

The measured worst case boundary effect SARuncertainty[%] for scanning distances larger than 4mm is 1.0% Limit ,2%).

#### 4 MEASUREMENT UNCERTAINTY

The guidelines outlined in the IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty associated with an E-field probe calibration using the waveguide technique. All uncertainties listed below represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2, traceable to the Internationally Accepted Guides to Measurement Uncertainty.

| Uncertainty analysis of the probe calibration in waveguide |                       |                          |         |    |                          |
|------------------------------------------------------------|-----------------------|--------------------------|---------|----|--------------------------|
| ERROR SOURCES                                              | Uncertainty value (%) | Probability Distribution | Divisor | ci | Standard Uncertainty (%) |
| Expanded uncertainty<br>95 % confidence level k = 2        |                       |                          |         |    | 14 %                     |

#### 5 CALIBRATION MEASUREMENT RESULTS

| Calibration Parameters |             |
|------------------------|-------------|
| Liquid Temperature     | 20 +/- 1 °C |
| Lab Temperature        | 20 +/- 1 °C |
| Lab Humidity           | 30-80 %     |

##### 5.1 SENSITIVITY IN AIR

|                                            |                                            |                                            |
|--------------------------------------------|--------------------------------------------|--------------------------------------------|
| Normx dipole<br>1 (μV/(V/m) <sup>2</sup> ) | Normy dipole<br>2 (μV/(V/m) <sup>2</sup> ) | Normz dipole<br>3 (μV/(V/m) <sup>2</sup> ) |
| 0.81                                       | 0.71                                       | 0.80                                       |

|                      |                      |                      |
|----------------------|----------------------|----------------------|
| DCP dipole 1<br>(mV) | DCP dipole 2<br>(mV) | DCP dipole 3<br>(mV) |
| 115                  | 112                  | 112                  |

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

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

Page: 6/10

Template\_ACR.DDD.N.YY.MVGB.ISSUE\_COMOSAR Probe vH

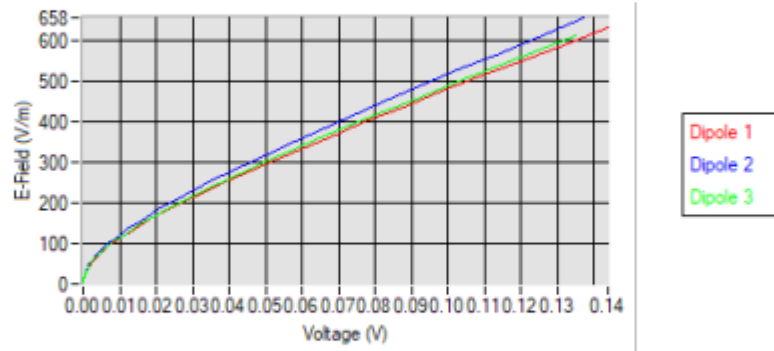
This document shall not be reproduced, except in full or in part, without the written approval of MVG. The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## COMOSAR E-FIELD PROBE CALIBRATION REPORT

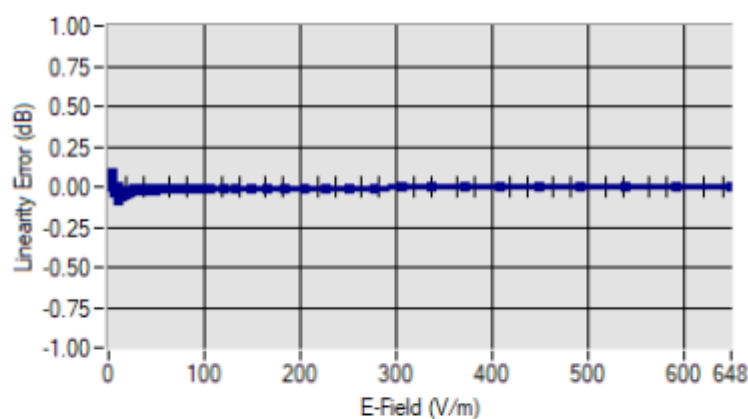
Ref: ACR.297.1.20.MVGB.A

Calibration curves



### 5.2 LINEARITY

Linearity



Linearity:  $\pm 1.97\%$  ( $\pm 0.09\text{dB}$ )

Page: 7/10

Template\_ACR.DDD.N.YY.MVGB.ISSUE\_COMOSAR Probe vH

This document shall not be reproduced, except in full or in part, without the written approval of MVG. The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.297.1.20.MVGB.A

5.3 SENSITIVITY IN LIQUID

| Liquid | Frequency<br>(MHz +/-<br>100MHz) | ConvF | Epsilon (S/m) | Permittivity |
|--------|----------------------------------|-------|---------------|--------------|
| HL750  | 750                              | 1.71  | 0.93          | 40.76        |
| BL750  | 750                              | 1.78  | 0.98          | 56.70        |
| HL900  | 900                              | 1.91  | 0.93          | 41.94        |
| BL900  | 900                              | 1.96  | 0.98          | 54.62        |
| HL1800 | 1800                             | 2.08  | 1.29          | 40.86        |
| BL1800 | 1800                             | 2.16  | 1.47          | 52.27        |
| HL2000 | 2000                             | 2.03  | 1.42          | 38.37        |
| BL2000 | 2000                             | 2.10  | 1.52          | 52.03        |
| HL2450 | 2450                             | 2.31  | 1.80          | 38.72        |
| BL2450 | 2450                             | 2.37  | 1.97          | 54.91        |
| HL2600 | 2600                             | 2.16  | 1.89          | 39.98        |
| BL2600 | 2600                             | 2.23  | 2.18          | 54.42        |
| HL5200 | 5200                             | 2.01  | 4.45          | 36.68        |
| BL5200 | 5200                             | 2.08  | 5.46          | 49.02        |
| HL5800 | 5800                             | 2.06  | 5.08          | 34.81        |
| BL5800 | 5800                             | 2.13  | 6.12          | 47.81        |

LOWER DETECTION LIMIT: 8mW/kg

Page: 8/10

Template\_ACR.DDD.N.YY.MVGB.ISSUE\_COMOSAR Probe vH

This document shall not be reproduced, except in full or in part, without the written approval of MVG. The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.

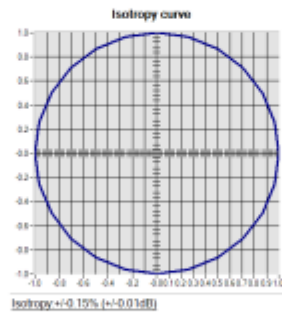


COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.297.1.20.MVGB.A

5.4 ISOTROPY

HL1800 MHz



Page: 9/10

Template\_ACR.DDD.N.YY.MVGB.ISSUE\_COMOSAR Probe vH

This document shall not be reproduced, except in full or in part, without the written approval of MVG. The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.297.1.20.MVGB.A

### 6 LIST OF EQUIPMENT

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

Page: 10/10

Template\_ACR.DDD.N.YY.MVGB.ISSUE\_COMOSAR Probe vH

This document shall not be reproduced, except in full or in part, without the written approval of MVG. The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.

Dielectric Probe Calibration



**Dielectric Probe Calibration Report**

Ref : ACR.138.4.33.SATU.A

**SHENZHEN TCT TESTING TECHNOLOGY CO., LTD**  
**2101&2201, ZHENCHANG FACTORY, RENSHAN**  
**INDUSTRIAL ZONE, FUHAI SUBDISTRICT, BAOAN**  
**DISTRICT, SHENZHEN, GUANGDONG, 518103,**  
**PEOPLES REPUBLIC OF CHINA**

**MVG COMOSAR DOSIMETRIC E-FIELD PROBE**

**FREQUENCY: 0.3-6 GHZ**  
**SERIAL NO.: SN 19/15 OCPG 71**

**Calibrated at MVG US**  
**2105 Barrett Park Dr. - Kennesaw, GA 30144**



**Calibration Date: 06/05/2021**

*Summary:*

This document presents the method and results from an accredited Dielectric Probe calibration performed in MVG USA using the LIMESAR test bench. All calibration results are traceable to national metrology institutions.



## SAR DIELECTRIC PROBE CALIBRATION REPORT

Ref: ACR.138.4.33.SATU.A

|               | Name          | Function        | Date       | Signature            |
|---------------|---------------|-----------------|------------|----------------------|
| Prepared by : | Jérôme LUC    | Product Manager | 06/05/2021 | <i>JS</i>            |
| Checked by :  | Jérôme LUC    | Product Manager | 06/05/2021 | <i>JS</i>            |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 06/05/2021 | <i>Kim Rutkowski</i> |

|                | Customer Name                            |
|----------------|------------------------------------------|
| Distribution : | SHENZHEN TCT TESTING TECHNOLOGY CO., LTD |

| Issue | Date       | Modifications   |
|-------|------------|-----------------|
| A     | 06/05/2021 | Initial release |
|       |            |                 |
|       |            |                 |
|       |            |                 |

Page: 2/7

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## TABLE OF CONTENTS

|     |                                           |   |
|-----|-------------------------------------------|---|
| 1   | Introduction.....                         | 4 |
| 2   | Device Under Test .....                   | 4 |
| 3   | Product Description .....                 | 4 |
| 3.1 | General Information .....                 | 4 |
| 4   | Measurement Method .....                  | 5 |
| 4.1 | Liquid Permittivity Measurements .....    | 5 |
| 5   | Measurement Uncertainty.....              | 5 |
| 5.1 | Dielectric Permittivity Measurement ..... | 5 |
| 6   | Calibration Measurement Results.....      | 6 |
| 6.1 | Liquid Permittivity Measurement .....     | 6 |
| 7   | List of Equipment .....                   | 7 |

Page: 3/7

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*





## SAR DIELECTRIC PROBE CALIBRATION REPORT

Ref: ACR.138.4.33..SATU.A

### 1 INTRODUCTION

This document contains a summary of the suggested methods and requirements set forth by the IEEE 1528 and CEI/IEC 62209 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 19/15 OCPG 71         |
| Product Condition (new / used) | Used                     |

A yearly calibration interval is recommended.

