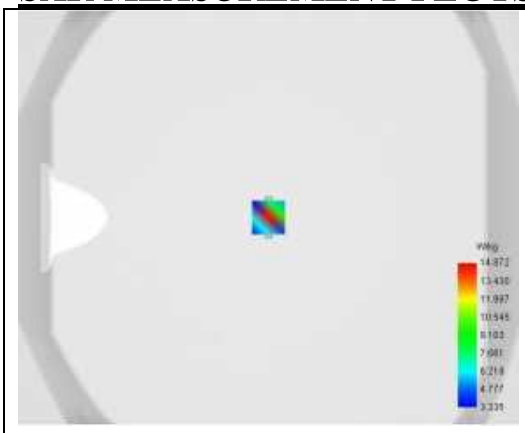
SAR MEASUREMENT PLOTS @ 5400 MHz

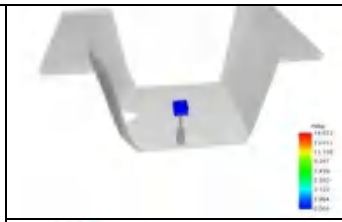


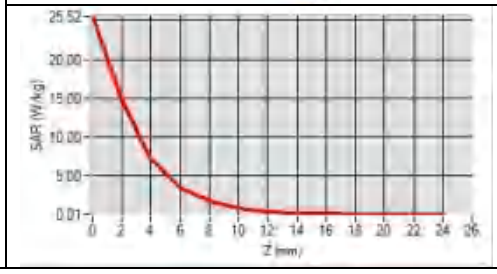




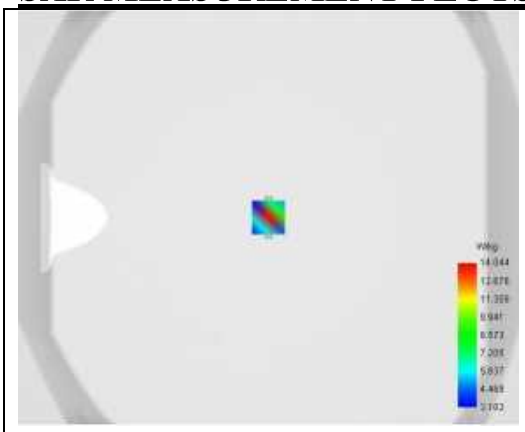
SAR MEASUREMENT PLOTS @ 5600 MHz

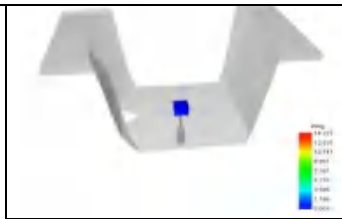


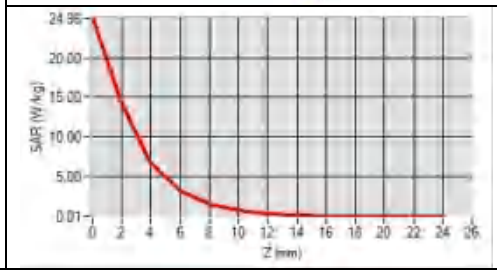




SAR MEASUREMENT PLOTS @ 5800 MHz







7.3 BODY LIQUID MEASUREMENT

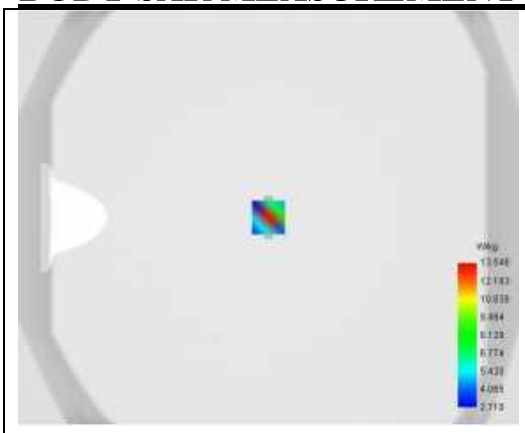
Frequency MHz	Relative permittivity (ε_r')		Conductivity (σ) S/m	
	required	measured	required	measured
5200	49.0 ±10 %	45.50	5.30 ±10 %	5.63
5300	48.9 ±10 %		5.42 ±10 %	
5400	48.7 ±10 %	44.78	5.53 ±10 %	5.95
5500	48.6 ±10 %		5.65 ±10 %	
5600	48.5 ±10 %	44.85	5.77 ±10 %	6.26
5800	48.2 ±10 %	44.45	6.00 ±10 %	6.58

