

# FCC SAR Test Report

**Report No.** : SA180327W001-1  
**Applicant** : North of You, LLC  
**Address** : 2434 Lasso Ave, Bozeman MT, 59718 USA  
**Product** : Arsenal  
**FCC ID** : 2AOYX-NOYP1  
**Brand** : Arsenal  
**Model No.** : Madison  
**Standards** : FCC 47 CFR Part 2 (2.1093) / ANSI/IEEE C95.1:1992 / IEEE 1528:2013  
KDB 865664 D01 v01r04 / KDB 865664 D02 v01r02  
KDB 248227 D01 v02r02 / KDB 447498 D01 v06 / KDB 941225 D06 v02r01  
**Sample Received Date** : Mar. 27, 2018  
**Date of Testing** : Apr. 07, 2018 ~ Apr. 08, 2018

**CERTIFICATION:** The above equipment have been tested by **BV 7LAYERS COMMUNICATIONS TECHNOLOGY (SHENZHEN) CO. LTD.**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's SAR characteristics under the conditions specified in this report. It should not be reproduced except in full, without the written approval of our laboratory. The client should not use it to claim product certification, approval, or endorsement by A2LA or any government agencies.

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## Release Control Record

| Report No.     | Reason for Change | Date Issued   |
|----------------|-------------------|---------------|
| SA180327W001-1 | Initial release   | Apr. 10, 2018 |
|                |                   |               |
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### 1. Summary of Maximum SAR Value

| Equipment Class | Mode      | Highest Reported Body SAR <sub>1g</sub><br>(0.5 cm Gap)<br>(W/kg) |
|-----------------|-----------|-------------------------------------------------------------------|
| DTS             | 2.4G WLAN | 0.12                                                              |

**Note:**

1. The SAR limit (**Head & Body: SAR<sub>1g</sub> 1.6 W/kg**) for general population / uncontrolled exposure is specified in FCC 47 CFR part 2 (2.1093) and ANSI/IEEE C95.1-1992.

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### 2. Description of Equipment Under Test

|                                                |                                    |
|------------------------------------------------|------------------------------------|
| EUT Type                                       | Arsenal                            |
| FCC ID                                         | 2AOYX-NOYP1                        |
| Brand Name                                     | Arsenal                            |
| Model Name                                     | Madison                            |
| HW Version                                     | Madison                            |
| SW Version                                     | 1.0.0                              |
| Tx Frequency Bands<br>(Unit: MHz)              | WLAN : 2412 ~ 2462                 |
| Uplink Modulations                             | 802.11b : DSSS<br>802.11g/n : OFDM |
| Maximum Tune-up Conducted Power<br>(Unit: dBm) | WLAN 2.4G : 19.0                   |
| Antenna Type                                   | WLAN: Fixed Internal Antenna       |
| EUT Stage                                      | Production Unit                    |

#### Note:

- The above EUT information is declared by manufacturer and for more detailed features description please refers to the manufacturer's specifications or User's Manual.

#### List of Accessory:

|         |              |                 |
|---------|--------------|-----------------|
| Battery | Brand Name   | N/A             |
|         | Model Name   | N/A             |
|         | Power Rating | 3.7Vdc, 1400mAh |
|         | Type         | Li-ion          |

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### 3. SAR Measurement System

#### 3.1 Definition of Specific Absorption Rate (SAR)

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

$$SAR = \frac{d}{dt} \left( \frac{dW}{dm} \right) = \frac{d}{dt} \left( \frac{dW}{\rho dv} \right)$$

SAR is expressed in units of Watts per kilogram (W/kg)

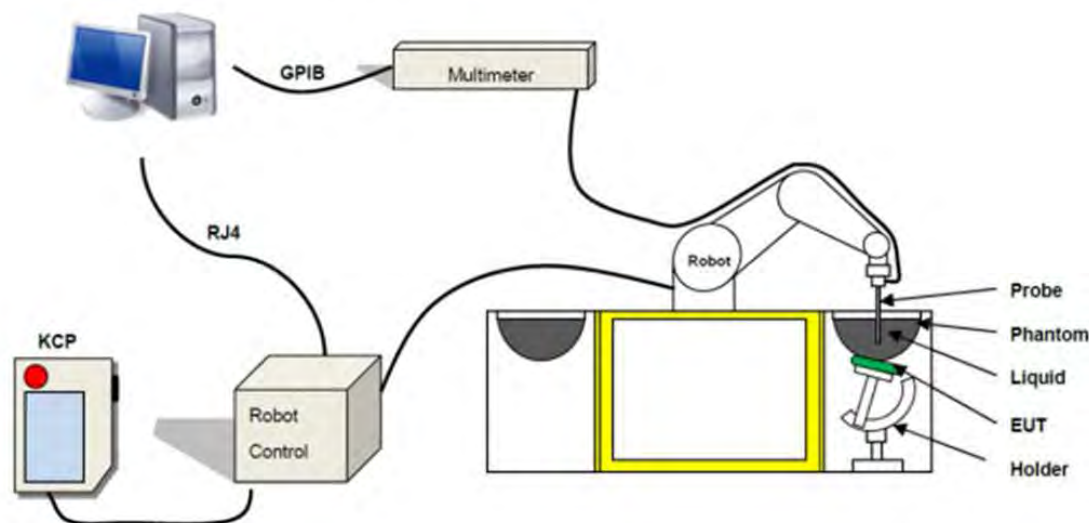
SAR measurement can be related to the electrical field in the tissue by

$$SAR = \frac{\sigma |E|^2}{\rho}$$

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

#### 3.2 COMOSAR System

##### 3.2.1 Measurement System Diagram



These measurements were performed with the automated near-field scanning system COMOSAR from SATIMO. The system is based on a high precision robot (working range: 850 mm), which positions the probes with a positional repeatability of better than  $\pm 0.02$  mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit.

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The SAR measurements were conducted with dosimetric probe (manufactured by SATIMO), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure described in SAR standard with accuracy of better than  $\pm 10\%$ . The spherical isotropy was evaluated with the procedure described in SAR standard and found to be better than  $\pm 0.25$  dB. The phantom used was the SAM Phantom as described in FCC supplement C, IEEE P1528.

### 3.2.2 Robot

The COMOSAR system uses the high precision robots from KUKA. For the 6-axis controller system, the robot controller version (KUKA-KRC2sr) from KUKA is used. The KUKA robot series have many features that are important for our application:

- High precision (repeatability  $\pm 0.02$  mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)



Fig-3.2 KUKA KR5

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### 3.2.3 E-Field Probes

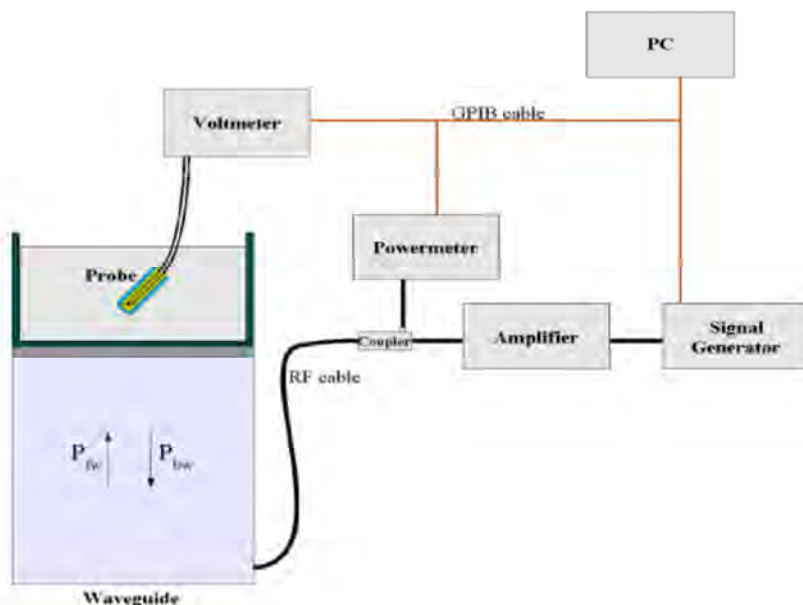
The SAR measurement is conducted with the dosimetric probe. The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency.



|                 |                                                                                                               |
|-----------------|---------------------------------------------------------------------------------------------------------------|
| Device Type     | COMOSAR DOSIMETRIC E FIELD PROBE                                                                              |
| Model           | SSE2                                                                                                          |
| Frequency       | 100 MHz to 6 GHz                                                                                              |
| Directivity     | ±0.25 dB in brain tissue (rotation around probe axis)<br>±0.5 dB in brain tissue (rotation normal probe axis) |
| Dynamic Range   | 0.001W/kg to > 100W/kg                                                                                        |
| Probe Linearity | ± 0.25 dB                                                                                                     |
| Dimensions      | Overall length: 330 mm<br>Tip diameter: 2.5 mm<br>Distance from probe tip to dipole centers: <1.5 mm          |

### E-Field Probe Calibration Process

Probe calibration is realized, in compliance with EN/IEC 62209-1/-2 and IEEE 1528 std, with CALISAR, SATIMO proprietary calibration system. The calibration is performed with the technique using reference waveguide.



$$SAR = \frac{4(P_{fw} - P_{bw})}{ab\delta} \cos^2\left(\pi \frac{y}{a}\right) e^{-(2z/\delta)}$$

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$$SAR = \frac{4(P_{fw} - P_{bw})}{ab\sigma} \cos^2 \left( \pi \frac{y}{a} \right) e^{-(2\pi/\sigma)z}$$

Where :

- $P_{fw}$  = Forward Power
- $P_{bw}$  = Backward Power
- $a$  and  $b$  = Waveguide Dimensions
- $\sigma$  = Skin Depth

Keithley configuration

Rate=Medium; Filter=ON; RDGS=10; FILTER TYPE=MOVING AVERAGE; RANGE AUTO

After each calibration, a SAR measurement performed on a validation dipole and compared with a NPL calibrated probe, to verify it.