### 3 PRODUCT DESCRIPTION

#### 3.1 GENERAL INFORMATION

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



Figure 1 – MVG LIMESAR Dielectric Probe

Page: 4/7

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



#### 4 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C and CEI/TEC 62209-1 & 2 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 (+/- %) |
| Repeatability (n repeats, mid-band)                      | 4.00%                     | N                        | 1          | 1  | 4.000%                       |
| Deviation from reference liquid                          | 5.00%                     | R                        | $\sqrt{3}$ | 1  | 2.887%                       |
| Network analyser-drift, linearity                        | 2.00%                     | R                        | $\sqrt{3}$ | 1  | 1.155%                       |
| Test-port cable variations                               | 0.00%                     | U                        | $\sqrt{2}$ | 1  | 0.000%                       |
| Combined standard uncertainty                            |                           |                          |            |    | 5.066%                       |
| Expanded uncertainty (confidence level of 95%, $k = 2$ ) |                           |                          |            |    | 10.0%                        |

| Uncertainty analysis of Conductivity Measurement         |                           |                          |            |    |                              |
|----------------------------------------------------------|---------------------------|--------------------------|------------|----|------------------------------|
| ERROR SOURCES                                            | Uncertainty value (+/- %) | Probability Distribution | Divisor    | ci | Standard Uncertainty (+/- %) |
| Repeatability (n repeats, mid-band)                      | 3.50%                     | N                        | 1          | 1  | 3.500%                       |
| Deviation from reference liquid                          | 3.00%                     | R                        | $\sqrt{3}$ | 1  | 1.732%                       |
| Network analyser-drift, linearity                        | 2.00%                     | R                        | $\sqrt{3}$ | 1  | 1.155%                       |
| Test-port cable variations                               | 0.00%                     | U                        | $\sqrt{2}$ | 1  | 0.000%                       |
| Combined standard uncertainty                            |                           |                          |            |    | 4.072%                       |
| Expanded uncertainty (confidence level of 95%, $k = 2$ ) |                           |                          |            |    | 8.1%                         |

Page: 5/7

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR DIELECTRIC PROBE CALIBRATION REPORT

Ref: ACR.138.4.33\_SATU.A

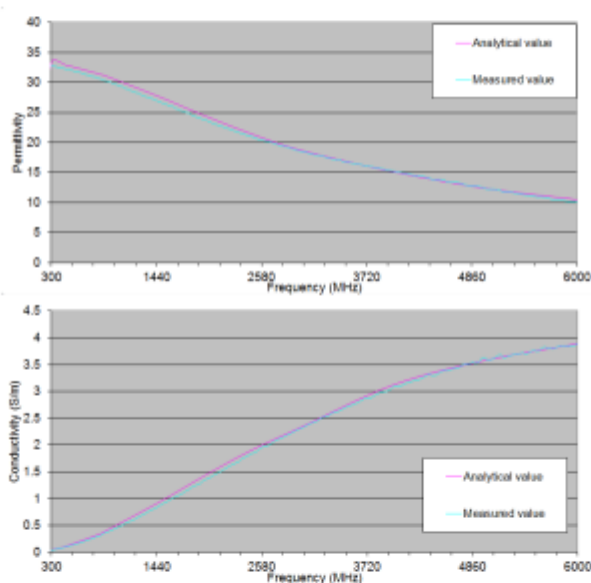
### 6 CALIBRATION MEASUREMENT RESULTS

#### Measurement Condition

|                    |         |
|--------------------|---------|
| Software           | LIMESAR |
| Liquid Temperature | 21°C    |
| Lab Temperature    | 21°C    |
| Lab Humidity       | 44%     |

#### 6.1 LIQUID PERMITTIVITY MEASUREMENT

A liquid of known characteristics (methanol at 20°C) is measured with the probe and the results (complex permittivity  $\epsilon' + j\epsilon''$ ) are compared with the well-known theoretical values for this liquid.



Page: 6/7

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



SAR DIELECTRIC PROBE CALIBRATION REPORT

Ref: ACR.138.433..SATU.A

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. |
| Network Analyzer                | Rhode & Schwarz ZVA  | SN100132           | 02/2021                     | 02/2024                     |
| Methanol CAS 67-56-1            | Alpha Aesar          | Lot D13W011        | Validated. No cal required. | Validated. No cal required. |
| Temperature and Humidity Sensor | Control Company      | 11-661-9           | 09/2021                     | 09/2022                     |

Page: 7/7

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*

## Appendix D: Dipole Calibration Report

SID2450



### SAR Reference Dipole Calibration Report

Ref : ACR.156.9.15.SATU.A

#### SHENZHEN TCT TESTING TECHNOLOGY CO., LTD

2101&2201, ZHENCHANG FACTORY, RENSHAN INDUSTRIAL  
FUHAI SUBDISTRICT, BAOAN DISTRICT, SHENZHEN,  
GUANGDONG, 518103, PEOPLES REPUBLIC OF CHINA

#### MVG COMOSAR REFERENCE DIPOLE

FREQUENCY: 2450 MHZ

SERIAL NO.: SN 16/15 DIP 2G450-374

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144



Calibration Date: 06/05/2021

#### Summary:

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



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

|               | Name          | Function        | Date       | Signature            |
|---------------|---------------|-----------------|------------|----------------------|
| Prepared by : | Jérôme LUC    | Product Manager | 06/05/2021 | <i>JS</i>            |
| Checked by :  | Jérôme LUC    | Product Manager | 06/05/2021 | <i>JS</i>            |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 06/05/2021 | <i>Kim Rutkowski</i> |

|                | Customer Name                            |
|----------------|------------------------------------------|
| Distribution : | SHENZHEN TCT TESTING TECHNOLOGY CO., LTD |

| Issue | Date       | Modifications   |
|-------|------------|-----------------|
| A     | 06/05/2021 | Initial release |
|       |            |                 |
|       |            |                 |
|       |            |                 |

Page: 2/11

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



**SAR REFERENCE DIPOLE CALIBRATION REPORT**

Ref: ACR.156.9.15.SATU.A

**TABLE OF CONTENTS**

|     |                                                |    |
|-----|------------------------------------------------|----|
| 1   | Introduction.....                              | 4  |
| 2   | Device Under Test .....                        | 4  |
| 3   | Product Description .....                      | 4  |
| 3.1 | General Information .....                      | 4  |
| 4   | Measurement Method .....                       | 5  |
| 4.1 | Return Loss Requirements .....                 | 5  |
| 4.2 | Mechanical Requirements .....                  | 5  |
| 5   | Measurement Uncertainty .....                  | 5  |
| 5.1 | Return Loss .....                              | 5  |
| 5.2 | Dimension Measurement .....                    | 5  |
| 5.3 | Validation Measurement .....                   | 5  |
| 6   | Calibration Measurement Results .....          | 6  |
| 6.1 | Return Loss and Impedance In Head Liquid ..... | 6  |
| 6.2 | Return Loss and Impedance In Body Liquid ..... | 6  |
| 6.3 | Mechanical Dimensions .....                    | 6  |
| 7   | Validation measurement .....                   | 7  |
| 7.1 | Head Liquid Measurement .....                  | 7  |
| 7.2 | SAR Measurement Result With Head Liquid .....  | 8  |
| 7.3 | Body Liquid Measurement .....                  | 9  |
| 7.4 | SAR Measurement Result With Body Liquid .....  | 10 |
| 8   | List of Equipment .....                        | 11 |

Page: 3/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*





## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

### 1 INTRODUCTION

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

### 2 DEVICE UNDER TEST

| Device Under Test              |                                   |
|--------------------------------|-----------------------------------|
| Device Type                    | COMOSAR 2450 MHz REFERENCE DIPOLE |
| Manufacturer                   | MVG                               |
| Model                          | SID2450                           |
| Serial Number                  | SN 16/15 DIP 2G450-374            |
| Product Condition (new / used) | Used                              |

A yearly calibration interval is recommended.

### 3 PRODUCT DESCRIPTION

#### 3.1 GENERAL INFORMATION

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



Figure 1 – MVG COMOSAR Validation Dipole

Page: 4/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*





## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

#### 4 MEASUREMENT METHOD

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

##### 4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards.

##### 4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions 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.

#### 5 MEASUREMENT UNCERTAINTY

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

##### 5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz    | 0.1 dB                              |

##### 5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300     | 0.05 mm                        |

##### 5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, FCC KDBs, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g         | 20.3 %               |

Page: 5/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



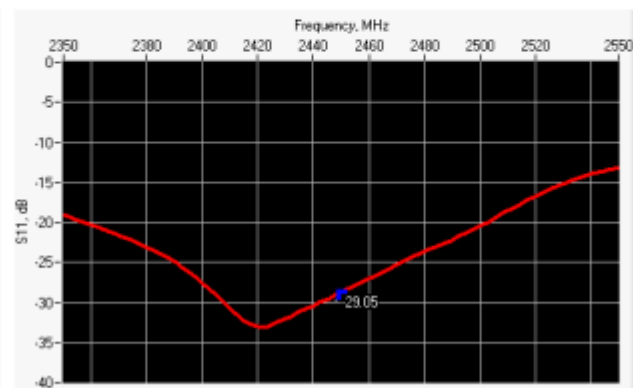
## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

|      |        |
|------|--------|
| 10 g | 20.1 % |
|------|--------|

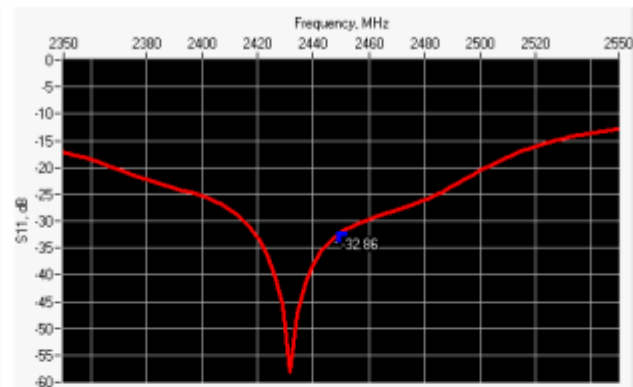
### 6 CALIBRATION MEASUREMENT RESULTS

#### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                      |
|-----------------|------------------|------------------|--------------------------------|
| 2450            | -29.05           | -20              | 46.7 $\Omega$ - 0.2 j $\Omega$ |

#### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                      |
|-----------------|------------------|------------------|--------------------------------|
| 2450            | -32.86           | -20              | 48.6 $\Omega$ - 1.9 j $\Omega$ |

#### 6.3 MECHANICAL DIMENSIONS

| Frequency MHz | L mm            |          | h mm            |          | d mm           |          |
|---------------|-----------------|----------|-----------------|----------|----------------|----------|
|               | required        | measured | required        | measured | required       | measured |
| 300           | 420.0 $\pm$ 1 % |          | 250.0 $\pm$ 1 % |          | 6.35 $\pm$ 1 % |          |