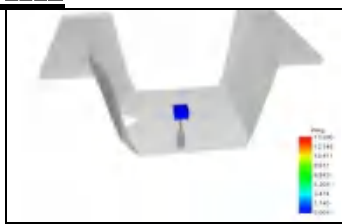
7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

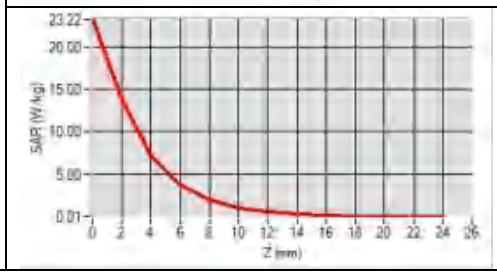
Software	OPENSAR V5
Phantom	SN 13/09 SAM68
Probe	SN 41/18 EPGO333
Liquid	Body Liquid Values 5200 MHz: eps' :45.50 sigma : 5.63 Body Liquid Values 5400 MHz: eps' :44.78 sigma : 5.95 Body Liquid Values 5600 MHz: eps' :44.85 sigma : 6.26 Body Liquid Values 5800 MHz: eps' :44.45 sigma : 6.58
Distance between dipole and liquid	10 mm
Area scan resolution	dx=8mm/dy=8mm
Zoon Scan Resolution	dx=4mm/dy=4m/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 (MHz)	1 g SAR (W/kg)	10 g SAR (W/kg)
	measured	measured
5200	71.75 (7.18)	20.38 (2.04)
5400	75.93 (7.59)	21.44 (2.14)
5600	77.44 (7.74)	22.16 (2.22)
5800	69.01 (6.90)	19.75 (1.97)