The Calibration factors, CF(N), for the 3 sensors corresponding to dipole 1, dipole 2 and dipole 3 are:

$$CF(N) = SAR(N)/V_{lin}(N) \quad (N=1,2,3)$$

The linearized output voltage  $V_{lin}(N)$  is obtained from the displayed output voltage  $V(N)$  using

$$V_{lin}(N) = V(N) * (1 + V(N)/DCP(N)) \quad N=1,2,3$$

Where the DCP is the dipole compression point in mV

### 3.2.4 Phantoms

The phantom developed by SATIMO is produced in accordance with the specified in the standards. It has been designed to fit the COMOSAR phantom tables and is delivered with a plastic cover to prevent liquid evaporation.

|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                       |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Model</b>           | SAM Phantom                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |
| <b>Construction</b>    | The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by teaching reference points with the robot. |                                                                                       |
| <b>Material</b>        | The material is resistant to Glycol and offers high rigidity composite material based on fiberglass).                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                       |
| <b>Shell Thickness</b> | 2 ± 0.2 mm (6 ± 0.2 mm at ear point)                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                       |
| <b>Dimensions</b>      | Length: 1000 mm<br>Width: 500 mm<br>Height: 200 mm                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                       |
| <b>Filling Volume</b>  | approx. 27 liters                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                       |

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|                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                     |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| <b>Model</b>           | Elliptic Phantom                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |
| <b>Construction</b>    | Elliptic Phantom for compliance testing of handheld and body-mounted wireless devices. Elliptic Phantom is fully compatible with the IEC/EN 62209-2 standard and all known tissue simulating liquids. Elliptic Phantom has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching reference points. |                                                                                     |
| <b>Material</b>        | The material is resistant to Glycol and offers high rigidity composite material based on fiberglass).                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                     |
| <b>Shell Thickness</b> | 2.0 ± 0.2 mm (bottom plate)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                     |
| <b>Dimensions</b>      | Length: 600 mm<br>Width: 400 mm<br>Height: 200 mm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                     |
| <b>Filling Volume</b>  | approx. 25 liters                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                     |

### 3.2.5 Device Holder

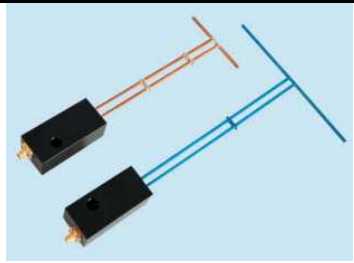
The positioning system is made of an extremely stable material, which ensures easy handling and reproducible positioning. It also allows correct positioning of the dipoles referenced by the IEEE, ANSI and IEC.

|                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                       |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Model</b>                  | Handset Positioning System                                                                                                                                                                                                                                                                                                                                                                                                                              |  |
| <b>Material properties</b>    | The positioning system is made of PETP. This material offers a low permittivity of 3.2 and low loss, with a loss tangent of 0.005 to minimize the influence of the DUT on measurement results.                                                                                                                                                                                                                                                          |                                                                                       |
| <b>Mechanical properties</b>  | The positioning system developed by SATIMO allows a positioning resolution better than 1 mm. The system is fixed on a bottom rail "x axis" so that the positioning system can be quickly moved from the right to the left part of the phantom. In addition, it can be moved on a perpendicular "y axis" and the height can be adapted. The system is also composed of three rotation points for accurate positioning of the device's acoustical output. |                                                                                       |
| <b>Accuracy and precision</b> | A curved rail on the top part allows the fast switch from the cheek to the tilt position. The required 15° angle for the tilt position can be easily checked thanks to a printed scale on the curved rail with a tolerance of ± 1°                                                                                                                                                                                                                      |                                                                                       |

|                               |                                                                                                                                                                                                |                                                                                       |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Model</b>                  | Device Positioning System                                                                                                                                                                      |  |
| <b>Material properties</b>    | The positioning system is made of PETP. This material offers a low permittivity of 3.2 and low loss, with a loss tangent of 0.005 to minimize the influence of the DUT on measurement results. |                                                                                       |
| <b>Mechanical properties</b>  | 2 rows of rail to cover easily the surface of the phantom. The fixing plate is perfectly adapted to larger devices, such as a PC which can be positioned in all configurations.                |                                                                                       |
| <b>Accuracy and precision</b> | Graduated scale available on each axis. The DUT is fixed with a specific adaptable grip.                                                                                                       |                                                                                       |

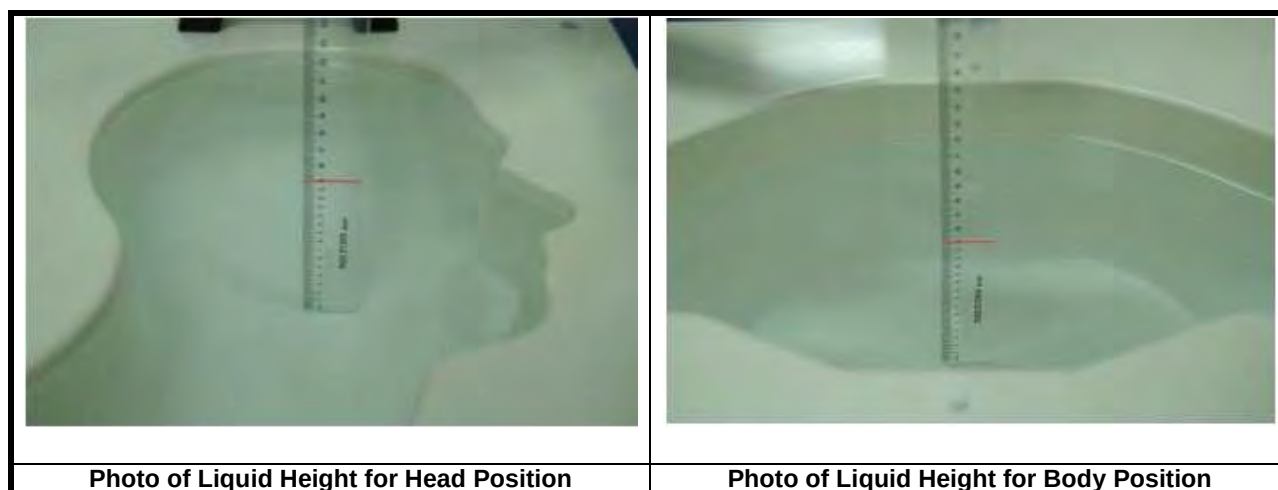
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### 3.2.6 System Validation Dipoles

|                     |                                                                                                                                                                               |                                                                                     |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| <b>Model</b>        | D-Serial                                                                                                                                                                      |  |
| <b>Construction</b> | Symmetrical dipole with $\lambda/4$ ablaun. Enables measurement of feed point impedance with NWA. Matched for use near flat phantoms filled with tissue simulating solutions. |                                                                                     |
| <b>Frequency</b>    | 300 MHz to 6000 MHz                                                                                                                                                           |                                                                                     |
| <b>Return Loss</b>  | > 20 dB                                                                                                                                                                       |                                                                                     |
| <b>Adaptation</b>   | S11 < -20 dB in specified validation Position                                                                                                                                 |                                                                                     |

### 3.2.7 Tissue Simulating Liquids

For SAR measurement of the field distribution inside the phantom, the phantom must be filled with homogeneous tissue simulating liquid to a depth of at least 15 cm. For head SAR testing, the liquid height from the ear reference point (ERP) of the phantom to the liquid top surface is larger than 15 cm. For body SAR testing, the liquid height from the center of the flat phantom to the liquid top surface is larger than 15 cm. The nominal dielectric values of the tissue simulating liquids in the phantom and the tolerance of 5% are listed in Table-3.1.



The dielectric properties of the head tissue simulating liquids are defined in IEEE 1528, and KDB 865664 D01 Appendix A. For the body tissue simulating liquids, the dielectric properties are defined in KDB 865664 D01 Appendix A. The dielectric properties of the tissue simulating liquids were verified prior to the SAR evaluation using a dielectric assessment kit and a network analyzer.