Page: 6/11

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

|      |            |      |            |      |           |      |
|------|------------|------|------------|------|-----------|------|
| 450  | 290.0 ±1 % |      | 166.7 ±1 % |      | 6.35 ±1 % |      |
| 750  | 176.0 ±1 % |      | 100.0 ±1 % |      | 6.35 ±1 % |      |
| 835  | 161.0 ±1 % |      | 89.8 ±1 %  |      | 3.6 ±1 %  |      |
| 900  | 149.0 ±1 % |      | 83.3 ±1 %  |      | 3.6 ±1 %  |      |
| 1450 | 89.1 ±1 %  |      | 51.7 ±1 %  |      | 3.6 ±1 %  |      |
| 1500 | 80.5 ±1 %  |      | 50.0 ±1 %  |      | 3.6 ±1 %  |      |
| 1640 | 79.0 ±1 %  |      | 45.7 ±1 %  |      | 3.6 ±1 %  |      |
| 1750 | 75.2 ±1 %  |      | 42.9 ±1 %  |      | 3.6 ±1 %  |      |
| 1800 | 72.0 ±1 %  |      | 41.7 ±1 %  |      | 3.6 ±1 %  |      |
| 1900 | 68.0 ±1 %  |      | 39.5 ±1 %  |      | 3.6 ±1 %  |      |
| 1950 | 66.3 ±1 %  |      | 38.5 ±1 %  |      | 3.6 ±1 %  |      |
| 2000 | 64.5 ±1 %  |      | 37.5 ±1 %  |      | 3.6 ±1 %  |      |
| 2100 | 61.0 ±1 %  |      | 35.7 ±1 %  |      | 3.6 ±1 %  |      |
| 2300 | 55.5 ±1 %  |      | 32.6 ±1 %  |      | 3.6 ±1 %  |      |
| 2450 | 51.5 ±1 %  | PASS | 30.4 ±1 %  | PASS | 3.6 ±1 %  | PASS |
| 2600 | 48.5 ±1 %  |      | 28.8 ±1 %  |      | 3.6 ±1 %  |      |
| 3000 | 41.5 ±1 %  |      | 25.0 ±1 %  |      | 3.6 ±1 %  |      |
| 3500 | 37.0 ±1 %  |      | 26.4 ±1 %  |      | 3.6 ±1 %  |      |
| 3700 | 34.7 ±1 %  |      | 26.4 ±1 %  |      | 3.6 ±1 %  |      |

## 7 VALIDATION MEASUREMENT

The IEEE Std. 1528, FCC KDBs and CEI/IEC 62209 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<br>MHz | Relative permittivity (ε <sub>r</sub> ) |          | Conductivity (σ) S/m |          |
|------------------|-----------------------------------------|----------|----------------------|----------|
|                  | required                                | measured | required             | measured |
| 300              | 45.3 ±5 %                               |          | 0.87 ±5 %            |          |
| 450              | 43.5 ±5 %                               |          | 0.87 ±5 %            |          |
| 750              | 41.9 ±5 %                               |          | 0.89 ±5 %            |          |
| 835              | 41.5 ±5 %                               |          | 0.90 ±5 %            |          |
| 900              | 41.5 ±5 %                               |          | 0.97 ±5 %            |          |
| 1450             | 40.5 ±5 %                               |          | 1.20 ±5 %            |          |
| 1500             | 40.4 ±5 %                               |          | 1.23 ±5 %            |          |
| 1640             | 40.2 ±5 %                               |          | 1.31 ±5 %            |          |
| 1750             | 40.1 ±5 %                               |          | 1.37 ±5 %            |          |

Page: 7/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

|      |           |      |           |      |
|------|-----------|------|-----------|------|
| 1800 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 1900 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 1950 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 2000 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 2100 | 39.8 ±5 % |      | 1.49 ±5 % |      |
| 2300 | 39.5 ±5 % |      | 1.67 ±5 % |      |
| 2450 | 39.2 ±5 % | PASS | 1.80 ±5 % | PASS |
| 2600 | 39.0 ±5 % |      | 1.96 ±5 % |      |
| 3000 | 38.5 ±5 % |      | 2.40 ±5 % |      |
| 3500 | 37.9 ±5 % |      | 2.91 ±5 % |      |

### 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEEE Std. 1528 and CEI/IEC 62209 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 V4                                   |
| Phantom                                   | SN 20/09 SAM71                               |
| Probe                                     | SN 18/11 EPG122                              |
| Liquid                                    | Head Liquid Values: eps' : 38.3 sigma : 1.80 |
| 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                        | 21 °C                                        |
| Lab Temperature                           | 21 °C                                        |
| Lab Humidity                              | 45 %                                         |

| Frequency<br>MHz | 1 g SAR (W/kg/W) |          | 10 g SAR (W/kg/W) |          |
|------------------|------------------|----------|-------------------|----------|
|                  | required         | measured | required          | measured |
| 300              | 2.85             |          | 1.94              |          |
| 450              | 4.58             |          | 3.06              |          |
| 750              | 8.49             |          | 5.55              |          |
| 835              | 9.56             |          | 6.22              |          |
| 900              | 10.9             |          | 6.99              |          |
| 1450             | 29               |          | 16                |          |
| 1500             | 30.5             |          | 16.8              |          |
| 1640             | 34.2             |          | 18.4              |          |
| 1750             | 36.4             |          | 19.3              |          |
| 1800             | 38.4             |          | 20.1              |          |

Page: 8/11

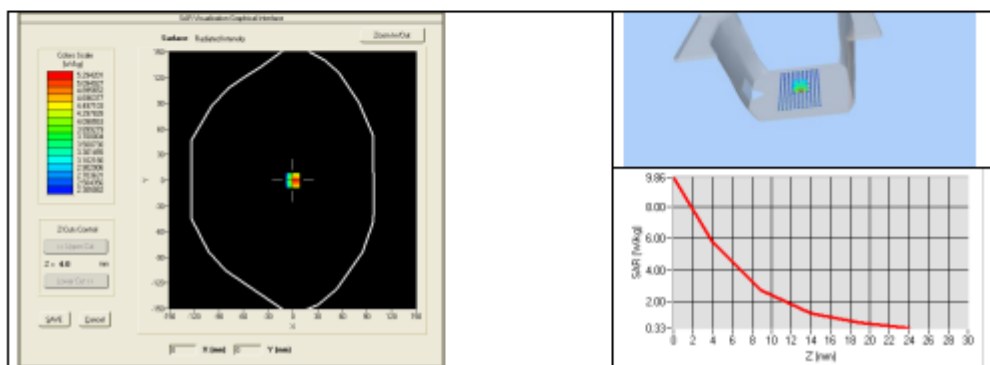
This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

|      |      |              |      |              |
|------|------|--------------|------|--------------|
| 1900 | 39.7 |              | 20.5 |              |
| 1950 | 40.5 |              | 20.9 |              |
| 2000 | 41.1 |              | 21.1 |              |
| 2100 | 43.6 |              | 21.9 |              |
| 2300 | 48.7 |              | 23.3 |              |
| 2450 | 52.4 | 53.26 (5.38) | 24   | 24.15 (2.49) |
| 2600 | 55.3 |              | 24.6 |              |
| 3000 | 63.8 |              | 25.7 |              |
| 3500 | 67.1 |              | 25   |              |



### 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|-----------------------------------------|----------|-------------------------------|----------|
|                  | required                                | measured | required                      | measured |
| 150              | 61.9 $\pm$ 5 %                          |          | 0.80 $\pm$ 5 %                |          |
| 300              | 58.2 $\pm$ 5 %                          |          | 0.92 $\pm$ 5 %                |          |
| 450              | 56.7 $\pm$ 5 %                          |          | 0.94 $\pm$ 5 %                |          |
| 750              | 55.5 $\pm$ 5 %                          |          | 0.96 $\pm$ 5 %                |          |
| 835              | 55.2 $\pm$ 5 %                          |          | 0.97 $\pm$ 5 %                |          |
| 900              | 55.0 $\pm$ 5 %                          |          | 1.05 $\pm$ 5 %                |          |
| 915              | 55.0 $\pm$ 5 %                          |          | 1.06 $\pm$ 5 %                |          |
| 1450             | 54.0 $\pm$ 5 %                          |          | 1.30 $\pm$ 5 %                |          |
| 1610             | 53.8 $\pm$ 5 %                          |          | 1.40 $\pm$ 5 %                |          |
| 1800             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 1900             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 2000             | 53.3 $\pm$ 5 %                          |          | 1.52 $\pm$ 5 %                |          |
| 2100             | 53.2 $\pm$ 5 %                          |          | 1.62 $\pm$ 5 %                |          |
| 2450             | 52.7 $\pm$ 5 %                          | PASS     | 1.95 $\pm$ 5 %                | PASS     |

Page: 9/11

This document shall not be reproduced, except in full or in part, without the written approval of MVA.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVA.



## SAR REFERENCE DIPOLE CALIBRATION REPORT

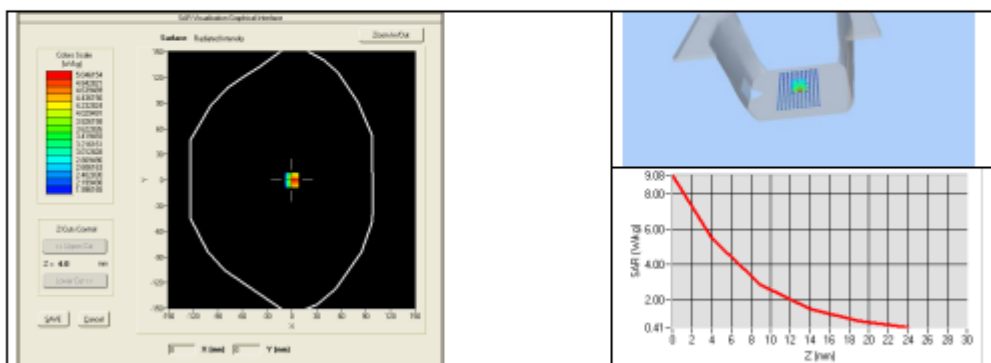
Ref: ACR.156.9.15.SATU.A

|      |            |  |            |  |
|------|------------|--|------------|--|
| 2600 | 52.5 ±5 %  |  | 2.16 ±5 %  |  |
| 3000 | 52.0 ±5 %  |  | 2.73 ±5 %  |  |
| 3500 | 51.3 ±5 %  |  | 3.31 ±5 %  |  |
| 5200 | 49.0 ±10 % |  | 5.30 ±10 % |  |
| 5300 | 48.9 ±10 % |  | 5.42 ±10 % |  |
| 5400 | 48.7 ±10 % |  | 5.53 ±10 % |  |
| 5500 | 48.6 ±10 % |  | 5.65 ±10 % |  |
| 5600 | 48.5 ±10 % |  | 5.77 ±10 % |  |
| 5800 | 48.2 ±10 % |  | 6.00 ±10 % |  |

### 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                           |                                                         |
|-------------------------------------------|---------------------------------------------------------|
| Software                                  | OPENSAR V4                                              |
| Phantom                                   | SN 20/09 SAM71                                          |
| Probe                                     | SN 18/11 EPG122                                         |
| Liquid                                    | Body Liquid Values: $\epsilon_p$ : 52.7 $\sigma$ : 1.94 |
| 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                        | 21 °C                                                   |
| Lab Temperature                           | 21 °C                                                   |
| Lab Humidity                              | 45 %                                                    |

| Frequency<br>MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
|                  | measured         | measured          |
| 2450             | 50.63 (5.01)     | 23.40 (2.37)      |



Page: 10/11

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.





## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.9.15.SATU.A

### 8 LIST OF EQUIPMENT

| Equipment Summary Sheet         |                      |                    |                                               |                                               |
|---------------------------------|----------------------|--------------------|-----------------------------------------------|-----------------------------------------------|
| Equipment Description           | Manufacturer / Model | Identification No. | Current Calibration Date                      | Next Calibration Date                         |
| SAM Phantom                     | MVG                  | SN-20/09-SAM71     | Validated. No cal required.                   | Validated. No cal required.                   |
| COMOSAR Test Bench              | Version 3            | NA                 | Validated. No cal required.                   | Validated. No cal required.                   |
| Network Analyzer                | Rhode & Schwarz ZVA  | SN100132           | 02/2021                                       | 02/2024                                       |
| Calipers                        | Carrera              | CALIPER-01         | 02/2021                                       | 02/2024                                       |
| Reference Probe                 | MVG                  | EPG122 SN 18/11    | 02/2021                                       | 02/2022                                       |
| Multimeter                      | Keithley 2000        | 1188656            | 02/2021                                       | 02/2024                                       |
| Signal Generator                | Agilent E4438C       | MY49070581         | 02/2021                                       | 02/2024                                       |
| Amplifier                       | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                     | HP E4418A            | US38261498         | 02/2021                                       | 02/2024                                       |
| Power Sensor                    | HP ECP-E26A          | US37181460         | 02/2021                                       | 02/2024                                       |
| Directional Coupler             | Narda 4216-20        | 01386              | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company      | 11-661-9           | 02/2021                                       | 02/2024                                       |

Page: 11/11

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



SID2600



## SAR Reference Dipole Calibration Report

Ref : ACR.156.10.15.SATU.A

**SHENZHEN TCT TESTING TECHNOLOGY CO., LTD**

**2101&2201, ZHENCHANG FACTORY, RENSHAN INDUSTRIAL  
ZONE, FUHAI SUBDISTRICT, BAOAN DISTRICT, SHENZHEN,  
GUANGDONG, 518103, PEOPLES REPUBLIC OF CHINA**

**MVG COMOSAR REFERENCE DIPOLE**

**FREQUENCY: 2600 MHZ**

**SERIAL NO.: SN 16/15 DIP 2G600-375**

**Calibrated at MVG US**

**2105 Barrett Park Dr. - Kennesaw, GA 30144**



**Calibration Date: 06/05/2021**

### *Summary:*

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



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref. ACR.156.10.15.SATU.A

|               | Name          | Function        | Date       | Signature            |
|---------------|---------------|-----------------|------------|----------------------|
| Prepared by : | Jérôme LUC    | Product Manager | 06/05/2021 | <i>JS</i>            |
| Checked by :  | Jérôme LUC    | Product Manager | 06/05/2021 | <i>JS</i>            |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 06/05/2021 | <i>Kim Rutkowski</i> |

|                | Customer Name                            |
|----------------|------------------------------------------|
| Distribution : | SHENZHEN TCT TESTING TECHNOLOGY CO., LTD |

| Issue | Date       | Modifications   |
|-------|------------|-----------------|
| A     | 06/05/2021 | Initial release |
|       |            |                 |
|       |            |                 |
|       |            |                 |

Page: 2/11

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.10.15.SATU.A

### TABLE OF CONTENTS

|     |                                                |    |
|-----|------------------------------------------------|----|
| 1   | Introduction.....                              | 4  |
| 2   | Device Under Test .....                        | 4  |
| 3   | Product Description .....                      | 4  |
| 3.1 | General Information .....                      | 4  |
| 4   | Measurement Method .....                       | 5  |
| 4.1 | Return Loss Requirements .....                 | 5  |
| 4.2 | Mechanical Requirements .....                  | 5  |
| 5   | Measurement Uncertainty .....                  | 5  |
| 5.1 | Return Loss .....                              | 5  |
| 5.2 | Dimension Measurement .....                    | 5  |
| 5.3 | Validation Measurement .....                   | 5  |
| 6   | Calibration Measurement Results .....          | 6  |
| 6.1 | Return Loss and Impedance In Head Liquid ..... | 6  |
| 6.2 | Return Loss and Impedance In Body Liquid ..... | 6  |
| 6.3 | Mechanical Dimensions .....                    | 6  |
| 7   | Validation measurement .....                   | 7  |
| 7.1 | Head Liquid Measurement .....                  | 7  |
| 7.2 | SAR Measurement Result With Head Liquid .....  | 8  |
| 7.3 | Body Liquid Measurement .....                  | 9  |
| 7.4 | SAR Measurement Result With Body Liquid .....  | 10 |
| 8   | List of Equipment .....                        | 11 |

Page: 3/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.10.15.SATU.A

### 1 INTRODUCTION

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

### 2 DEVICE UNDER TEST

| Device Under Test              |                                   |
|--------------------------------|-----------------------------------|
| Device Type                    | COMOSAR 2600 MHz REFERENCE DIPOLE |
| Manufacturer                   | MVG                               |
| Model                          | SID2600                           |
| Serial Number                  | SN 16/15 DIP 2G600-375            |
| Product Condition (new / used) | Used                              |

A yearly calibration interval is recommended.

### 3 PRODUCT DESCRIPTION

#### 3.1 GENERAL INFORMATION

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



Figure 1 – MVG COMOSAR Validation Dipole

Page: 4/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



#### 4 MEASUREMENT METHOD

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

##### 4.1 RETURN LOSS REQUIREMENTS

The dipole used for SAR system validation measurements and checks must have a return loss of -20 dB or better. The return loss measurement shall be performed against a liquid filled flat phantom, with the phantom constructed as outlined in the fore mentioned standards.

##### 4.2 MECHANICAL REQUIREMENTS

The IEEE Std. 1528 and CEI/IEC 62209 standards specify the mechanical components and dimensions of the validation dipoles, with the dimensions 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.

#### 5 MEASUREMENT UNCERTAINTY

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

##### 5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz    | 0.1 dB                              |

##### 5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300     | 0.05 mm                        |

##### 5.3 VALIDATION MEASUREMENT

The guidelines outlined in the IEEE 1528, FCC KDBs, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g         | 20.3 %               |

Page: 5/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



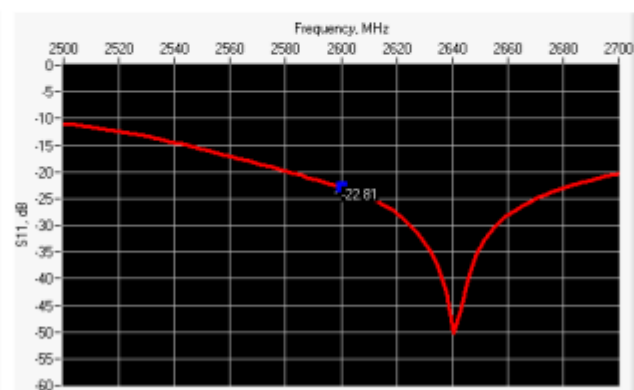
## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.10.15.SATUA

|      |        |
|------|--------|
| 10 g | 20.1 % |
|------|--------|

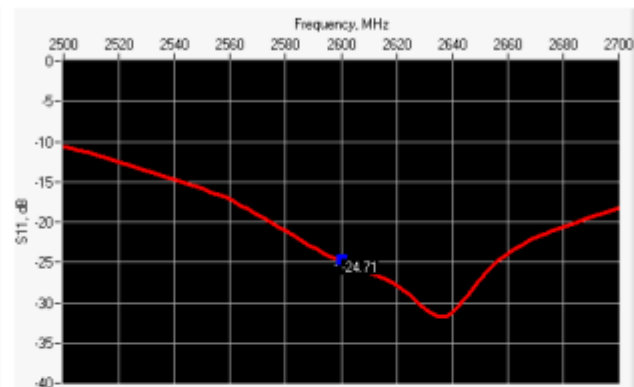
### 6 CALIBRATION MEASUREMENT RESULTS

#### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                      |
|-----------------|------------------|------------------|--------------------------------|
| 2600            | -22.81           | -20              | 55.3 $\Omega$ - 5.1 j $\Omega$ |

#### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                      |
|-----------------|------------------|------------------|--------------------------------|
| 2600            | -24.71           | -20              | 51.5 $\Omega$ - 5.5 j $\Omega$ |

#### 6.3 MECHANICAL DIMENSIONS

| Frequency MHz | L mm            |          | h mm            |          | d mm           |          |
|---------------|-----------------|----------|-----------------|----------|----------------|----------|
|               | required        | measured | required        | measured | required       | measured |
| 300           | 420.0 $\pm$ 1 % |          | 250.0 $\pm$ 1 % |          | 6.35 $\pm$ 1 % |          |

Page: 6/11

This document shall not be reproduced, except in full or in part, without the written approval of MFG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MFG.





**SAR REFERENCE DIPOLE CALIBRATION REPORT**

Ref: ACR.156.10.15.SATU.A

|      |             |      |             |      |            |      |
|------|-------------|------|-------------|------|------------|------|
| 450  | 290.0 ±1 %. |      | 166.7 ±1 %. |      | 6.35 ±1 %. |      |
| 750  | 176.0 ±1 %. |      | 100.0 ±1 %. |      | 6.35 ±1 %. |      |
| 835  | 161.0 ±1 %. |      | 89.8 ±1 %.  |      | 3.6 ±1 %.  |      |
| 900  | 149.0 ±1 %. |      | 83.3 ±1 %.  |      | 3.6 ±1 %.  |      |
| 1450 | 89.1 ±1 %.  |      | 51.7 ±1 %.  |      | 3.6 ±1 %.  |      |
| 1500 | 80.5 ±1 %.  |      | 50.0 ±1 %.  |      | 3.6 ±1 %.  |      |
| 1640 | 79.0 ±1 %.  |      | 45.7 ±1 %.  |      | 3.6 ±1 %.  |      |
| 1750 | 75.2 ±1 %.  |      | 42.9 ±1 %.  |      | 3.6 ±1 %.  |      |
| 1800 | 72.0 ±1 %.  |      | 41.7 ±1 %.  |      | 3.6 ±1 %.  |      |
| 1900 | 68.0 ±1 %.  |      | 39.5 ±1 %.  |      | 3.6 ±1 %.  |      |
| 1950 | 66.3 ±1 %.  |      | 38.5 ±1 %.  |      | 3.6 ±1 %.  |      |
| 2000 | 64.5 ±1 %.  |      | 37.5 ±1 %.  |      | 3.6 ±1 %.  |      |
| 2100 | 61.0 ±1 %.  |      | 35.7 ±1 %.  |      | 3.6 ±1 %.  |      |
| 2300 | 55.5 ±1 %.  |      | 32.6 ±1 %.  |      | 3.6 ±1 %.  |      |
| 2450 | 51.5 ±1 %.  |      | 30.4 ±1 %.  |      | 3.6 ±1 %.  |      |
| 2600 | 48.5 ±1 %.  | PASS | 28.8 ±1 %.  | PASS | 3.6 ±1 %.  | PASS |
| 3000 | 41.5 ±1 %.  |      | 25.0 ±1 %.  |      | 3.6 ±1 %.  |      |
| 3500 | 37.0 ±1 %.  |      | 26.4 ±1 %.  |      | 3.6 ±1 %.  |      |
| 3700 | 34.7 ±1 %.  |      | 26.4 ±1 %.  |      | 3.6 ±1 %.  |      |