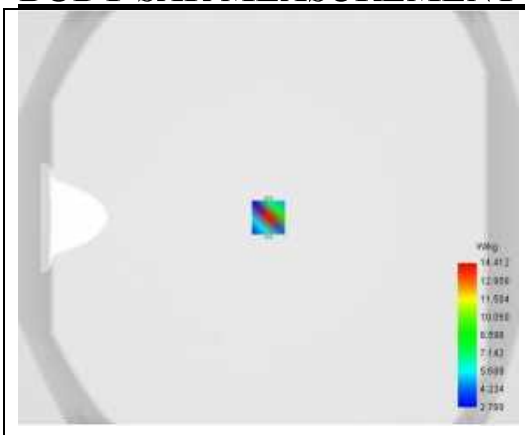
BODY SAR MEASUREMENT PLOTS @ 5200 MHz

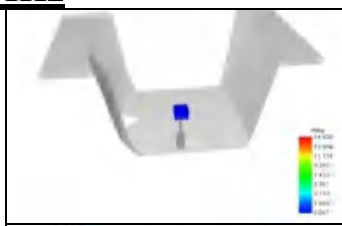


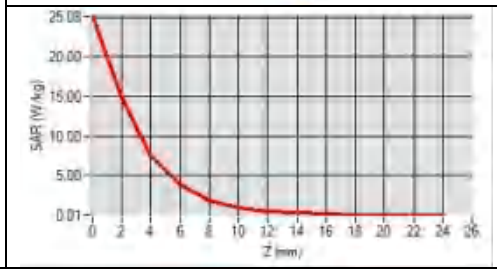




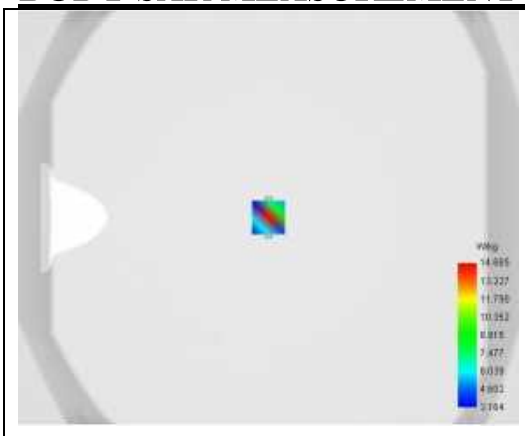
BODY SAR MEASUREMENT PLOTS @ 5400 MHz

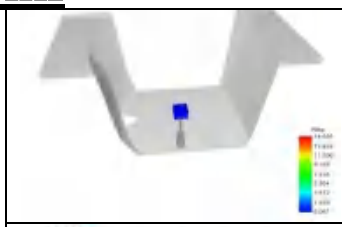


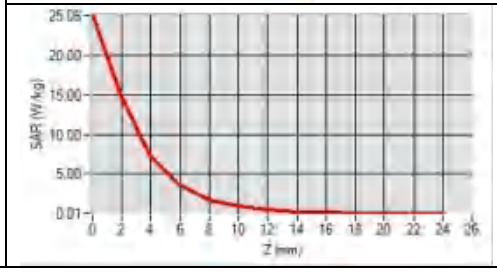




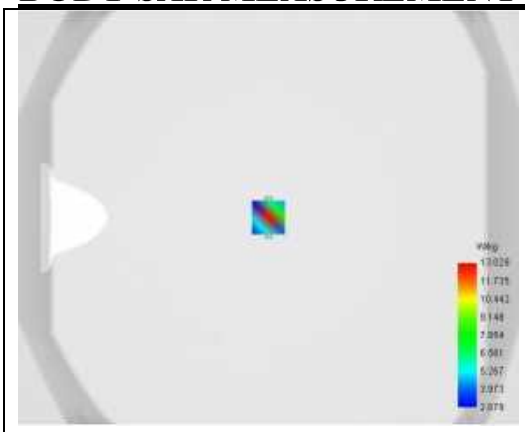
BODY SAR MEASUREMENT PLOTS @ 5600 MHz

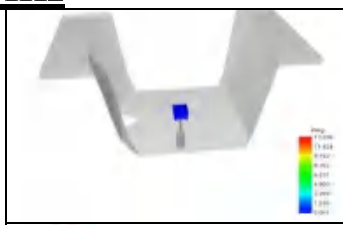


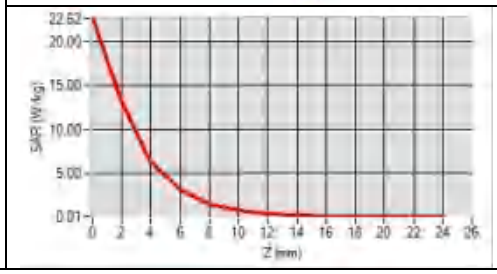




BODY SAR MEASUREMENT PLOTS @ 5800 MHz







8 LIST OF EQUIPMENT

Equipment Summary Sheet				
Equipment Description	**Manufacturer / Model**	**Identification No.**	**Current Calibration Date**	**Next Calibration Date**
SAM Phantom	MVG	SN 13/09 SAM68	Validated. No cal required.	Validated. No cal required.
COMOSAR Test Bench	Version 3	NA	Validated. No cal required.	Validated. No cal required.
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2021	10/2024
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2021	05/2024
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Calipers	Mitutoyo	SN 0009732	10/2021	10/2024
Reference Probe	MVG	SN 41/18 EPGO333	10/2021	10/2024
Multimeter	Keithley 2000	1160271	02/2021	02/2024
Signal Generator	Rohde & Schwarz SMB	106589	04/2021	04/2024
Amplifier	MVG	MODU-023-C-0002	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Power Meter	NI-USB 5680	170100013	06/2021	06/2024
Power Meter	Rohde & Schwarz NRVD	832839-056	11/2021	11/2024
Directional Coupler	Krytar 158020	131467	Characterized prior to test. No cal required.	Characterized prior to test. No cal required.
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024

Dielectric Probe Calibration Report

Ref : ACR.49.20.22.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: 0.4-6 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: 02/02/2024

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 :	Jérôme Luc	Technical Manager	2/2/2024	
Checked by :	Jérôme Luc	Technical Manager	2/2/2024	
Approved by :	Yann Toutain	Laboratory Director	2/2/2024	Yann TOUTAIN 2024.02.03 11:29:33 +01'00'