Table-3.1 Targets of Tissue Simulating Liquid

| Frequency (MHz) | Target Permittivity | Range of $\pm 5\%$ | Target Conductivity | Range of $\pm 5\%$ |
|-----------------|---------------------|--------------------|---------------------|--------------------|
| <b>For Head</b> |                     |                    |                     |                    |
| 750             | 41.9                | 39.8 ~ 44.0        | 0.89                | 0.85 ~ 0.93        |
| 835             | 41.5                | 39.4 ~ 43.6        | 0.90                | 0.86 ~ 0.95        |
| 900             | 41.5                | 39.4 ~ 43.6        | 0.97                | 0.92 ~ 1.02        |
| 1450            | 40.5                | 38.5 ~ 42.5        | 1.20                | 1.14 ~ 1.26        |
| 1640            | 40.3                | 38.3 ~ 42.3        | 1.29                | 1.23 ~ 1.35        |
| 1750            | 40.1                | 38.1 ~ 42.1        | 1.37                | 1.30 ~ 1.44        |
| 1800            | 40.0                | 38.0 ~ 42.0        | 1.40                | 1.33 ~ 1.47        |
| 1900            | 40.0                | 38.0 ~ 42.0        | 1.40                | 1.33 ~ 1.47        |
| 2000            | 40.0                | 38.0 ~ 42.0        | 1.40                | 1.33 ~ 1.47        |
| 2300            | 39.5                | 37.5 ~ 41.5        | 1.67                | 1.59 ~ 1.75        |
| 2450            | 39.2                | 37.2 ~ 41.2        | 1.80                | 1.71 ~ 1.89        |
| 2600            | 39.0                | 37.1 ~ 41.0        | 1.96                | 1.86 ~ 2.06        |
| 3500            | 37.9                | 36.0 ~ 39.8        | 2.91                | 2.76 ~ 3.06        |
| 5200            | 36.0                | 34.2 ~ 37.8        | 4.66                | 4.43 ~ 4.89        |
| 5300            | 35.9                | 34.1 ~ 37.7        | 4.76                | 4.52 ~ 5.00        |
| 5500            | 35.6                | 33.8 ~ 37.4        | 4.96                | 4.71 ~ 5.21        |
| 5600            | 35.5                | 33.7 ~ 37.3        | 5.07                | 4.82 ~ 5.32        |
| 5800            | 35.3                | 33.5 ~ 37.1        | 5.27                | 5.01 ~ 5.53        |
| <b>For Body</b> |                     |                    |                     |                    |
| 750             | 55.5                | 52.7 ~ 58.3        | 0.96                | 0.91 ~ 1.01        |
| 835             | 55.2                | 52.4 ~ 58.0        | 0.97                | 0.92 ~ 1.02        |
| 900             | 55.0                | 52.3 ~ 57.8        | 1.05                | 1.00 ~ 1.10        |
| 1450            | 54.0                | 51.3 ~ 56.7        | 1.30                | 1.24 ~ 1.37        |
| 1640            | 53.8                | 51.1 ~ 56.5        | 1.40                | 1.33 ~ 1.47        |
| 1750            | 53.4                | 50.7 ~ 56.1        | 1.49                | 1.42 ~ 1.56        |
| 1800            | 53.3                | 50.6 ~ 56.0        | 1.52                | 1.44 ~ 1.60        |
| 1900            | 53.3                | 50.6 ~ 56.0        | 1.52                | 1.44 ~ 1.60        |
| 2000            | 53.3                | 50.6 ~ 56.0        | 1.52                | 1.44 ~ 1.60        |
| 2300            | 52.9                | 50.3 ~ 55.5        | 1.81                | 1.72 ~ 1.90        |
| 2450            | 52.7                | 50.1 ~ 55.3        | 1.95                | 1.85 ~ 2.05        |
| 2600            | 52.5                | 49.9 ~ 55.1        | 2.16                | 2.05 ~ 2.27        |
| 3500            | 51.3                | 48.7 ~ 53.9        | 3.31                | 3.14 ~ 3.48        |
| 5200            | 49.0                | 46.6 ~ 51.5        | 5.30                | 5.04 ~ 5.57        |
| 5300            | 48.9                | 46.5 ~ 51.3        | 5.42                | 5.15 ~ 5.69        |
| 5500            | 48.6                | 46.2 ~ 51.0        | 5.65                | 5.37 ~ 5.93        |
| 5600            | 48.5                | 46.1 ~ 50.9        | 5.77                | 5.48 ~ 6.06        |
| 5800            | 48.2                | 45.8 ~ 50.6        | 6.00                | 5.70 ~ 6.30        |

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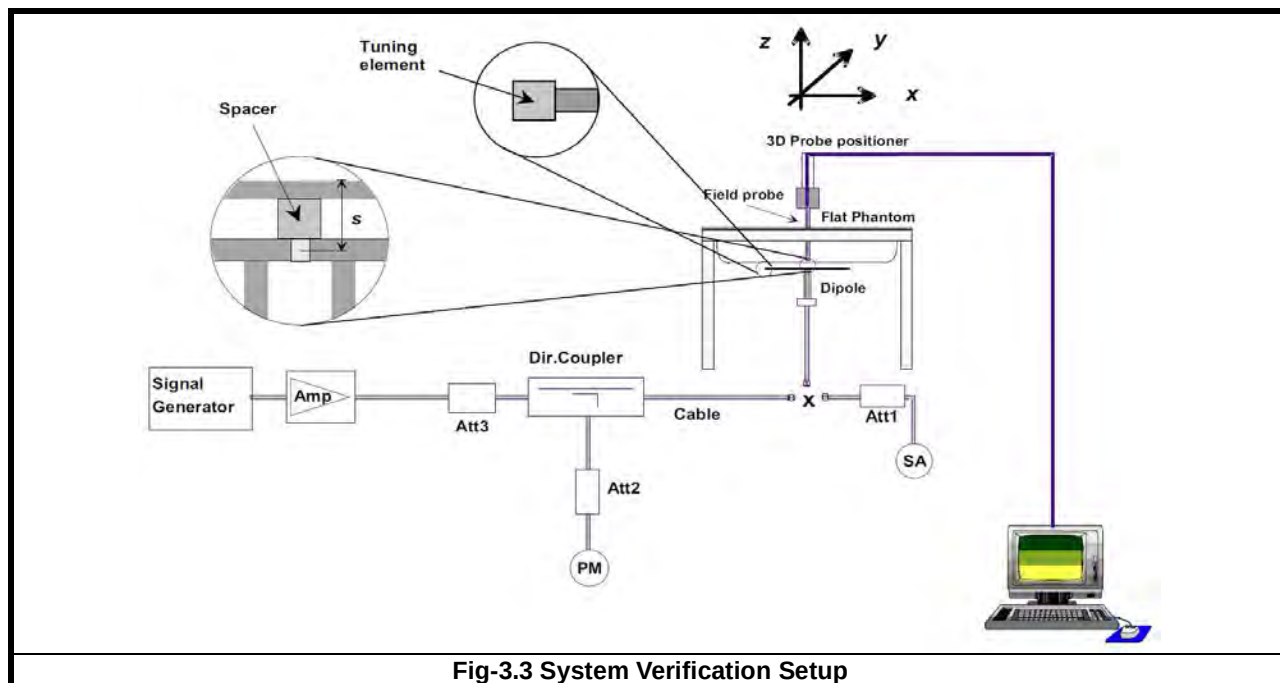
The following table gives the recipes for tissue simulating liquids.

**Table-3.2 Recipes of Tissue Simulating Liquid**

| Tissue Type | Bactericide | DGBE | HEC | NaCl | Sucrose | Triton X-100 | Water | Diethylene Glycol Mono-hexylether |
|-------------|-------------|------|-----|------|---------|--------------|-------|-----------------------------------|
| H750        | 0.2         | -    | 0.2 | 1.5  | 56.0    | -            | 42.1  | -                                 |
| H835        | 0.2         | -    | 0.2 | 1.5  | 57.0    | -            | 41.1  | -                                 |
| H900        | 0.2         | -    | 0.2 | 1.4  | 58.0    | -            | 40.2  | -                                 |
| H1450       | -           | 43.3 | -   | 0.6  | -       | -            | 56.1  | -                                 |
| H1640       | -           | 45.8 | -   | 0.5  | -       | -            | 53.7  | -                                 |
| H1750       | -           | 47.0 | -   | 0.4  | -       | -            | 52.6  | -                                 |
| H1800       | -           | 44.5 | -   | 0.3  | -       | -            | 55.2  | -                                 |
| H1900       | -           | 44.5 | -   | 0.2  | -       | -            | 55.3  | -                                 |
| H2000       | -           | 44.5 | -   | 0.1  | -       | -            | 55.4  | -                                 |
| H2300       | -           | 44.9 | -   | 0.1  | -       | -            | 55.0  | -                                 |
| H2450       | -           | 45.0 | -   | 0.1  | -       | -            | 54.9  | -                                 |
| H2600       | -           | 45.1 | -   | 0.1  | -       | -            | 54.8  | -                                 |
| H3500       | -           | 8.0  | -   | 0.2  | -       | 20.0         | 71.8  | -                                 |
| H5G         | -           | -    | -   | -    | -       | 17.2         | 65.5  | 17.3                              |
| B750        | 0.2         | -    | 0.2 | 0.8  | 48.8    | -            | 50.0  | -                                 |
| B835        | 0.2         | -    | 0.2 | 0.9  | 48.5    | -            | 50.2  | -                                 |
| B900        | 0.2         | -    | 0.2 | 0.9  | 48.2    | -            | 50.5  | -                                 |
| B1450       | -           | 34.0 | -   | 0.3  | -       | -            | 65.7  | -                                 |
| B1640       | -           | 32.5 | -   | 0.3  | -       | -            | 67.2  | -                                 |
| B1750       | -           | 31.0 | -   | 0.2  | -       | -            | 68.8  | -                                 |
| B1800       | -           | 29.5 | -   | 0.4  | -       | -            | 70.1  | -                                 |
| B1900       | -           | 29.5 | -   | 0.3  | -       | -            | 70.2  | -                                 |
| B2000       | -           | 30.0 | -   | 0.2  | -       | -            | 69.8  | -                                 |
| B2300       | -           | 31.0 | -   | 0.1  | -       | -            | 68.9  | -                                 |
| B2450       | -           | 31.4 | -   | 0.1  | -       | -            | 68.5  | -                                 |
| B2600       | -           | 31.8 | -   | 0.1  | -       | -            | 68.1  | -                                 |
| B3500       | -           | 28.8 | -   | 0.1  | -       | -            | 71.1  | -                                 |
| B5G         | -           | -    | -   | -    | -       | 10.7         | 78.6  | 10.7                              |

## 3.3 SAR System Verification

The system check verifies that the system operates within its specifications. It is performed daily or before every SAR measurement. The system check uses normal SAR measurements in the flat section of the phantom with a matched dipole at a specified distance. The system verification setup is shown as below.