## 7 VALIDATION MEASUREMENT

The IEEE Std. 1528, FCC KDBs and CEI/IEC 62209 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<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|----------------------------------------|----------|-------------------------------|----------|
|                  | required                               | measured | required                      | measured |
| 300              | 45.3 ±5 %                              |          | 0.87 ±5 %                     |          |
| 450              | 43.5 ±5 %                              |          | 0.87 ±5 %                     |          |
| 750              | 41.9 ±5 %                              |          | 0.89 ±5 %                     |          |
| 835              | 41.5 ±5 %                              |          | 0.90 ±5 %                     |          |
| 900              | 41.5 ±5 %                              |          | 0.97 ±5 %                     |          |
| 1450             | 40.5 ±5 %                              |          | 1.20 ±5 %                     |          |
| 1500             | 40.4 ±5 %                              |          | 1.23 ±5 %                     |          |
| 1640             | 40.2 ±5 %                              |          | 1.31 ±5 %                     |          |
| 1750             | 40.1 ±5 %                              |          | 1.37 ±5 %                     |          |

Page: 7/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*





## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.10.15.SATU.A

|      |           |      |           |      |
|------|-----------|------|-----------|------|
| 1800 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 1900 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 1950 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 2000 | 40.0 ±5 % |      | 1.40 ±5 % |      |
| 2100 | 39.8 ±5 % |      | 1.49 ±5 % |      |
| 2300 | 39.5 ±5 % |      | 1.67 ±5 % |      |
| 2450 | 39.2 ±5 % |      | 1.80 ±5 % |      |
| 2600 | 39.0 ±5 % | PASS | 1.96 ±5 % | PASS |
| 3000 | 38.5 ±5 % |      | 2.40 ±5 % |      |
| 3500 | 37.9 ±5 % |      | 2.91 ±5 % |      |

### 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

The IEEE Std. 1528 and CEI/IEC 62209 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 V4                                   |
| Phantom                                   | SN 20/09 SAM71                               |
| Probe                                     | SN 18/11 EPG122                              |
| Liquid                                    | Head Liquid Values: eps' : 38.2 sigma : 1.93 |
| 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                        | 21 °C                                        |
| Lab Temperature                           | 21 °C                                        |
| Lab Humidity                              | 45 %                                         |

| Frequency<br>MHz | 1 g SAR (W/kg/W) |          | 10 g SAR (W/kg/W) |          |
|------------------|------------------|----------|-------------------|----------|
|                  | required         | measured | required          | measured |
| 300              | 2.85             |          | 1.94              |          |
| 450              | 4.58             |          | 3.06              |          |
| 750              | 8.49             |          | 5.55              |          |
| 835              | 9.56             |          | 6.22              |          |
| 900              | 10.9             |          | 6.99              |          |
| 1450             | 29               |          | 16                |          |
| 1500             | 30.5             |          | 16.8              |          |
| 1640             | 34.2             |          | 18.4              |          |
| 1750             | 36.4             |          | 19.3              |          |
| 1800             | 38.4             |          | 20.1              |          |

Page: 8/11

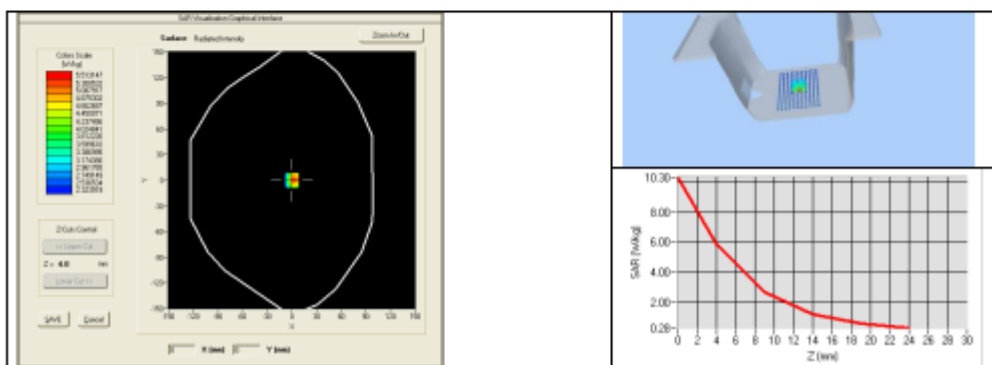
This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.10.15.SATU.A

|      |      |              |      |              |
|------|------|--------------|------|--------------|
| 1900 | 39.7 |              | 20.5 |              |
| 1950 | 40.5 |              | 20.9 |              |
| 2000 | 41.1 |              | 21.1 |              |
| 2100 | 43.6 |              | 21.9 |              |
| 2300 | 48.7 |              | 23.3 |              |
| 2450 | 52.4 |              | 24   |              |
| 2600 | 55.3 | 54.31 (5.36) | 24.6 | 24.14 (2.42) |
| 3000 | 63.8 |              | 25.7 |              |
| 3500 | 67.1 |              | 25   |              |



### 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|----------------------------------------|----------|-------------------------------|----------|
|                  | required                               | measured | required                      | measured |
| 150              | 61.9 $\pm$ 5 %                         |          | 0.80 $\pm$ 5 %                |          |
| 300              | 58.2 $\pm$ 5 %                         |          | 0.92 $\pm$ 5 %                |          |
| 450              | 56.7 $\pm$ 5 %                         |          | 0.94 $\pm$ 5 %                |          |
| 750              | 55.5 $\pm$ 5 %                         |          | 0.96 $\pm$ 5 %                |          |
| 835              | 55.2 $\pm$ 5 %                         |          | 0.97 $\pm$ 5 %                |          |
| 900              | 55.0 $\pm$ 5 %                         |          | 1.05 $\pm$ 5 %                |          |
| 915              | 55.0 $\pm$ 5 %                         |          | 1.06 $\pm$ 5 %                |          |
| 1450             | 54.0 $\pm$ 5 %                         |          | 1.30 $\pm$ 5 %                |          |
| 1610             | 53.8 $\pm$ 5 %                         |          | 1.40 $\pm$ 5 %                |          |
| 1800             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 1900             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 2000             | 53.3 $\pm$ 5 %                         |          | 1.52 $\pm$ 5 %                |          |
| 2100             | 53.2 $\pm$ 5 %                         |          | 1.62 $\pm$ 5 %                |          |
| 2450             | 52.7 $\pm$ 5 %                         |          | 1.95 $\pm$ 5 %                |          |

Page: 9/11

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR REFERENCE DIPOLE CALIBRATION REPORT

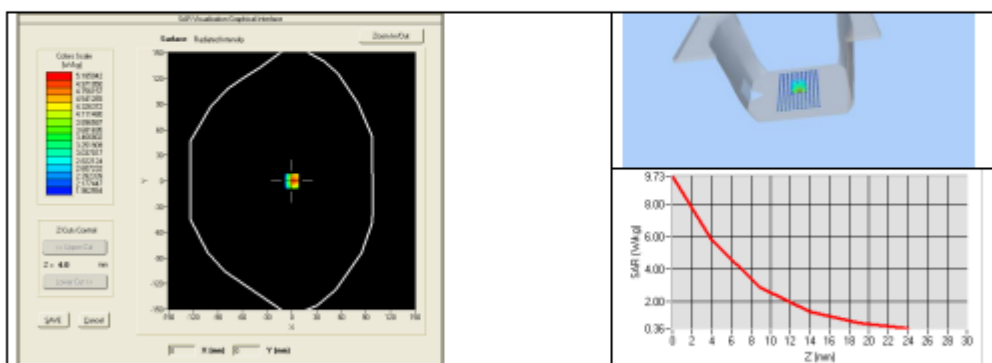
Ref. ACR.156.10.15.SATU.A

|      |            |      |            |      |
|------|------------|------|------------|------|
| 2600 | 52.5 ±5 %  | PASS | 2.16 ±5 %  | PASS |
| 3000 | 52.0 ±5 %  |      | 2.73 ±5 %  |      |
| 3500 | 51.3 ±5 %  |      | 3.31 ±5 %  |      |
| 5200 | 49.0 ±10 % |      | 5.30 ±10 % |      |
| 5300 | 48.9 ±10 % |      | 5.42 ±10 % |      |
| 5400 | 48.7 ±10 % |      | 5.53 ±10 % |      |
| 5500 | 48.6 ±10 % |      | 5.65 ±10 % |      |
| 5600 | 48.5 ±10 % |      | 5.77 ±10 % |      |
| 5800 | 48.2 ±10 % |      | 6.00 ±10 % |      |

### 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                           |                                                            |
|-------------------------------------------|------------------------------------------------------------|
| Software                                  | OPENSAR V4                                                 |
| Phantom                                   | SN 20/09 SAM71                                             |
| Probe                                     | SN 18/11 EPG122                                            |
| Liquid                                    | Body Liquid Values: $\epsilon_{ps}$ : 51.6 $\sigma$ : 2.21 |
| 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                        | 21 °C                                                      |
| Lab Temperature                           | 21 °C                                                      |
| Lab Humidity                              | 45 %                                                       |

| Frequency<br>MHz | 1 g SAR (W/kg/W) | 10 g SAR (W/kg/W) |
|------------------|------------------|-------------------|
|                  | measured         | measured          |
| 2600             | 53.26 (5.12)     | 23.89 (2.30)      |



Page: 10/11

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



SAR REFERENCE DIPOLE CALIBRATION REPORT

Ref: ACR.156.10.15.SATU.A

**8 LIST OF EQUIPMENT**

| Equipment Summary Sheet         |                      |                    |                                               |                                               |
|---------------------------------|----------------------|--------------------|-----------------------------------------------|-----------------------------------------------|
| Equipment Description           | Manufacturer / Model | Identification No. | Current Calibration Date                      | Next Calibration Date                         |
| SAM Phantom                     | MVG                  | SN-20/09-SAM71     | Validated. No cal required.                   | Validated. No cal required.                   |
| COMOSAR Test Bench              | Version 3            | NA                 | Validated. No cal required.                   | Validated. No cal required.                   |
| Network Analyzer                | Rhode & Schwarz ZVA  | SN100132           | 02/2021                                       | 02/2024                                       |
| Calipers                        | Carrera              | CALIPER-01         | 02/2021                                       | 02/2024                                       |
| Reference Probe                 | MVG                  | EPG122 SN 18/11    | 02/2021                                       | 02/2022                                       |
| Multimeter                      | Keithley 2000        | 1188656            | 02/2021                                       | 02/2024                                       |
| Signal Generator                | Agilent E4438C       | MY49070581         | 02/2021                                       | 02/2024                                       |
| Amplifier                       | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                     | HP E4418A            | US38261498         | 02/2021                                       | 02/2024                                       |
| Power Sensor                    | HP ECP-E26A          | US37181460         | 02/2021                                       | 02/2024                                       |
| Directional Coupler             | Narda 4216-20        | 01386              | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company      | 11-661-9           | 09/2021                                       | 09/2022                                       |

