

## 5. CALIBRATION CERTIFICATES

### 5.1 Probe-EPGO324 Calibration Certificate



## COMOSAR E-Field Probe Calibration Report

Ref : ACR.281.2.18.SATU.A

### SHENZHEN LCS COMPLIANCE TESTING LABORATORY LTD.

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**MVG COMOSAR DOSIMETRIC E-FIELD PROBE**

SERIAL NO.: SN 31/17 EPGO324

Calibrated at MVG US

2105 Barrett Park Dr. - Kennesaw, GA 30144



Calibration Date: 10/08/2018

#### Summary:

This document presents the method and results from an accredited COMOSAR Dosimetric E-Field Probe calibration performed in MVG USA using the CALISAR / CALIBAIR test bench, for use with a COMOSAR system only. All calibration results are traceable to national metrology institutions.



## COMOSAR E-FIELD PROBE CALIBRATION REPORT

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|                      | <i>Name</i>   | <i>Function</i> | <i>Date</i> | <i>Signature</i>     |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC    | Product Manager | 10/8/2018   | <i>JS</i>            |
| <i>Checked by :</i>  | Jérôme LUC    | Product Manager | 10/8/2018   | <i>JS</i>            |
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|                       | <i>Customer Name</i>                                  |
|-----------------------|-------------------------------------------------------|
| <i>Distribution :</i> | Shenzhen LCS<br>Compliance Testing<br>Laboratory Ltd. |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A            | 10/8/2018   | Initial release      |
|              |             |                      |
|              |             |                      |
|              |             |                      |



## COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.281.2.18.SATU.A

## TABLE OF CONTENTS

|     |                                       |    |
|-----|---------------------------------------|----|
| 1   | Device Under Test .....               | 4  |
| 2   | Product Description .....             | 4  |
| 2.1 | General Information .....             | 4  |
| 3   | Measurement Method .....              | 4  |
| 3.1 | Linearity .....                       | 4  |
| 3.2 | Sensitivity .....                     | 5  |
| 3.3 | Lower Detection Limit .....           | 5  |
| 3.4 | Isotropy .....                        | 5  |
| 3.5 | Boundary Effect .....                 | 5  |
| 4   | Measurement Uncertainty .....         | 5  |
| 5   | Calibration Measurement Results ..... | 6  |
| 5.1 | Sensitivity in air .....              | 6  |
| 5.2 | Linearity .....                       | 7  |
| 5.3 | Sensitivity in liquid .....           | 7  |
| 5.4 | Isotropy .....                        | 8  |
| 6   | List of Equipment .....               | 10 |

Page: 3/10

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## COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.281.2.18.SATU.A

## 1 DEVICE UNDER TEST

| Device Under Test                        |                                                                         |
|------------------------------------------|-------------------------------------------------------------------------|
| Device Type                              | COMOSAR DOSIMETRIC E FIELD PROBE                                        |
| Manufacturer                             | MVG                                                                     |
| Model                                    | SSE2                                                                    |
| Serial Number                            | SN 31/17 EPG0324                                                        |
| Product Condition (new / used)           | New                                                                     |
| Frequency Range of Probe                 | 0.15 GHz-6GHz                                                           |
| Resistance of Three Dipoles at Connector | Dipole 1: R1=0.189 MΩ<br>Dipole 2: R2=0.203 MΩ<br>Dipole 3: R3=0.218 MΩ |

A yearly calibration interval is recommended.

## 2 PRODUCT DESCRIPTION

### 2.1 GENERAL INFORMATION

MVG's COMOSAR E field Probes are built in accordance to the IEEE 1528, OET 65 Bulletin C and CEI/IEC 62209 standards.



**Figure 1** – MVG COMOSAR Dosimetric E field Dipole

|                                            |        |
|--------------------------------------------|--------|
| Probe Length                               | 330 mm |
| Length of Individual Dipoles               | 2 mm   |
| Maximum external diameter                  | 8 mm   |
| Probe Tip External Diameter                | 2.5 mm |
| Distance between dipoles / probe extremity | 1 mm   |

## 3 MEASUREMENT METHOD

The IEEE 1528, OET 65 Bulletin C, CENELEC EN50361 and CEI/IEC 62209 standards provide recommended practices for the probe calibrations, including the performance characteristics of interest and methods by which to assess their affect. All calibrations / measurements performed meet the fore mentioned standards.