**Fig-3.3 System Verification Setup**

The validation dipole is placed beneath the flat phantom with the specific spacer in place. The distance spacer is touch the phantom surface with a light pressure at the reference marking and be oriented parallel to the long side of the phantom. The spectrum analyzer measures the forward power at the location of the system check dipole connector. The signal generator is adjusted for the desired forward power at the dipole connector and the power meter is read at that level. After connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter.

After system check testing, the SAR result will be normalized to 1W forward input power and compared with the reference SAR value derived from validation dipole certificate report. The deviation of system check should be within 10 %.

## FCC SAR Test Report

### 3.4 SAR Measurement Procedure

According to the SAR test standard, the recommended procedure for assessing the peak spatial-average SAR value consists of the following steps:

- Power reference measurement
- Area scan
- Zoom scan
- Power drift measurement

The SAR measurement procedures for each of test conditions are as follows:

- Make EUT to transmit maximum output power
- Measure conducted output power through RF cable
- Place the EUT in the specific position of phantom
- Perform SAR testing steps on the COMOSAR system
- Record the SAR value

#### 3.4.1 Area & Zoom Scan Procedure

First Area Scan is used to locate the approximate location(s) of the local peak SAR value(s). The measurement grid within an Area Scan is defined by the grid extent, grid step size and grid offset. Next, in order to determine the EM field distribution in a three-dimensional spatial extension, Zoom Scan is required. The Zoom Scan is performed around the highest E-field value to determine the averaged SAR-distribution over 10 g. According to KDB 865664 D01, the resolution for Area and Zoom scan is specified in the table below.

| Items                                 | $\leq 2$ GHz | 2-3 GHz      | 3-4 GHz      | 4-5 GHz      | 5-6 GHz      |
|---------------------------------------|--------------|--------------|--------------|--------------|--------------|
| Area Scan<br>( $\Delta x, \Delta y$ ) | $\leq 15$ mm | $\leq 12$ mm | $\leq 12$ mm | $\leq 10$ mm | $\leq 10$ mm |
| Zoom Scan<br>( $\Delta x, \Delta y$ ) | $\leq 8$ mm  | $\leq 5$ mm  | $\leq 5$ mm  | $\leq 4$ mm  | $\leq 4$ mm  |
| Zoom Scan<br>( $\Delta z$ )           | $\leq 5$ mm  | $\leq 5$ mm  | $\leq 4$ mm  | $\leq 3$ mm  | $\leq 2$ mm  |
| Zoom Scan<br>Volume                   | $\geq 30$ mm | $\geq 30$ mm | $\geq 28$ mm | $\geq 25$ mm | $\geq 22$ mm |

**Note:**

When zoom scan is required and report SAR is  $\leq 1.4$  W/kg, the zoom scan resolution of  $\Delta x / \Delta y$  (2-3GHz:  $\leq 8$  mm, 3-4GHz:  $\leq 7$  mm, 4-6GHz:  $\leq 5$  mm) may be applied.

#### 3.4.2 Volume Scan Procedure

The volume scan is used for assess overlapping SAR distributions for antennas transmitting in different frequency bands. It is equivalent to an oversized zoom scan used in standalone measurements. The measurement volume will be used to enclose all the simultaneous transmitting antennas. For antennas transmitting simultaneously in different frequency bands, the volume scan is measured separately in each frequency band. In order to sum correctly to compute the 1g aggregate SAR, the EUT remain in the same test position for all measurements and all volume scan use the same spatial resolution and grid spacing. When all volume scan were completed, the software can combine and subsequently superpose these measurement data to calculating the multiband SAR.

## FCC SAR Test Report

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### 3.4.3 Power Drift Monitoring

All SAR testing is under the EUT install full charged battery and transmit maximum output power. In COMOSAR measurement software, the power reference measurement and power drift measurement procedures are used for monitoring the power drift of EUT during SAR test. Both these procedures measure the field at a specified reference position before and after the SAR testing. If the power drift more than 5%, the SAR will be retested.

### 3.4.4 Spatial Peak SAR Evaluation

The procedure for spatial peak SAR evaluation has been implemented according to the test standard. It can be conducted for 1g and 10g, as well as for user-specific masses. The OPENSAR software includes all numerical procedures necessary to evaluate the spatial peak SAR value.

The base for the evaluation is a "cube" measurement. The measured volume must include the 1g and 10g cubes with the highest averaged SAR values. For that purpose, the center of the measured volume is aligned to the interpolated peak SAR value of a previously performed area scan.

The entire evaluation of the spatial peak values is performed within the post-processing engine. The system always gives the maximum values for the 1g and 10g cubes. The algorithm to find the cube with highest averaged SAR is divided into the following stages:

- (a) Extraction of the measured data (grid and values) from the Zoom Scan
- (b) Calculation of the SAR value at every measurement point based on all stored data (A/D values and measurement parameters)
- (c) Generation of a high-resolution mesh within the measured volume
- (d) Interpolation of all measured values from the measurement grid to the high-resolution grid
- (e) Extrapolation of the entire 3-D field distribution to the phantom surface over the distance from sensor to surface
- (f) Calculation of the averaged SAR within masses of 1g and 10g

### 3.4.5 SAR Averaged Methods

In COMOSAR System, the interpolation and extrapolation are both based on the modified Quadratic Shepard's method. The interpolation scheme combines a least-square fitted function method and a weighted average method which are the two basic types of computational interpolation and approximation.

## **4. SAR Measurement Evaluation**

### **4.1 EUT Configuration and Setting**

#### **<Considerations Related to WLAN for Setup and Testing>**

In general, various vendor specific external test software and chipset based internal test modes are typically used for SAR measurement. These chipset based test mode utilities are generally hardware and manufacturer dependent, and often include substantial flexibility to reconfigure or reprogram a device. A Wi-Fi device must be configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor supported by the test mode tools for SAR measurement. The test frequencies established using test mode must correspond to the actual channel frequencies. When 802.11 frame gaps are accounted for in the transmission, a maximum transmission duty factor of 92 - 96% is typically achievable in most test mode configurations. A minimum transmission duty factor of 85% is required to avoid certain hardware and device implementation issues related to wide range SAR scaling. In addition, a periodic transmission duty factor is required for current generation SAR systems to measure SAR correctly. The reported SAR must be scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

According to KDB 248227 D01, this device has installed WLAN engineering testing software which can provide continuous transmitting RF signal. During WLAN SAR testing, this device was operated to transmit continuously at the maximum transmission duty with specified transmission mode, operating frequency, lowest data rate, and maximum output power.

#### **Initial Test Configuration**

An initial test configuration is determined for OFDM transmission modes in 2.4 GHz and 5 GHz bands according to the channel bandwidth, modulation and data rate combination(s) with the highest maximum output power specified for production units in each standalone and aggregated frequency band. When the same maximum power is specified for multiple transmission modes in a frequency band, the largest channel bandwidth, lowest order modulation, lowest data rate and lowest order 802.11a/g/n/ac mode is used for SAR measurement, on the highest measured output power channel in the initial test configuration, for each frequency band.

#### **Subsequent Test Configuration**

SAR measurement requirements for the remaining 802.11 transmission mode configurations that have not been tested in the initial test configuration are determined separately for each standalone and aggregated frequency band, in each exposure condition, according to the maximum output power specified for production units. Additional power measurements may be required to determine if SAR measurements are required for subsequent highest output power channels in a subsequent test configuration. When the highest reported SAR for the initial test configuration according to the initial test position or fixed exposure position requirements, is adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power and the adjusted SAR is  $\leq 1.2$  W/kg, SAR is not required for that subsequent test configuration.

#### **SAR Test Configuration and Channel Selection**

When multiple channel bandwidth configurations in a frequency band have the same specified maximum output power, the initial test configuration is using largest channel bandwidth, lowest order modulation, lowest data rate, and lowest order 802.11 mode (i.e., 802.11a is chosen over 802.11n then 802.11ac or 802.11g is chosen over

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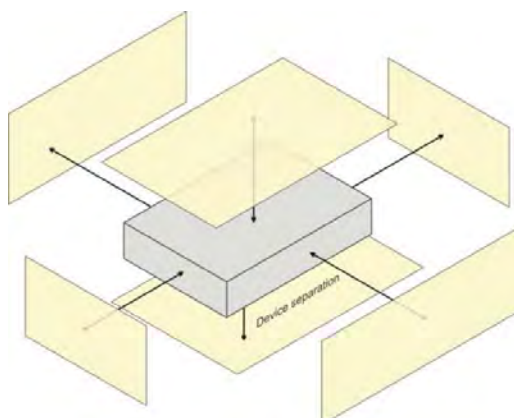
802.11n). After an initial test configuration is determined, if multiple test channels have the same measured maximum output power, the channel chosen for SAR measurement is determined according to the following.

- 1) The channel closest to mid-band frequency is selected for SAR measurement.
- 2) For channels with equal separation from mid-band frequency; for example, high and low channels or two mid-band channels, the higher frequency (number) channel is selected for SAR measurement.

### 4.2 EUT Testing Position

#### 4.2.1 Hotspot Mode Exposure Conditions

For device that support hotspot mode operations, with wireless router capabilities and various web browsing functions, the relevant hand and body exposure conditions are tested according to the hotspot SAR procedures in KDB 941225 D06. When the form factor is smaller than 9 cm x 5 cm, a test separation distance of 10 mm is required between the phantom and all surfaces and edges with a transmitting antenna located within 25 mm from that surface or edge.