Page: 11/11

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



## SAR Reference Waveguide Calibration Report

Ref : ACR.256.12.15.SATU.A

**SHENZHEN TCT TESTING TECHNOLOGY CO., LTD**  
2101&2201, ZHENCHANG FACTORY, RENSHAN INDUSTRIAL  
ZONE, FUHAI SUBDISTRICT, BAOAN DISTRICT, SHENZHEN,  
GUANGDONG, 518103, PEOPLES REPUBLIC OF CHINA  
**MVG COMOSAR REFERENCE WAVEGUIDE**  
FREQUENCY: 5000-6000 MHZ  
SERIAL NO.: SN 13/14 WGA32

Calibrated at MVG US  
2105 Barrett Park Dr. - Kennesaw, GA 30144



Calibration Date: 05/15/2021

### Summary:

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



SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

Ref: ACR.256.12.15.SATU.A

|               | Name          | Function        | Date      | Signature            |
|---------------|---------------|-----------------|-----------|----------------------|
| Prepared by : | Jérôme LUC    | Product Manager | 8/29/2021 | <i>JS</i>            |
| Checked by :  | Jérôme LUC    | Product Manager | 8/29/2021 | <i>JS</i>            |
| Approved by : | Kim RUTKOWSKI | Quality Manager | 8/29/2021 | <i>Kim Rutkowski</i> |

|                | Customer Name                            |
|----------------|------------------------------------------|
| Distribution : | SHENZHEN TCT TESTING TECHNOLOGY CO., LTD |

| Issue | Date      | Modifications   |
|-------|-----------|-----------------|
| A     | 8/29/2021 | Initial release |
|       |           |                 |
|       |           |                 |
|       |           |                 |

Page: 2/13

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## TABLE OF CONTENTS

|     |                                      |    |
|-----|--------------------------------------|----|
| 1   | Introduction.....                    | 4  |
| 2   | Device Under Test .....              | 4  |
| 3   | Product Description .....            | 4  |
| 3.1 | General Information .....            | 4  |
| 4   | Measurement Method .....             | 4  |
| 4.1 | Return Loss Requirements .....       | 4  |
| 4.2 | Mechanical Requirements .....        | 4  |
| 5   | Measurement Uncertainty.....         | 5  |
| 5.1 | Return Loss .....                    | 5  |
| 5.2 | Dimension Measurement .....          | 5  |
| 5.3 | Validation Measurement .....         | 5  |
| 6   | Calibration Measurement Results..... | 5  |
| 6.1 | Return Loss .....                    | 5  |
| 6.2 | Mechanical Dimensions .....          | 6  |
| 7   | Validation measurement .....         | 6  |
| 7.1 | Head Liquid Measurement .....        | 7  |
| 7.2 | Measurement Result .....             | 7  |
| 7.3 | Body Measurement Result .....        | 10 |
| 8   | List of Equipment .....              | 13 |

Page: 3/13

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*





## 1 INTRODUCTION

This document contains a summary of the requirements set forth by the IEEE 1528 and CEI/IEC 62209 standards for reference waveguides 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 5000-6000 MHz REFERENCE WAVEGUIDE |
| Manufacturer                   | MVG                                       |
| Model                          | SWG5500                                   |
| Serial Number                  | SN 13/14 WGA32                            |
| Product Condition (new / used) | New                                       |

A yearly calibration interval is recommended.

## 3 PRODUCT DESCRIPTION

### 3.1 GENERAL INFORMATION

MVG's COMOSAR Validation Waveguides are built in accordance to the IEEE 1528 and CEI/IEC 62209 standards.

## 4 MEASUREMENT METHOD

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

### 4.1 RETURN LOSS REQUIREMENTS

The waveguide used for SAR system validation measurements and checks must have a return loss of -8 dB or better. The return loss measurement shall be performed with matching layer placed in the open end of the waveguide, with the waveguide and matching layer in direct contact with the phantom shell as outlined in the fore mentioned standards.

### 4.2 MECHANICAL REQUIREMENTS

The IEEE 1528 and CEI/IEC 62209 standards specify the mechanical dimensions of the validation waveguide, the specified dimensions are as shown in Section 6.2. Figure 1 shows how the dimensions relate to the physical construction of the waveguide.

Page: 4/13

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*



## 5 MEASUREMENT UNCERTAINTY

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

### 5.1 RETURN LOSS

The following uncertainties apply to the return loss measurement:

| Frequency band | Expanded Uncertainty on Return Loss |
|----------------|-------------------------------------|
| 400-6000MHz    | 0.1 dB                              |

### 5.2 DIMENSION MEASUREMENT

The following uncertainties apply to the dimension measurements:

| Length (mm) | Expanded Uncertainty on Length |
|-------------|--------------------------------|
| 3 - 300     | 0.05 mm                        |

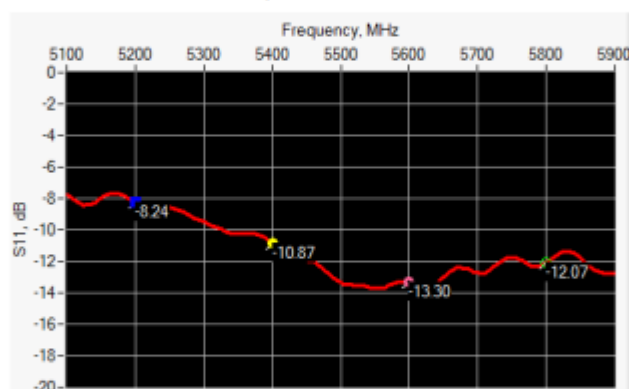
### 5.3 VALIDATION MEASUREMENT

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

| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g         | 20.3 %               |
| 10 g        | 20.1 %               |

## 6 CALIBRATION MEASUREMENT RESULTS

### 6.1 RETURN LOSS IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) |
|-----------------|------------------|------------------|
| 5000-6000       | < -8.24          | -8               |

Page: 5/13

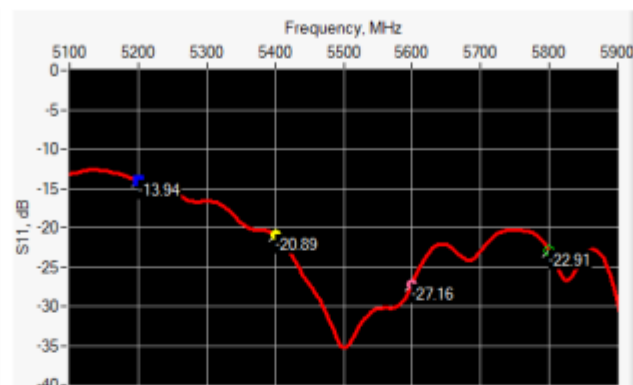
This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

Ref: ACR.256.12.15.SATUA

### 6.2 RETURN LOSS IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) |
|-----------------|------------------|------------------|
| 5000-6000       | < -13.94         | -8               |

### 6.3 MECHANICAL DIMENSIONS

| Frequency (MHz) | L (mm)       |           | W (mm)       |           | L <sub>r</sub> (mm) |           | W <sub>r</sub> (mm) |           | T (mm)    |           |
|-----------------|--------------|-----------|--------------|-----------|---------------------|-----------|---------------------|-----------|-----------|-----------|
|                 | Require d    | Measure d | Require d    | Measure d | Require d           | Measure d | Require d           | Measure d | Require d | Measure d |
| 5200            | 40.39 ± 0.13 | PASS      | 20.19 ± 0.13 | PASS      | 81.03 ± 0.13        | PASS      | 61.98 ± 0.13        | PASS      | 5.3*      | PASS      |
| 5800            | 40.39 ± 0.13 | PASS      | 20.19 ± 0.13 | PASS      | 81.03 ± 0.13        | PASS      | 61.98 ± 0.13        | PASS      | 4.3*      | PASS      |

\* The tolerance for the matching layer is included in the return loss measurement.

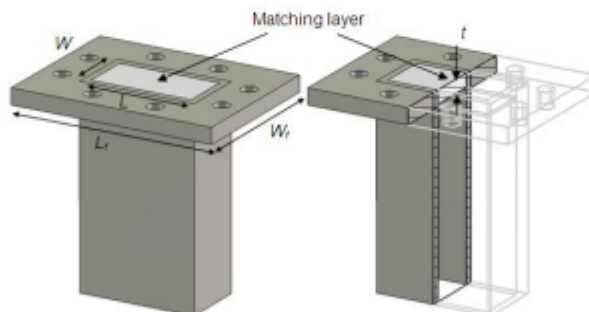


Figure 1: Validation Waveguide Dimensions

## 7 VALIDATION MEASUREMENT

The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements must be performed using a reference waveguide meeting the fore mentioned return loss and mechanical dimension requirements. The validation measurement must be performed with the matching layer placed in the open end of the waveguide, with the waveguide and matching layer in direct contact with the phantom shell.

Page: 6/13

This document shall not be reproduced, except in full or in part, without the written approval of MVG. The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

Ref: ACR.256.12.15.STUA

### 7.1 HEAD LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|----------------------------------------|----------|-------------------------------|----------|
|                  | required                               | measured | required                      | measured |
| 5000             | 36.2 $\pm$ 10 %                        |          | 4.45 $\pm$ 10 %               |          |
| 5100             | 36.1 $\pm$ 10 %                        |          | 4.56 $\pm$ 10 %               |          |
| 5200             | 36.0 $\pm$ 10 %                        | PASS     | 4.66 $\pm$ 10 %               | PASS     |
| 5300             | 35.9 $\pm$ 10 %                        |          | 4.76 $\pm$ 10 %               |          |
| 5400             | 35.8 $\pm$ 10 %                        | PASS     | 4.86 $\pm$ 10 %               | PASS     |
| 5500             | 35.6 $\pm$ 10 %                        |          | 4.97 $\pm$ 10 %               |          |
| 5600             | 35.5 $\pm$ 10 %                        | PASS     | 5.07 $\pm$ 10 %               | PASS     |
| 5700             | 35.4 $\pm$ 10 %                        |          | 5.17 $\pm$ 10 %               |          |
| 5800             | 35.3 $\pm$ 10 %                        | PASS     | 5.27 $\pm$ 10 %               | PASS     |
| 5900             | 35.2 $\pm$ 10 %                        |          | 5.38 $\pm$ 10 %               |          |
| 6000             | 35.1 $\pm$ 10 %                        |          | 5.48 $\pm$ 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 V4                                                                                                                                                                                                                                                       |
| Phantom                                      | SN 20/09 SAM71                                                                                                                                                                                                                                                   |
| Probe                                        | SN 18/11 EPG122                                                                                                                                                                                                                                                  |
| Liquid                                       | Head Liquid Values 5200 MHz: $\epsilon_r$ :36.62 sigma : 4.93<br>Head Liquid Values 5400 MHz: $\epsilon_r$ :35.95 sigma : 5.18<br>Head Liquid Values 5600 MHz: $\epsilon_r$ :36.08 sigma : 5.60<br>Head Liquid Values 5800 MHz: $\epsilon_r$ :34.73 sigma : 5.74 |
| Distance between dipole waveguide and liquid | 0 mm                                                                                                                                                                                                                                                             |
| Area scan resolution                         | dx=8mm/dy=8mm                                                                                                                                                                                                                                                    |
| Zoon Scan Resolution                         | dx=4mm/dy=4m/dz=2mm                                                                                                                                                                                                                                              |
| Frequency                                    | 5200 MHz<br>5400 MHz<br>5600 MHz<br>5800 MHz                                                                                                                                                                                                                     |
| Input power                                  | 20 dBm                                                                                                                                                                                                                                                           |
| Liquid Temperature                           | 21 °C                                                                                                                                                                                                                                                            |
| Lab Temperature                              | 21 °C                                                                                                                                                                                                                                                            |
| Lab Humidity                                 | 45 %                                                                                                                                                                                                                                                             |