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

Issue	*Name*	*Date*	*Modifications*
A	Jérôme Luc	2/2/2024	Initial release

TABLE OF CONTENTS

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)	New

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 DMS 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 PERMITTIVITY MEASUREMENTS

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

5 MEASUREMENT UNCERTAINTY

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

5.1 DIELECTRIC PERMITTIVITY MEASUREMENT

The following uncertainties apply to the Dielectric Permittivity measurement:

Uncertainty analysis of Permittivity Measurement					
ERROR SOURCES	**Uncertainty value (+/-%)**	**Probability Distribution**	**Divisor**	**ci**	**Standard Uncertainty (+/-%)**
Expanded uncertainty (confidence level of 95%, k = 2)					10 %

Uncertainty analysis of Conductivity Measurement					
ERROR SOURCES	**Uncertainty value (+/-%)**	**Probability Distribution**	**Divisor**	**ci**	**Standard Uncertainty (+/-%)**
Expanded uncertainty (confidence level of 95%, k = 2)					8.2%

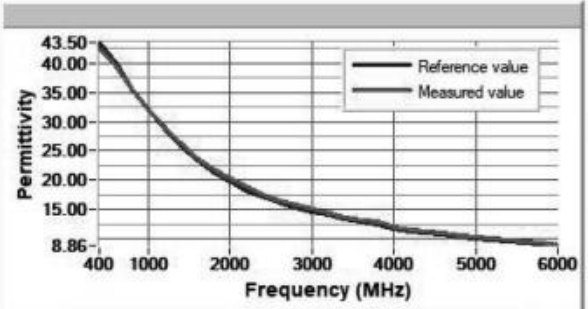
6 CALIBRATION MEASUREMENT RESULTS

Measurement Condition

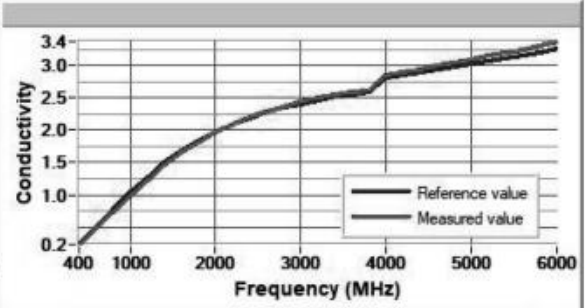
Software	LIMESAR
Liquid Temperature	20 +/- 1 °C
Lab Temperature	20 +/- 1 °C
Lab Humidity	30-70 %

6.1 LIQUID 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)	Ethanediol Permittivity (Reference)	Ethanediol Permittivity (Measure)	Difference (%)	Limit (+/- %)
400	43.50	42.34	2.2	10.0
600	39.92	39.37	1.4	10.0
800	35.68	35.51	0.3	10.0
1000	31.98	32.06	-0.2	10.0
1200	28.77	29.01	-0.8	10.0
1400	25.86	26.26	-1.6	10.0
1600	23.36	22.78	-1.8	10.0
1800	21.33	21.68	-1.7	10.0
2000	19.78	20.82	-3.2	10.0
2200	18.27	18.78	-2.8	10.0
2400	17.17	17.48	-1.8	10.0
2600	16.16	16.79	-2.0	10.0
2800	15.29	15.74	-2.9	10.0
3000	14.60	14.97	-2.5	10.0
3200	14.03	14.51	-2.0	10.0
3400	13.49	13.75	-1.9	10.0
3600	12.95	13.24	-2.3	10.0
3800	12.53	12.83	-2.3	10.0
4000	11.62	11.29	-2.3	10.0
4200	11.28	11.53	-2.3	10.0
4400	10.97	11.23	-2.3	10.0
4600	10.68	10.96	-2.1	10.0
4800	10.40	10.60	-1.9	10.0
5000	10.11	10.39	-1.8	10.0
5200	9.85	10.01	-1.7	10.0
5400	9.59	9.73	-1.5	10.0
5600	9.35	9.48	-1.5	10.0
5800	9.14	9.25	-1.0	10.0
6000	8.86	8.95	-1.0	10.0