### 3.1 LINEARITY

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

Page: 4/10

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Ref: ACR.281.2.18.SATU.A

### 3.2 SENSITIVITY

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

### 3.3 LOWER DETECTION LIMIT

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

### 3.4 ISOTROPY

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

### 3.5 BOUNDARY EFFECT

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

## 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 (%) |
| Incident or forward power                                  | 3.00%                 | Rectangular              | $\sqrt{3}$ | 1  | 1.732%                   |
| Reflected power                                            | 3.00%                 | Rectangular              | $\sqrt{3}$ | 1  | 1.732%                   |
| Liquid conductivity                                        | 5.00%                 | Rectangular              | $\sqrt{3}$ | 1  | 2.887%                   |
| Liquid permittivity                                        | 4.00%                 | Rectangular              | $\sqrt{3}$ | 1  | 2.309%                   |
| Field homogeneity                                          | 3.00%                 | Rectangular              | $\sqrt{3}$ | 1  | 1.732%                   |
| Field probe positioning                                    | 5.00%                 | Rectangular              | $\sqrt{3}$ | 1  | 2.887%                   |

Page: 5/10

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## COMOSAR E-FIELD PROBE CALIBRATION REPORT

Ref: ACR.281.2.18.SATU.A

|                                                            |       |             |            |   |        |
|------------------------------------------------------------|-------|-------------|------------|---|--------|
| Field probe linearity                                      | 3.00% | Rectangular | $\sqrt{3}$ | 1 | 1.732% |
| <b>Combined standard uncertainty</b>                       |       |             |            |   | 5.831% |
| <b>Expanded uncertainty</b><br>95 % confidence level k = 2 |       |             |            |   | 12.0%  |

## 5 CALIBRATION MEASUREMENT RESULTS

| Calibration Parameters |       |
|------------------------|-------|
| Liquid Temperature     | 21 °C |
| Lab Temperature        | 21 °C |
| Lab Humidity           | 45 %  |

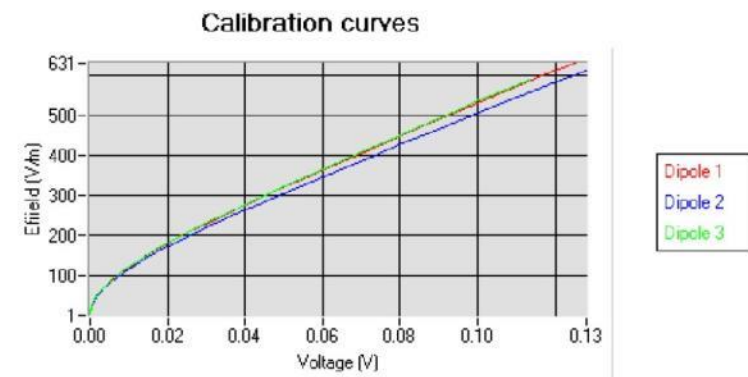
## 5.1 SENSITIVITY IN AIR

| Normx dipole<br>1 ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | Normy dipole<br>2 ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | Normz dipole<br>3 ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) |
|-----------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|
| 0.80                                                      | 0.83                                                      | 0.68                                                      |

| DCP dipole 1<br>(mV) | DCP dipole 2<br>(mV) | DCP dipole 3<br>(mV) |
|----------------------|----------------------|----------------------|
| 95                   | 90                   | 93                   |