Page: 7/13

*This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.*

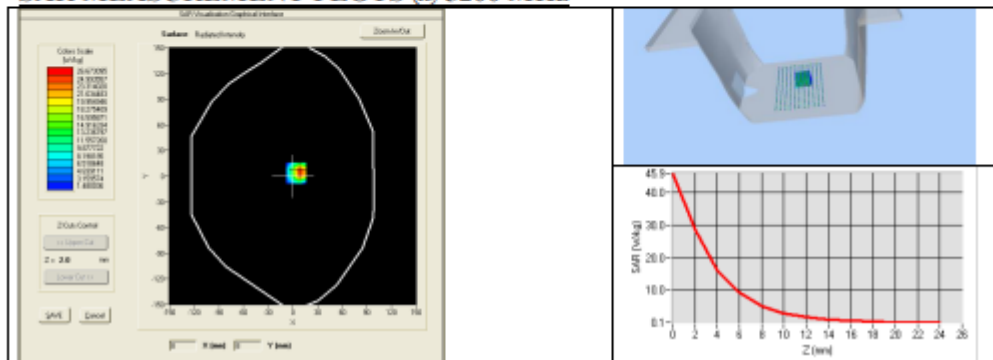


## SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

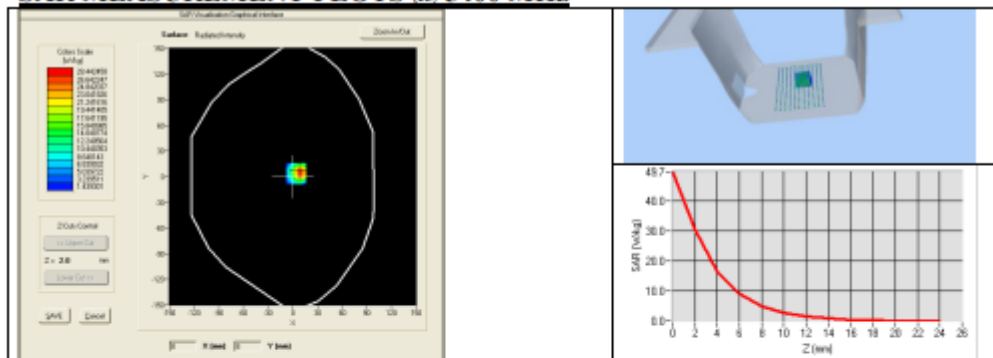
Ref: ACR.256.12.15.SAT.U.A

| Frequency (MHz) | 1 g SAR (W/kg) |                | 10 g SAR (W/kg) |              |
|-----------------|----------------|----------------|-----------------|--------------|
|                 | required       | measured       | required        | measured     |
| 5200            | 159.00         | 163.88 (16.39) | 56.90           | 57.29 (5.73) |
| 5400            | 166.40         | 172.23 (17.22) | 58.43           | 59.16 (5.92) |
| 5600            | 173.80         | 181.28 (18.13) | 59.97           | 61.57 (6.16) |
| 5800            | 181.20         | 188.95 (18.90) | 61.50           | 63.45 (6.35) |

### SAR MEASUREMENT PLOTS @ 5200 MHz



### SAR MEASUREMENT PLOTS @ 5400 MHz



Page: 8/13

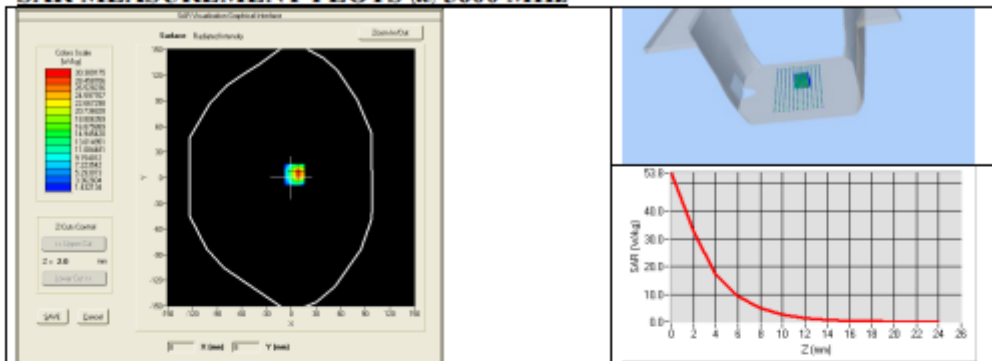
This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



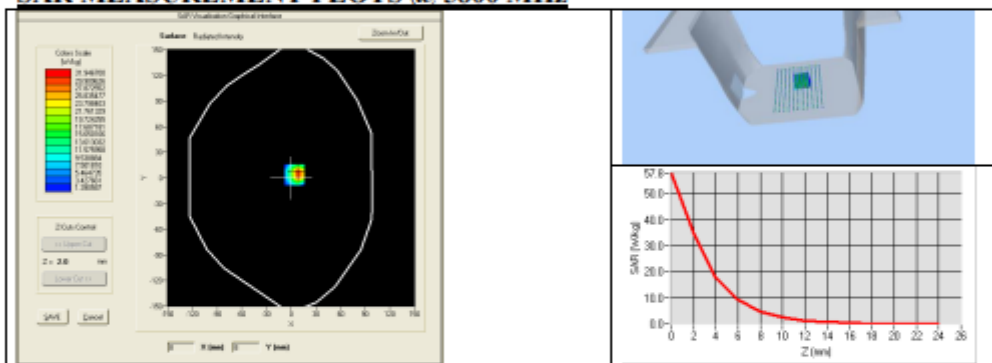
## SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

Ref: ACR.256.12.15.SATUA

### SAR MEASUREMENT PLOTS @ 5600 MHz



### SAR MEASUREMENT PLOTS @ 5800 MHz



Page: 9/13

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.





## SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

Ref: ACR.256.12.15.SATUA

### 7.3 BODY LIQUID MEASUREMENT

| Frequency<br>MHz | Relative permittivity ( $\epsilon_r'$ ) |          | Conductivity ( $\sigma$ ) S/m |          |
|------------------|-----------------------------------------|----------|-------------------------------|----------|
|                  | required                                | measured | required                      | measured |
| 5200             | 49.0 $\pm$ 10 %                         | PASS     | 5.30 $\pm$ 10 %               | PASS     |
| 5300             | 48.9 $\pm$ 10 %                         |          | 5.42 $\pm$ 10 %               |          |
| 5400             | 48.7 $\pm$ 10 %                         | PASS     | 5.53 $\pm$ 10 %               | PASS     |
| 5500             | 48.6 $\pm$ 10 %                         |          | 5.65 $\pm$ 10 %               |          |
| 5600             | 48.5 $\pm$ 10 %                         | PASS     | 5.77 $\pm$ 10 %               | PASS     |
| 5800             | 48.2 $\pm$ 10 %                         | PASS     | 6.00 $\pm$ 10 %               | PASS     |

### 7.4 SAR MEASUREMENT RESULT WITH BODY LIQUID

|                                              |                                                                                                                                                                                                                                                                      |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Software                                     | OPENSAR V4                                                                                                                                                                                                                                                           |
| Phantom                                      | SN 20/09 SAM71                                                                                                                                                                                                                                                       |
| Probe                                        | SN 18/11 EPG122                                                                                                                                                                                                                                                      |
| Liquid                                       | Body Liquid Values 5200 MHz: $\epsilon_r'$ :50.69 sigma : 4.98<br>Body Liquid Values 5400 MHz: $\epsilon_r'$ :48.45 sigma : 5.82<br>Body Liquid Values 5600 MHz: $\epsilon_r'$ :50.57 sigma : 6.37<br>Body Liquid Values 5800 MHz: $\epsilon_r'$ :48.19 sigma : 6.45 |
| Distance between dipole waveguide and liquid | 0 mm                                                                                                                                                                                                                                                                 |
| Area scan resolution                         | dx=8mm/dy=8mm                                                                                                                                                                                                                                                        |
| Zoon Scan Resolution                         | dx=4mm/dy=4m/dz=2mm                                                                                                                                                                                                                                                  |
| Frequency                                    | 5200 MHz<br>5400 MHz<br>5600 MHz<br>5800 MHz                                                                                                                                                                                                                         |
| Input power                                  | 20 dBm                                                                                                                                                                                                                                                               |
| Liquid Temperature                           | 21 °C                                                                                                                                                                                                                                                                |
| Lab Temperature                              | 21 °C                                                                                                                                                                                                                                                                |
| Lab Humidity                                 | 45 %                                                                                                                                                                                                                                                                 |

| Frequency (MHz) | 1 g SAR (W/kg) | 10 g SAR (W/kg) |
|-----------------|----------------|-----------------|
|                 | measured       | measured        |
| 5200            | 158.49 (15.85) | 55.40 (5.54)    |
| 5400            | 167.20 (16.72) | 57.39 (5.74)    |
| 5600            | 175.65 (17.57) | 59.48 (5.95)    |
| 5800            | 183.06 (18.31) | 61.62 (6.16)    |

Page: 10/13

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.