Frequency (MHz)	Ethanediol Conductivity (Reference)	Ethanediol Conductivity (Measure)	Difference (%)	Limit (+/- %)
400	0.24	0.23	3.5	8.2
600	0.50	0.46	6.9	8.2
800	0.78	0.74	5.4	8.2
1000	1.05	1.00	4.6	8.2
1200	1.27	1.20	3.4	8.2
1400	1.50	1.47	1.8	8.2
1600	1.69	1.64	1.8	8.2
1800	1.84	1.81	2.0	8.2
2000	1.97	1.94	0.4	8.2
2200	2.09	2.09	0.1	8.2
2400	2.19	2.22	-0.8	8.2
2600	2.29	2.29	0.1	8.2
2800	2.36	2.34	-0.1	8.2
3000	2.41	2.44	-1.2	8.2
3200	2.47	2.50	-1.5	8.2
3400	2.52	2.55	-1.0	8.2
3600	2.56	2.59	-1.3	8.2
3800	2.59	2.61	-1.3	8.2
4000	2.81	2.85	-1.5	8.2
4200	2.85	2.90	-1.8	8.2
4400	2.89	2.94	-1.7	8.2
4600	2.95	3.01	-2.1	8.2
4800	3.00	3.06	-2.1	8.2
5000	3.03	3.11	-2.3	8.2
5200	3.07	3.15	-2.6	8.2
5400	3.12	3.20	-2.7	8.2
5600	3.15	3.25	-3.0	8.2
5800	3.21	3.30	-3.0	8.2
6000	3.26	3.38	-3.5	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	11/2022	11/2023
Network Analyzer	Rohde & Schwarz ZVM	100203	08/2021	08/2024
Network Analyzer	Agilent 8753ES	MY40003210	10/2021	10/2024
Network Analyzer – Calibration kit	Rohde & Schwarz ZV-Z235	101223	05/2021	05/2024
Network Analyzer – Calibration kit	HP 85033D	3423A08186	06/2021	06/2027
Temperature / Humidity Sensor	Testo 184 H1	44225320	06/2021	06/2024

校 准 证 书
CALIBRATION CERTIFICATE

证书编号：S423066282
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	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	2023 / 11 / 16
接收状态: As Received	正常
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.

中检（深圳）计量测试服务有限公司 计量专用章
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: Cal.Date	2023 / 11 / 16	校准: Calibrated by	刘金辉
签发日期: Issue Date	2023 / 11 / 17	核验: Inspected by	何聪
建议复校日期: Next Cal. Date	2024 / 11 / 15	签发: Approved by	杨帆（总经理助理）

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：S423066282
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．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.

3. 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.

4. 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.

5. 本次校准的技术依据:

   Procedures for the Calibration:

参照JJG(电子)306001-2006《射频同轴阻抗标准器检定规程》 V.R. of RF Coaxial Impedance standard
参照 JZM 35118J-2017《微波元器件校准方法》 Microwave components calibration method

6. 本次校准所使用的主要标准器具：

   Standards Used in the Calibration:

器具名称 Instrument Description	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	CCIC-WX-1024	JL2315557151	2024/03/13	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	CCIC-WX-1006	GFJGJL1002220078220	2025/04/28	Reflection:U=0.02(k=2);Phase:U=1°(k=2);	二○三所

7.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：（23.5 ~ 24.5）℃ Temperature

相对湿度：（58 ~ 68）% Relative Humidity

校 准 结 果

CALIBRATION RESULT

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	1.003
100	1.005
200	1.005
500	1.006
1000	1.009
2000	1.012
3000	1.017
4000	1.021
5000	1.023
6000	1.021
7000	1.018
8000	1.015
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	0.996
5000	0.994
6000	0.992
7000	0.989
8000	0.988
9000	0.987

4、 开路相位

Open phase

频率 Frequency (MHz)	实测值 Measured (°)
10	-0.23
50	-1.11
100	-2.22
200	-4.43
500	-11.10
1000	-22.27
2000	-44.38
3000	-66.99
4000	-89.40
5000	-111.92
6000	-134.79
7000	-157.97
8000	179.05
9000	155.91

5、 短路反射