Based on the antenna location shown on appendix D of this report, the SAR testing required for hotspot mode is listed as below.

| Antenna | Front Face | Rear Face | Left Side | Right Side | Top Side | Bottom Side |
|---------|------------|-----------|-----------|------------|----------|-------------|
| WLAN    | V          | V         | V         | V          | V        | V           |

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### 4.3 Tissue Verification

The measuring results for tissue simulating liquid are shown as below.

| Test Date     | Tissue Type | Frequency (MHz) | Liquid Temp. (°C) | Measured Conductivity ( $\sigma$ ) | Measured Permittivity ( $\epsilon_r$ ) | Target Conductivity ( $\sigma$ ) | Target Permittivity ( $\epsilon_r$ ) | Conductivity Deviation (%) | Permittivity Deviation (%) |
|---------------|-------------|-----------------|-------------------|------------------------------------|----------------------------------------|----------------------------------|--------------------------------------|----------------------------|----------------------------|
| Apr. 07, 2018 | BL2450      | 2450            | 21.7              | 1.930                              | 51.240                                 | 1.95                             | 52.70                                | -1.03                      | -2.77                      |

**Note:**

1. The dielectric properties of the tissue simulating liquid must be measured within 24 hours before the SAR testing and within  $\pm 5\%$  of the target values. Liquid temperature during the SAR testing must be within  $\pm 2^\circ\text{C}$ .
2. Since the maximum deviation of dielectric properties of the tissue simulating liquid is within 5%, SAR correction is evaluated in the measurement uncertainty shown on section 6 of this report.

### 4.4 System Validation

The SAR measurement system was validated according to procedures in KDB 865664 D01. The validation status in tabulated summary is as below.

| Test Date     | Probe S/N        | Calibration Point |      | Measured Conductivity ( $\sigma$ ) | Measured Permittivity ( $\epsilon_r$ ) | Validation for CW |                 |                | Validation for Modulation |             |      |
|---------------|------------------|-------------------|------|------------------------------------|----------------------------------------|-------------------|-----------------|----------------|---------------------------|-------------|------|
|               |                  |                   |      |                                    |                                        | Sensitivity Range | Probe Linearity | Probe Isotropy | Modulation Type           | Duty Factor | PAR  |
| Apr. 07, 2018 | SN 27/15 EPGO262 | Body              | 2450 | 1.930                              | 51.240                                 | Pass              | Pass            | Pass           | OFDM                      | N/A         | Pass |

### 4.5 System Verification

The measuring result for system verification is tabulated as below.

| Test Date     | Mode | Frequency (MHz) | 1W Target SAR-1g (W/kg) | Measured SAR-1g (W/kg) | Normalized to 1W SAR-1g (W/kg) | Deviation (%) | Dipole S/N       | Probe S/N        |
|---------------|------|-----------------|-------------------------|------------------------|--------------------------------|---------------|------------------|------------------|
| Apr. 07, 2018 | Body | 2450            | 52.73                   | 5.15                   | 51.54                          | -2.26         | SN 18/11 DIPJ155 | SN 27/15 EPGO262 |

**Note:**

Comparing to the reference SAR value provided by MVG, the validation data should be within its specification of 10 %. The result indicates the system check can meet the variation criterion and the plots can be referred to Appendix A of this report.

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### 4.6 Maximum Output Power

#### 4.6.1 Maximum Conducted Power

The maximum conducted average power (Unit: dBm) including tune-up tolerance is shown as below.

| Mode         | 2.4G WLAN |
|--------------|-----------|
| 802.11b      | 19.0      |
| 802.11g      | 14.5      |
| 802.11n HT20 | 14.0      |
| 802.11n HT40 | 13.5      |

#### 4.6.2 Measured Conducted Power Result

The measuring conducted average power (Unit: dBm) is shown as below.

##### <WLAN 2.4G>

| Mode                      | 802.11b        |          |           |
|---------------------------|----------------|----------|-----------|
| Channel / Frequency (MHz) | 1 (2412)       | 6 (2437) | 11 (2462) |
| Average Power             | 17.03          | 17.70    | 18.39     |
| Mode                      | 802.11g        |          |           |
| Channel / Frequency (MHz) | 1 (2412)       | 6 (2437) | 11 (2462) |
| Average Power             | 13.03          | 13.52    | 14.08     |
| Mode                      | 802.11n (HT20) |          |           |
| Channel / Frequency (MHz) | 1 (2412)       | 6 (2437) | 11 (2462) |
| Average Power             | 12.94          | 13.59    | 13.27     |
| Mode                      | 802.11n (HT40) |          |           |
| Channel / Frequency (MHz) | 3 (2422)       | 6 (2437) | 9 (2452)  |
| Average Power             | 12.78          | 12.88    | 13.33     |

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### 4.7 SAR Testing Results

#### 4.7.1 SAR Test Reduction Considerations

##### <KDB 447498 D01, General RF Exposure Guidance>

Testing of other required channels within the operating mode of a frequency band is not required when the reported SAR for the mid-band or highest output power channel is:

- (1)  $\leq 0.8$  W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is  $\leq 100$  MHz
- (2)  $\leq 0.6$  W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
- (3)  $\leq 0.4$  W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is  $\geq 200$  MHz

##### <KDB 248227 D01, SAR Guidance for Wi-Fi Transmitters>

- (1) For handsets operating next to ear, hotspot mode or mini-tablet configurations, the initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When the reported SAR of initial test position is  $\leq 0.4$  W/kg, SAR testing for remaining test positions is not required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is  $\leq 0.8$  W/kg or all test positions are measured.
- (2) For WLAN 2.4 GHz, the highest measured maximum output power channel for DSSS was selected for SAR measurement. When the reported SAR is  $\leq 0.8$  W/kg, no further SAR testing is required. Otherwise, SAR is evaluated at the next highest measured output power channel. When any reported SAR is  $> 1.2$  W/kg, SAR is required for the third channel. For OFDM modes (802.11g/n), SAR is not required when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and it is  $\leq 1.2$  W/kg.

#### 4.7.2 SAR Results for Body-worn Exposure Condition (Separation Distance is 0.5 cm Gap)

| Plot No. | Band    | Mode | Test Position | Ch. | Max. Tune-up Power (dBm) | Measured Conducted Power (dBm) | Scaling Factor | Power Drift (%) | Measured SAR-1g (W/kg) | Scaled SAR-1g (W/kg) |
|----------|---------|------|---------------|-----|--------------------------|--------------------------------|----------------|-----------------|------------------------|----------------------|
|          | 802.11b | -    | Front Face    | 11  | 19.0                     | 18.39                          | 1.15           | -1.39           | 0.054                  | 0.06                 |
|          | 802.11b | -    | Rear Face     | 11  | 19.0                     | 18.39                          | 1.15           | 0.12            | 0.1                    | 0.12                 |
|          | 802.11b | -    | Left Side     | 11  | 19.0                     | 18.39                          | 1.15           | -0.31           | 0.027                  | 0.03                 |
|          | 802.11b | -    | Right Side    | 11  | 19.0                     | 18.39                          | 1.15           | 0.25            | 0.003                  | 0.00                 |
|          | 802.11b | -    | Top Side      | 11  | 19.0                     | 18.39                          | 1.15           | 1.03            | 0.003                  | 0.00                 |
|          | 802.11b | -    | Bottom Side   | 11  | 19.0                     | 18.39                          | 1.15           | 0.04            | 0.012                  | 0.01                 |

Test Engineer : Wiky Zhang

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### 5. Calibration of Test Equipment

| Equipment                       | Manufacturer | Model              | SN                  | Cal. Date     | Cal. Interval |
|---------------------------------|--------------|--------------------|---------------------|---------------|---------------|
| System Validation Dipole        | SATIMO       | SID2450            | SN 18/11<br>DIPJ155 | Jun. 08, 2017 | 1 Year        |
| E-Field Probe                   | MVG          | SSE2               | SN 27/15<br>EPGO262 | Sep. 20, 2016 | 1 .5Year      |
| MultiMeter                      | Keithley     | Multimate 2000     | 1331865             | Jun. 21, 2017 | 1 Year        |
| Radio Communication Analyzer    | ANRITSU      | MT8820C            | 6201300717          | Jul. 24, 2017 | 1 Year        |
| Wireless Communication Test Set | Agilent      | E5515C             | MY50260600          | Jun. 28, 2017 | 1 Year        |
| ENA Series Network Analyzer     | Agilent      | E5071C             | MY46214638          | Jul. 24, 2017 | 1 Year        |
| Spectrum Analyzer               | KEYSIGHT     | N9010A             | MY54510355          | Jun. 27, 2017 | 1Year         |
| MXG Analog Signal Generator     | KEYSIGHT     | N5183A             | MY50143024          | Mar. 01, 2018 | 1 Year        |
| Power Meter                     | Agilent      | N1914A             | MY52180044          | Aug. 12, 2016 | 2 Years       |
| Power Sensor                    | Agilent      | E9304A H18         | MY52050011          | Jan. 04, 2018 | 1 Year        |
| Power Meter                     | Agilent      | ML2495A            | 1506002             | Mar. 01, 2018 | 1 Year        |
| Power Sensor                    | Agilent      | MA2411B            | 1339353             | Mar. 01, 2018 | 1 Year        |
| Temp. & Humi. Recorder          | CLOCK        | HTC-1              | 157248              | Jul. 26, 2017 | 1 Year        |
| Electronic Thermometer          | YONGFA       | YF-160A            | 120100323           | Sep. 22, 2017 | 1 Year        |
| Coupler                         | Woken        | 0110A056020-<br>10 | COM27RW1A<br>3      | Sep. 20, 2017 | 1 Year        |