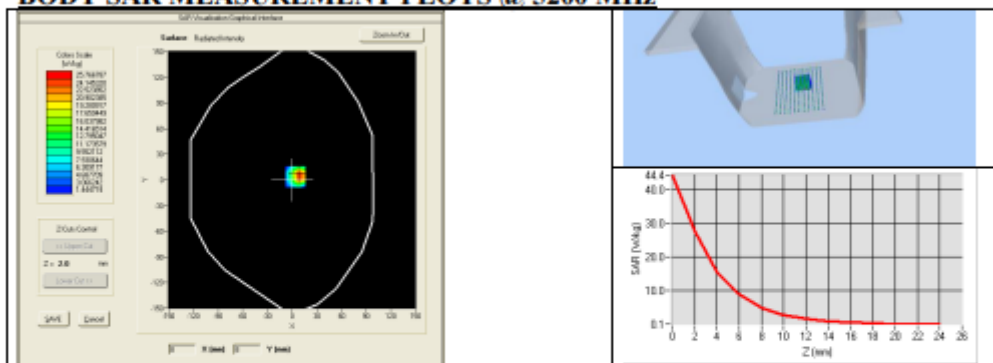




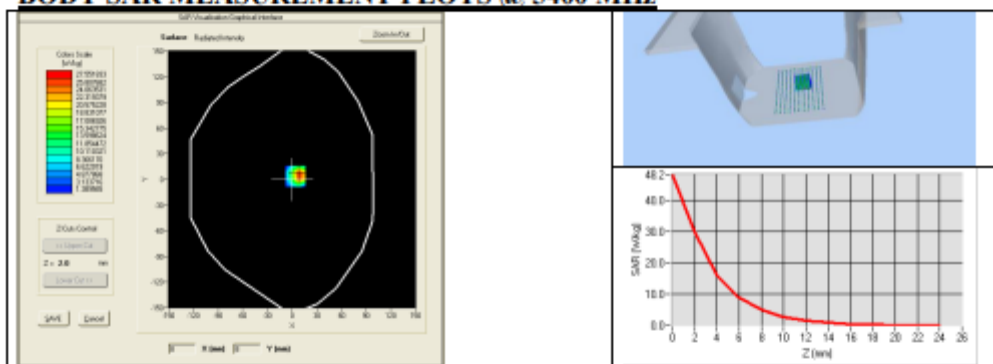
## SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

Ref: ACR.256.12.15.SAT.UA

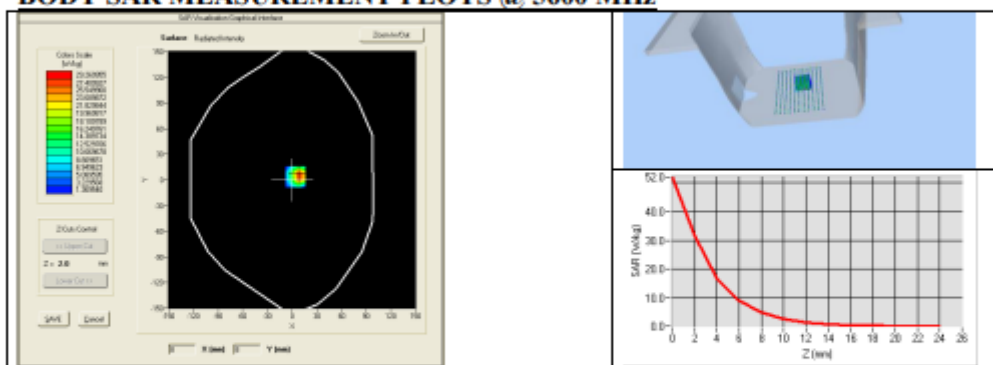
### BODY SAR MEASUREMENT PLOTS @ 5200 MHz



### BODY SAR MEASUREMENT PLOTS @ 5400 MHz



### BODY SAR MEASUREMENT PLOTS @ 5600 MHz



Page: 11/13

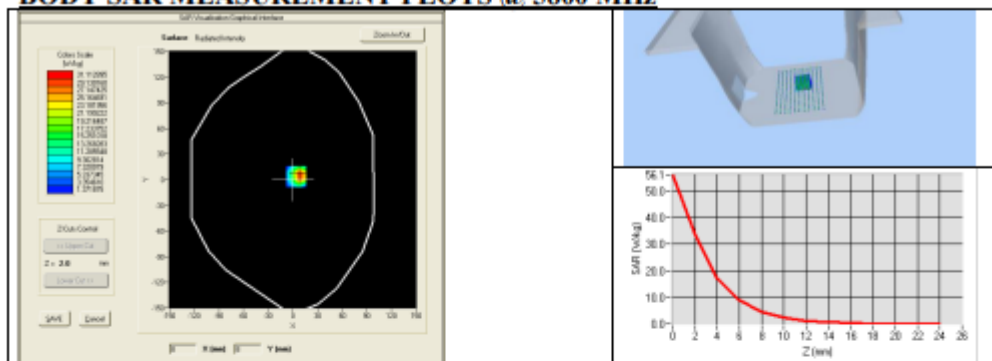
This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



SAR REFERENCE WAVEGUIDE CALIBRATION REPORT

Ref: ACR.256.12.15.SATU.A

**BODY SAR MEASUREMENT PLOTS @ 5800 MHz**



Page: 12/13

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.



## 8 LIST OF EQUIPMENT

| Equipment Summary Sheet         |                      |                    |                                               |                                               |
|---------------------------------|----------------------|--------------------|-----------------------------------------------|-----------------------------------------------|
| Equipment Description           | Manufacturer / Model | Identification No. | Current Calibration Date                      | Next Calibration Date                         |
| Flat Phantom                    | MVG                  | SN-20/09-SAM71     | Validated. No cal required.                   | Validated. No cal required.                   |
| COMOSAR Test Bench              | Version 3            | NA                 | Validated. No cal required.                   | Validated. No cal required.                   |
| Network Analyzer                | Rhode & Schwarz ZVA  | SN100132           | 02/2019                                       | 02/2022                                       |
| Calipers                        | Carrera              | CALIPER-01         | 01/2020                                       | 01/2023                                       |
| Reference Probe                 | MVG                  | EPG122 SN 18/11    | 10/2021                                       | 10/2022                                       |
| Multimeter                      | Keithley 2000        | 1188656            | 01/2020                                       | 01/2023                                       |
| Signal Generator                | Agilent E4438C       | MY49070581         | 01/2020                                       | 01/2023                                       |
| Amplifier                       | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                     | HP E4418A            | US38261498         | 01/2020                                       | 01/2023                                       |
| Power Sensor                    | HP ECP-E26A          | US37181460         | 01/2020                                       | 01/2023                                       |
| Directional Coupler             | Narda 4216-20        | 01386              | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company      | 150798832          | 10/2021                                       | 10/2022                                       |

Page: 13/13

This document shall not be reproduced, except in full or in part, without the written approval of MVG.  
The information contained herein is to be used only for the purpose for which it is submitted and is not to be released in whole or part without written approval of MVG.

## Appendix E: SAR SYSTEM VALIDATION

Per FCC KDB 865664 D02v01, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB 865664 D01 v01 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

**SAR System Validation Summary**

| Date       | Freq. [MHz] | Probe S/N         | Tissue type | COND. PERM.      | COND. PERM.  | CW Validation |                 |                | Mod. Validation |             |                             |
|------------|-------------|-------------------|-------------|------------------|--------------|---------------|-----------------|----------------|-----------------|-------------|-----------------------------|
|            |             |                   |             | ( $\epsilon_r$ ) | ( $\sigma$ ) | sensitivity   | Probe linearity | Probe isotropy | Mod. type       | Duty factor | Peak to average power ratio |
| 11/07/2022 | 2450        | SN 36/20EP GO 346 | Body        | 52.10            | 2.01         | PASS          | PASS            | PASS           | OFDM            | PASS        | N/A                         |
| 11/07/2022 | 2600        | SN 36/20EP GO 346 | Body        | 52.31            | 2.12         | PASS          | PASS            | PASS           | OFDM            | PASS        | N/A                         |
| 11/07/2022 | 5200        | SN 36/20EP GO 346 | Body        | 49.02            | 5.52         | PASS          | PASS            | PASS           | OFDM            | PASS        | N/A                         |

NOTE: While the probes have been calibrated for both a CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as OFDM according to KDB 865664.

## Appendix F: The Check Data of Impedance and Return Loss

The information are included in the SAR report to qualify for the three-year extended calibration interval;

| Impedance in body liquid |           |                        |        |                             |                        |        | Date: 11/07/2022            |
|--------------------------|-----------|------------------------|--------|-----------------------------|------------------------|--------|-----------------------------|
| Freq. (MHz)              | Temp (°C) | Dipole Impedance Re(z) |        |                             | Dipole Impedance Im(z) |        |                             |
|                          |           | measured               | Target | $\Delta$ ( $\pm 5 \Omega$ ) | measured               | Target | $\Delta$ ( $\pm 5 \Omega$ ) |
| 2450                     | 22        | 45.90                  | 48.60  | 0.06                        | 0.60                   | -1.90  | 0.06                        |
| 2600                     | 22        | 52.30                  | 51.50  | -0.02                       | 5.70                   | -5.50  | -0.02                       |
| 5200                     | 22        | 49.02                  | 50.01  | 0.02                        | 5.52                   | 5.70   | 0.02                        |

| Return loss in body liquid |           |                 |         |                         | Date: 11/07/2022 |
|----------------------------|-----------|-----------------|---------|-------------------------|------------------|
| Freq. (MHz)                | Temp (°C) | Return loss(dB) |         |                         |                  |
|                            |           | measured        | Target  | $\Delta$ ( $\pm 20\%$ ) |                  |
| 2450                       | 22        | -34.65          | -32.86  | -0.05                   |                  |
| 2600                       | 22        | -23.56          | -24.71  | 0.05                    |                  |
| 5200                       | 22        | -14.85          | <-13.94 | -0.07                   |                  |

| liquid | Freq. (MHz) | Temp (°C) | $\epsilon_r$ / relative permittivity |        |                        | $\sigma$ (s/m) / conductivity |        |                        | $\rho$ (kg/m3) |
|--------|-------------|-----------|--------------------------------------|--------|------------------------|-------------------------------|--------|------------------------|----------------|
|        |             |           | measured                             | Target | $\Delta$ ( $\pm 5\%$ ) | measured                      | Target | $\Delta$ ( $\pm 5\%$ ) |                |
|        | 2450        | 22        | 52.10                                | 52.70  | 0.01                   | 2.01                          | 1.95   | -0.03                  | 1000           |
|        | 2600        | 22        | 52.31                                | 52.50  | 0.00                   | 2.12                          | 2.16   | 0.02                   | 1000           |
|        | 5200        | 22        | 49.02                                | 49.00  | 0.00                   | 5.52                          | 5.30   | -0.04                  | 1000           |

| Test Equipment                | Manufacturer    | Model           | Serial Number | Calibration              |                         |
|-------------------------------|-----------------|-----------------|---------------|--------------------------|-------------------------|
|                               |                 |                 |               | Calibration Date (D.M.Y) | Calibration Due (D.M.Y) |
| Signal Generator              | Agilent         | N5182A          | MY47070282    | Jun. 08, 2022            | Jun. 07, 2023           |
| Multimeter                    | Keithley        | Multimeter 2000 | 4078275       | Jun. 08, 2022            | Jun. 07, 2023           |
| Network Analyzer              | Agilent         | 8753E           | US38432457    | Jun. 08, 2022            | Jun. 07, 2023           |
| Power Meter                   | Agilent         | E4418B          | GB43312526    | Jun. 08, 2022            | Jun. 07, 2023           |
| Power Sensor                  | Agilent         | E9301A          | MY41497725    | Jun. 08, 2022            | Jun. 07, 2023           |
| Power Amplifier               | PE              | PE15A4019       | 112342        | N/A                      | N/A                     |
| Temperature / Humidity Sensor | Control company | TH101B          | 152470214     | Jun. 08, 2022            | Jun. 07, 2023           |

\*\*\*\*\*END OF REPORT\*\*\*\*\*