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

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



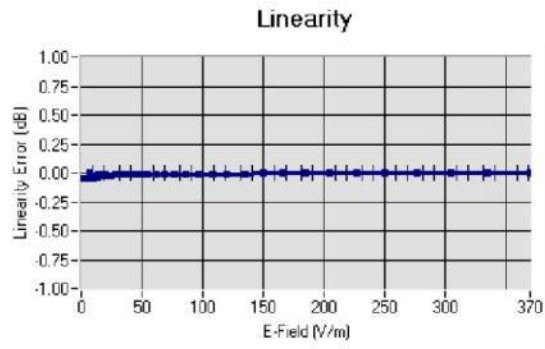
Page: 6/10

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Ref: ACR.281.2.18.SATU.A

5.2 LINEARITYLinearity:  $\pm 1.13\%$  ( $\pm 0.05\text{dB}$ )5.3 SENSITIVITY IN LIQUID

| Liquid | Frequency<br>(MHz $\pm$ 100MHz) | Permittivity | Epsilon (S/m) | ConvF |
|--------|---------------------------------|--------------|---------------|-------|
| HL450  | 450                             | 42.17        | 0.86          | 1.56  |
| BL450  | 450                             | 57.65        | 0.95          | 1.60  |
| HL750  | 750                             | 40.03        | 0.93          | 1.45  |
| BL750  | 750                             | 56.83        | 1.00          | 1.50  |
| HL850  | 835                             | 42.19        | 0.90          | 1.55  |
| BL850  | 835                             | 54.67        | 1.01          | 1.59  |
| HL900  | 900                             | 42.08        | 1.01          | 1.54  |
| BL900  | 900                             | 55.25        | 1.08          | 1.60  |
| HL1800 | 1800                            | 41.68        | 1.46          | 1.65  |
| BL1800 | 1800                            | 53.86        | 1.46          | 1.68  |
| HL1900 | 1900                            | 38.45        | 1.45          | 1.86  |
| BL1900 | 1900                            | 53.32        | 1.56          | 1.93  |
| HL2000 | 2000                            | 38.26        | 1.38          | 1.83  |
| BL2000 | 2000                            | 52.70        | 1.51          | 1.89  |
| HL2300 | 2300                            | 39.44        | 1.62          | 1.95  |
| BL2300 | 2300                            | 54.52        | 1.77          | 2.01  |
| HL2450 | 2450                            | 37.50        | 1.80          | 1.91  |
| BL2450 | 2450                            | 53.22        | 1.89          | 1.95  |
| HL2600 | 2600                            | 39.80        | 1.99          | 1.89  |
| BL2600 | 2600                            | 52.52        | 2.23          | 1.94  |
| HL5200 | 5200                            | 35.64        | 4.67          | 1.50  |
| BL5200 | 5200                            | 48.64        | 5.51          | 1.56  |
| HL5400 | 5400                            | 36.44        | 4.87          | 1.44  |
| BL5400 | 5400                            | 46.52        | 5.77          | 1.47  |
| HL5600 | 5600                            | 36.66        | 5.17          | 1.48  |
| BL5600 | 5600                            | 46.79        | 5.77          | 1.53  |
| HL5800 | 5800                            | 35.31        | 5.31          | 1.50  |
| BL5800 | 5800                            | 47.04        | 6.10          | 1.55  |

LOWER DETECTION LIMIT: 9mW/kg

Page: 7/10

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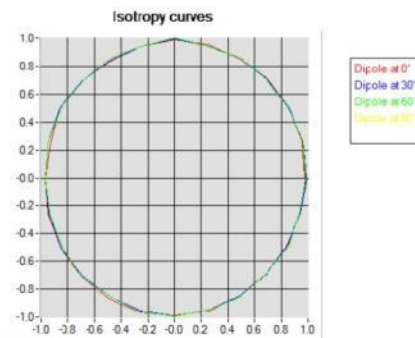
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#### 5.4 ISOTROPY

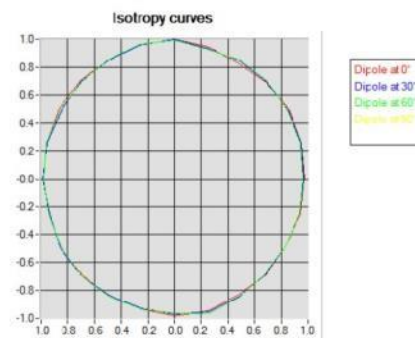
##### HL900 MHz

- Axial isotropy: 0.05 dB
- Hemispherical isotropy: 0.07 dB



##### HL1800 MHz

- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.07 dB



Page: 8/10

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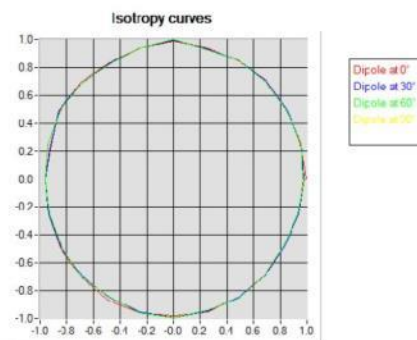


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Ref: ACR.281.2.18.SATU.A

**HL5600 MHz**

- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.10 dB



Page: 9/10

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Ref: ACR.281.2.18.SATU.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              | Rhode & Schwarz ZVA  | SN100132           | 02/2016                                       | 02/2019                                       |
| Reference Probe               | MVG                  | EP 94 SN 37/08     | 10/2017                                       | 10/2019                                       |
| Multimeter                    | Keithley 2000        | 1188656            | 01/2017                                       | 01/2020                                       |
| Signal Generator              | Agilent E4438C       | MY49070581         | 01/2017                                       | 01/2020                                       |
| Amplifier                     | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                   | HP E4418A            | US38261498         | 01/2017                                       | 01/2020                                       |
| Power Sensor                  | HP ECP-E26A          | US37181460         | 01/2017                                       | 01/2020                                       |
| 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 | Control Company      | 150798832          | 11/2017                                       | 11/2020                                       |

Page: 10/10

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