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## 6. Measurement Uncertainty

| Source of Uncertainty                        | Tolerance (± %) | Probability Distribution | Divisor | Ci (1g) | Ci (10g) | Standard Uncertainty (1g) | Standard Uncertainty (10g) | Vi Veff |
|----------------------------------------------|-----------------|--------------------------|---------|---------|----------|---------------------------|----------------------------|---------|
| <b>Measurement System</b>                    |                 |                          |         |         |          |                           |                            |         |
| Probe Calibration                            | 6.0             | N                        | 1       | 1       | 1        | 6.0                       | 6.0                        | ∞       |
| Axial Isotropy                               | 5.9             | R                        | 1.732   | 0.7     | 0.7      | 2.4                       | 2.4                        | ∞       |
| Hemispherical Isotropy                       | 12.2            | R                        | 1.732   | 0.7     | 0.7      | 4.9                       | 4.9                        | ∞       |
| Boundary Effects                             | 1.0             | R                        | 1.732   | 1       | 1        | 0.6                       | 0.6                        | ∞       |
| Linearity                                    | 5.9             | R                        | 1.732   | 1       | 1        | 3.4                       | 3.4                        | ∞       |
| System Detection Limits                      | 1.0             | R                        | 1.732   | 1       | 1        | 0.6                       | 0.6                        | ∞       |
| Readout Electronics                          | 1.0             | N                        | 1       | 1       | 1        | 1.0                       | 1.0                        | ∞       |
| Response Time                                | 0.0             | R                        | 1.732   | 1       | 1        | 0.0                       | 0.0                        | ∞       |
| Integration Time                             | 2.6             | R                        | 1.732   | 1       | 1        | 1.5                       | 1.5                        | ∞       |
| RF Ambient Noise                             | 3.0             | R                        | 1.732   | 1       | 1        | 1.7                       | 1.7                        | ∞       |
| RF Ambient Reflections                       | 3.0             | R                        | 1.732   | 1       | 1        | 1.7                       | 1.7                        | ∞       |
| Probe Positioner                             | 1.4             | R                        | 1.732   | 1       | 1        | 0.8                       | 0.8                        | ∞       |
| Probe Positioning                            | 1.4             | R                        | 1.732   | 1       | 1        | 0.8                       | 0.8                        | ∞       |
| Max. SAR Eval.                               | 2.3             | R                        | 1.732   | 1       | 1        | 1.3                       | 1.3                        | ∞       |
| <b>Test Sample Related</b>                   |                 |                          |         |         |          |                           |                            |         |
| Device Positioning                           | 2.3             | N                        | 1       | 1       | 1        | 2.3                       | 2.3                        | 35      |
| Device Holder                                | 2.7             | N                        | 1       | 1       | 1        | 2.7                       | 2.7                        | 12      |
| Power Drift                                  | 5.0             | R                        | 1.732   | 1       | 1        | 2.9                       | 2.9                        | ∞       |
| Power Scaling                                | 0.0             | R                        | 1.732   | 1       | 1        | 0.0                       | 0.0                        | ∞       |
| <b>Phantom and Setup</b>                     |                 |                          |         |         |          |                           |                            |         |
| Phantom Uncertainty                          | 4.0             | R                        | 1.732   | 1       | 1        | 2.3                       | 2.3                        | ∞       |
| SAR correction                               | 1.2             | R                        | 1.732   | 1       | 0.84     | 0.7                       | 0.6                        | ∞       |
| Liquid Conductivity (target)                 | 5.0             | R                        | 1.732   | 0.78    | 0.71     | 2.3                       | 2.0                        | ∞       |
| Liquid Conductivity (mea.)                   | 4.1             | R                        | 1.732   | 0.78    | 0.71     | 1.8                       | 1.7                        | ∞       |
| Temp. unc. - Conductivity                    | 3.4             | R                        | 1.732   | 0.78    | 0.71     | 1.5                       | 1.4                        | ∞       |
| Liquid Permittivity (target)                 | 5.0             | R                        | 1.732   | 0.23    | 0.26     | 0.7                       | 0.8                        | ∞       |
| Liquid Permittivity (mea.)                   | 5.0             | R                        | 1.732   | 0.23    | 0.26     | 0.7                       | 0.8                        | ∞       |
| Temp. unc. - Permittivity                    | 0.83            | R                        | 1.732   | 0.23    | 0.26     | 0.1                       | 0.1                        | ∞       |
| <b>Combined Standard Uncertainty (K = 1)</b> |                 |                          |         |         |          | ± 11.4 %                  | ± 11.3 %                   | 2923    |
| <b>Expanded Uncertainty (K = 2)</b>          |                 |                          |         |         |          | ± 22.7 %                  | ± 22.6 %                   |         |

## FCC SAR Test Report

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### 7. Information on the Testing Laboratories

We, BV 7LAYERS COMMUNICATIONS TECHNOLOGY (SHENZHEN) CO. LTD., were founded in 2015 to provide our best service in EMC, Radio, Telecom and Safety consultation. Our laboratories are accredited and approved according to ISO/IEC 17025.

If you have any comments, please feel free to contact us at the following:

Add: No. B102, Dazu Chuangxin Mansion, North of Beihuan Avenue, North Area, Hi-Tech Industry Park, Nanshan District, Shenzhen, Guangdong, China

Tel: 86-755-8869-6566

Fax: 86-755-8869-6577

Email: [customerservice.dg@cn.bureauveritas.com](mailto:customerservice.dg@cn.bureauveritas.com)

Web Site: [www.bureauveritas.com](http://www.bureauveritas.com)

The road map of all our labs can be found in our web site also.

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### Appendix A. SAR Plots of System Verification

The plots for system verification with largest deviation for each SAR system combination are shown as follows.

# System Verification Plots

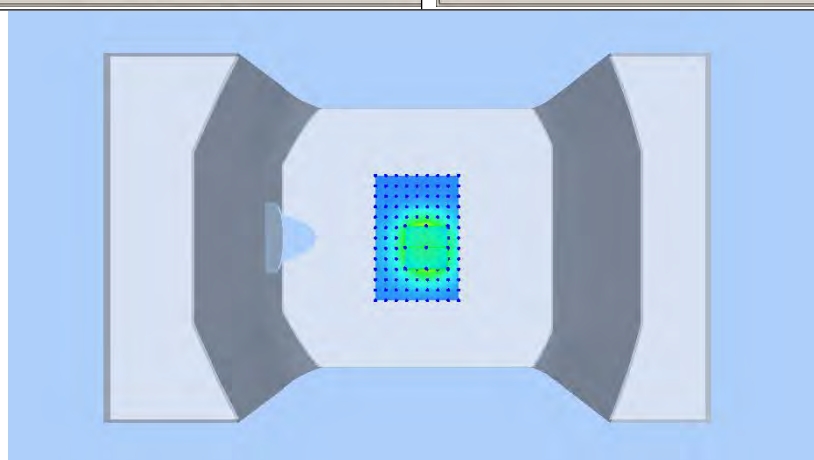
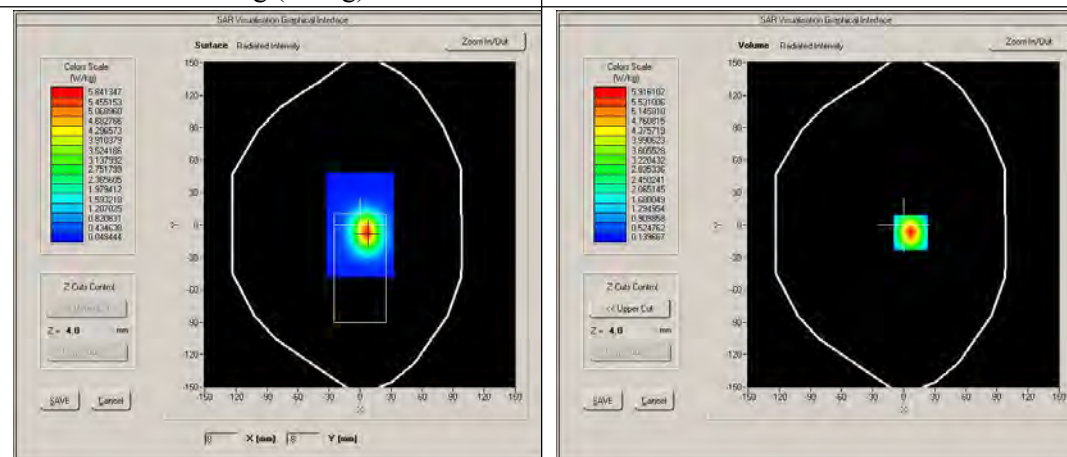
Product Description: Dipole

Model: SID2450

Test Date: Apr 7, 2018

Ambient Temperature: 22.5°C; Liquid Temperature: 21.7°C

|                                   |                            |
|-----------------------------------|----------------------------|
| Medium(liquid type)               | BL_2450                    |
| Frequency (MHz)                   | 2450                       |
| Relative permittivity (real part) | 51.24                      |
| Conductivity (S/m)                | 1.93                       |
| Input power                       | 100mW                      |
| Crest factor                      | 1.0                        |
| E-Field Probe                     | SN 27/15 EPGO262           |
| Conversion Factor                 | 2.12                       |
| Area Scan                         | dx=8mm dy=8mm              |
| Zoom Scan                         | 5x5x7,dx=8mm dy=8mm dz=5mm |
| Variation (%)                     | -1.280000                  |
| SAR 10g (W/Kg)                    | 2.405043                   |
| SAR 1g (W/Kg)                     | 5.151352                   |



### Appendix B. SAR Plots of SAR Measurement

The SAR plots for highest measured SAR in each exposure configuration, wireless mode and frequency band combination, and measured SAR > 1.5 W/kg are shown as follows.

## Maximum SAR measurement Plots

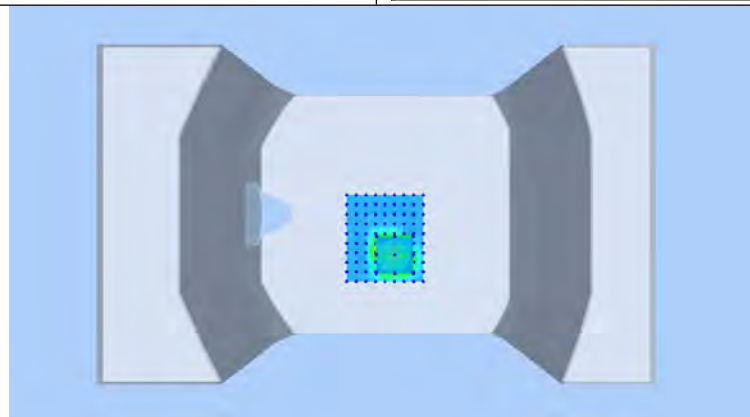
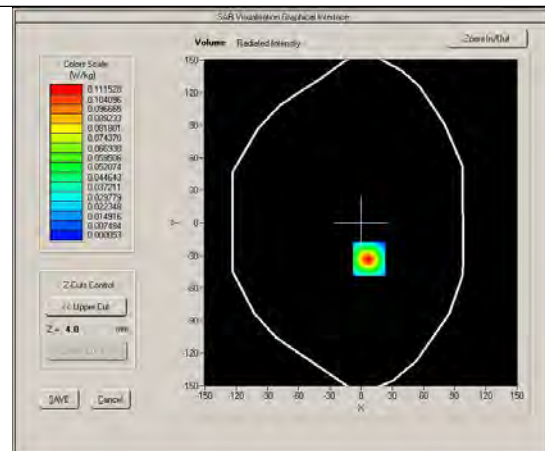
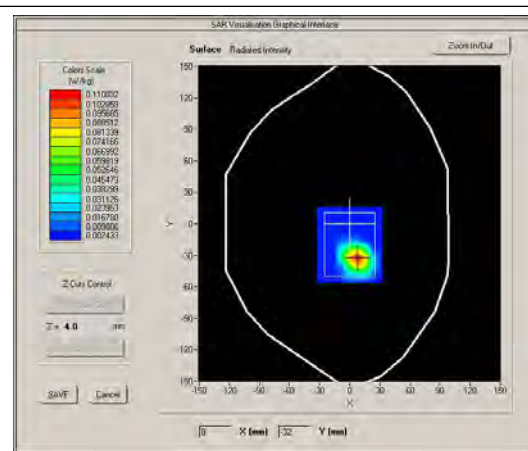
1# 802.11b\_Rear Face\_0.5cm\_Ch6

DUT:180327W001

Test Date: Apr 7, 2018

Ambient Temperature: 22.5°C; Liquid Temperature: 21.7°C

|                                   |                            |
|-----------------------------------|----------------------------|
| Medium(liquid type)               | BL2450                     |
| Frequency (MHz)                   | 2437                       |
| Relative permittivity (real part) | 51.24                      |
| Conductivity (S/m)                | 1.93                       |
| E-Field Probe                     | SN 27/15 EPGO262           |
| Crest factor                      | 1.0                        |
| Conversion Factor                 | 2.12                       |
| Sensor-Surface                    | 4mm                        |
| Area Scan                         | dx=8mm dy=8mm              |
| Zoom Scan                         | 5x5x7,dx=8mm dy=8mm dz=5mm |
| Variation (%)                     | 0.00000                    |
| SAR 10g (W/Kg)                    | 0.039553                   |
| SAR 1g (W/Kg)                     | 0.099680                   |
| <b>SURFACE SAR</b>                | <b>VOLUME SAR</b>          |





## **FCC SAR Test Report**

---

### **Appendix C. Calibration Certificate for Probe and Dipole**

The MVG calibration certificates are shown as follows.



## **COMOSAR E-Field Probe Calibration Report**

Ref : ACR.264.3.16.SATU.A

### **SIEMIC TESTING AND CERTIFICATION SERVICES**

**ZONE A,FLOOR 1,BUILDING 2,WAN YE LONG  
TECHNOLOGY PARK,SOUTH SIDE OF ZHOUSHI ROAD,  
SHIYAN STREET,BAO'AN DISTRICT, SHENZHEN 518108 ,  
GUANGDONG , P.R.C.**

**MVG COMOSAR DOSIMETRIC E-FIELD PROBE  
SERIAL NO.: SN 27/15 EPG0262**

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



**Calibration Date: 09/20/2016**

#### *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.



|                      | <i>Name</i>   | <i>Function</i> | <i>Date</i> | <i>Signature</i>     |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC    | Product Manager | 9/20/2016   | <i>JS</i>            |
| <i>Checked by :</i>  | Jérôme LUC    | Product Manager | 9/20/2016   | <i>JS</i>            |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 9/20/2016   | <i>Kim Rutkowski</i> |

|                       | <i>Customer Name</i>                            |
|-----------------------|-------------------------------------------------|
| <i>Distribution :</i> | SIEMIC Testing<br>and Certification<br>Services |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A            | 9/20/2016   | Initial release      |
|              |             |                      |
|              |             |                      |
|              |             |                      |



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## 1 DEVICE UNDER TEST

| Device Under Test                        |                                                                                                                   |
|------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Device Type                              | COMOSAR DOSIMETRIC E FIELD PROBE                                                                                  |
| Manufacturer                             | MVG                                                                                                               |
| Model                                    | SSE2                                                                                                              |
| Serial Number                            | SN 27/15 EPGO262                                                                                                  |
| Product Condition (new / used)           | Used                                                                                                              |
| Frequency Range of Probe                 | 0.7 GHz-6GHz                                                                                                      |
| Resistance of Three Dipoles at Connector | Dipole 1: $R1=0.221\text{ M}\Omega$<br>Dipole 2: $R2=0.199\text{ M}\Omega$<br>Dipole 3: $R3=0.199\text{ M}\Omega$ |

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.



### 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%                   |



|                                                            |       |             |            |   |        |
|------------------------------------------------------------|-------|-------------|------------|---|--------|
| 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 %  |

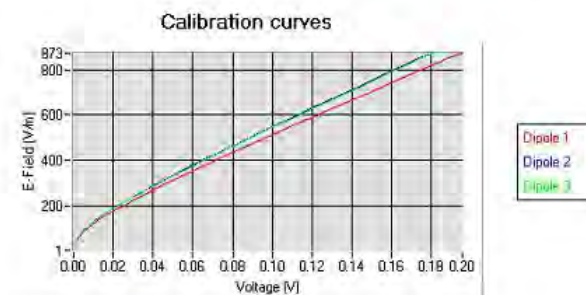
### 5.1 SENSITIVITY IN AIR

| Normx dipole 1 ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | Normy dipole 2 ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) | Normz dipole 3 ( $\mu\text{V}/(\text{V}/\text{m})^2$ ) |
|--------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|
| 0.80                                                   | 0.71                                                   | 0.72                                                   |

| DCP dipole 1 (mV) | DCP dipole 2 (mV) | DCP dipole 3 (mV) |
|-------------------|-------------------|-------------------|
| 92                | 90                | 91                |

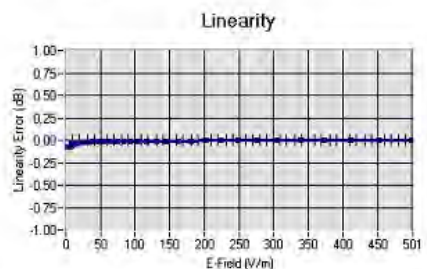
Calibration curves  $e_i=f(V)$  ( $i=1,2,3$ ) allow to obtain H-field value using the formula:

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





## 5.2 LINEARITY



Linearity  $\pm 1.69\%$  ( $\pm 0.07$  dB)

## 5.3 SENSITIVITY IN LIQUID

| Liquid | Frequency<br>(MHz +/-<br>100MHz) | Permittivity | Epsilon (S/m) | ConvF |
|--------|----------------------------------|--------------|---------------|-------|
| HL750  | 750                              | 40.03        | 0.93          | 1.57  |
| BL750  | 750                              | 56.83        | 1.00          | 1.62  |
| HL850  | 835                              | 42.19        | 0.90          | 1.74  |
| BL850  | 835                              | 54.67        | 1.01          | 1.81  |
| HL900  | 900                              | 42.08        | 1.01          | 1.67  |
| BL900  | 900                              | 55.25        | 1.08          | 1.73  |
| HL1800 | 1800                             | 41.68        | 1.46          | 1.81  |
| BL1800 | 1800                             | 53.86        | 1.46          | 1.87  |
| HL1900 | 1900                             | 38.45        | 1.45          | 2.01  |
| BL1900 | 1900                             | 53.32        | 1.56          | 2.05  |
| HL2000 | 2000                             | 38.26        | 1.38          | 1.86  |
| BL2000 | 2000                             | 52.70        | 1.51          | 1.91  |
| HL2450 | 2450                             | 37.50        | 1.80          | 2.04  |
| BL2450 | 2450                             | 53.22        | 1.89          | 2.12  |
| HL2600 | 2600                             | 39.80        | 1.99          | 2.05  |
| BL2600 | 2600                             | 52.52        | 2.23          | 2.12  |
| HL3500 | 3500                             | 38.21        | 2.98          | 2.02  |
| BL3500 | 3500                             | 52.95        | 3.43          | 2.08  |
| HL5200 | 5200                             | 35.64        | 4.67          | 1.51  |
| BL5200 | 5200                             | 48.64        | 5.51          | 1.55  |
| HL5400 | 5400                             | 36.44        | 4.87          | 1.56  |
| BL5400 | 5400                             | 46.52        | 5.77          | 1.61  |
| HL5600 | 5600                             | 36.66        | 5.17          | 1.55  |
| BL5600 | 5600                             | 46.79        | 5.77          | 1.60  |
| HL5800 | 5800                             | 35.31        | 5.31          | 1.44  |
| BL5800 | 5800                             | 47.04        | 6.10          | 1.48  |

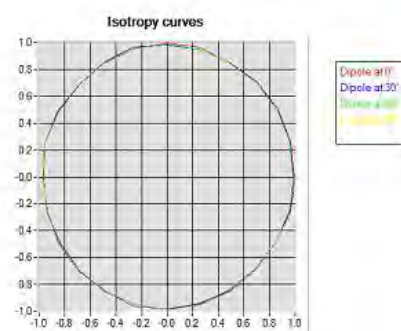
LOWER DETECTION LIMIT: 7mW/kg



#### 5.4 ISOTROPY

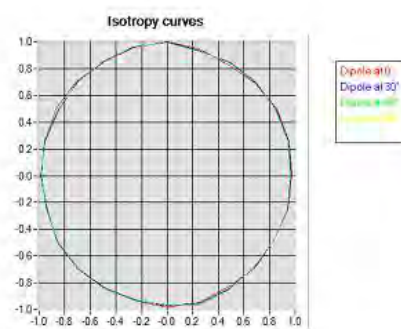
##### HL900 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.05 dB



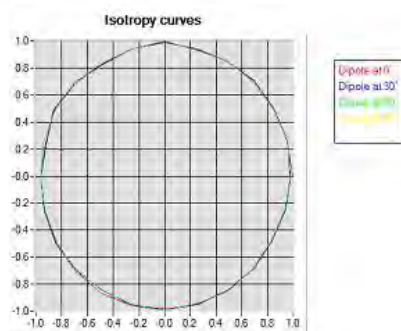
##### HL1800 MHz

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.06 dB



**HL5600 MHz**

- Axial isotropy: 0.06 dB
- Hemispherical isotropy: 0.08 dB



**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     | 10/2015                                       | 10/2016                                       |
| Multimeter                    | Keithley 2000        | 1188656            | 12/2013                                       | 12/2016                                       |
| Signal Generator              | Agilent E4438C       | MY49070581         | 12/2013                                       | 12/2016                                       |
| Amplifier                     | Aethercomm           | SN 046             | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter                   | HP E4418A            | US38261498         | 12/2013                                       | 12/2016                                       |
| Power Sensor                  | HP ECP-E26A          | US37181460         | 12/2013                                       | 12/2016                                       |
| 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          | 10/2015                                       | 10/2017                                       |



## **SAR Reference Dipole Calibration Report**

Ref: ACR.165.7.17.SATU.A

### **SIEMIC TESTING AND CERTIFICATION SERVICES**

**ZONE A,FLOOR 1,BUILDING 2,WAN YE LONG  
TECHNOLOGY PARK,SOUTH SIDE OF ZHOUSHI ROAD,  
SHIYAN STREET,BAO'AN DISTRICT, SHENZHEN 518108 ,  
GUANGDONG , P.R.C.**

#### **MVG COMOSAR REFERENCE DIPOLE**

**FREQUENCY: 2450 MHZ**

**SERIAL NO.: SN 18/11 DIPJ155**

**Calibrated at MVG US**

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



**Calibration Date: 06/8/2017**

#### *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.



|                      | <i>Name</i>   | <i>Function</i> | <i>Date</i> | <i>Signature</i>     |
|----------------------|---------------|-----------------|-------------|----------------------|
| <i>Prepared by :</i> | Jérôme LUC    | Product Manager | 6/14/2017   | <i>JS</i>            |
| <i>Checked by :</i>  | Jérôme LUC    | Product Manager | 6/14/2017   | <i>JS</i>            |
| <i>Approved by :</i> | Kim RUTKOWSKI | Quality Manager | 6/14/2017   | <i>Kim Rutkowski</i> |

|                       | <i>Customer Name</i>                            |
|-----------------------|-------------------------------------------------|
| <i>Distribution :</i> | SIEMIC Testing<br>and Certification<br>Services |

| <i>Issue</i> | <i>Date</i> | <i>Modifications</i> |
|--------------|-------------|----------------------|
| A            | 6/14/2017   | Initial release      |
|              |             |                      |
|              |             |                      |
|              |             |                      |



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## 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 18/11 DIPJ155                  |
| 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**



#### 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.

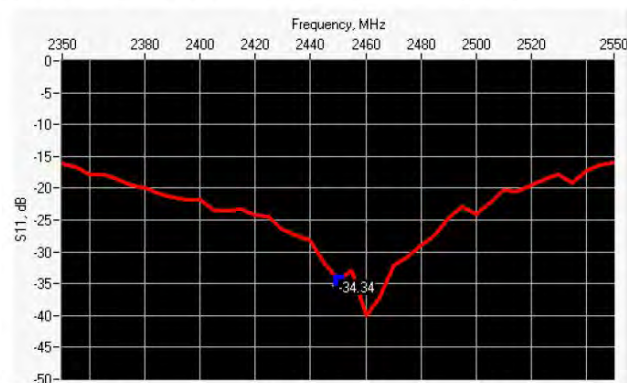
| Scan Volume | Expanded Uncertainty |
|-------------|----------------------|
| 1 g         | 20.3 %               |



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

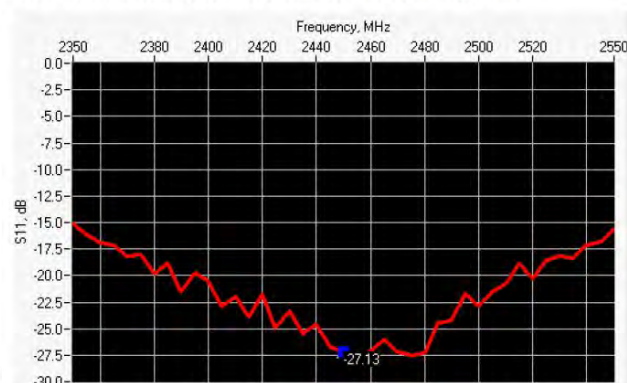
## 6 CALIBRATION MEASUREMENT RESULTS

### 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 2450            | -34.34           | -20              | $50.3 \Omega + 1.9 j\Omega$ |

### 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID



| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance                   |
|-----------------|------------------|------------------|-----------------------------|
| 2450            | -27.13           | -20              | $54.0 \Omega + 2.3 j\Omega$ |

### 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 % |          |



|      |             |      |             |      |            |      |
|------|-------------|------|-------------|------|------------|------|
| 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 ( $\epsilon_r'$ ) |          | 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 %                     |          |

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

## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

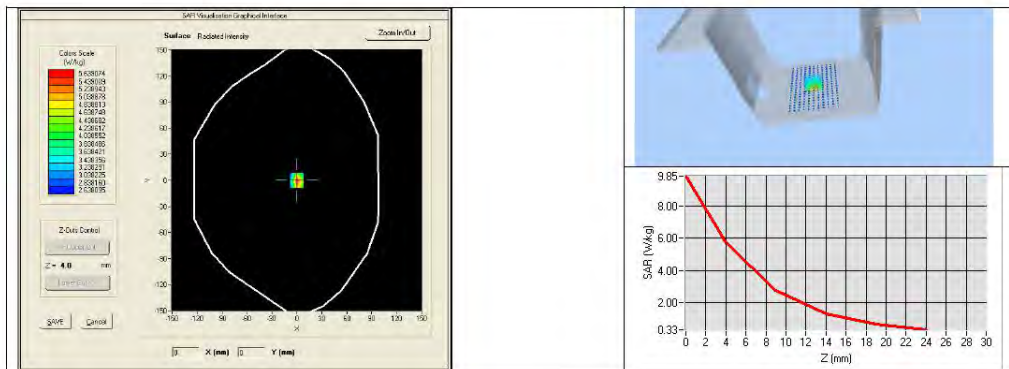
The IEEE Std. 1528 and CEI/IEC 62209 standards state that the system validation measurements should produce the SAR values shown below (for phantom thickness of 2 mm), within the uncertainty for the system validation. All SAR values are normalized to 1 W forward power. In bracket, the measured SAR is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

|                                           |                                                         |
|-------------------------------------------|---------------------------------------------------------|
| Software                                  | OPENSAR V4                                              |
| Phantom                                   | SN 20/09 SAM71                                          |
| Probe                                     | SN 18/11 EPG122                                         |
| Liquid                                    | Head Liquid Values: $\epsilon_{ps}$ : 37.5 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              |          |



|      |      |              |      |              |
|------|------|--------------|------|--------------|
| 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 | 53.18 (5.32) | 24   | 23.97 (2.40) |
| 2600 | 55.3 |              | 24.6 |              |
| 3000 | 63.8 |              | 25.7 |              |
| 3500 | 67.1 |              | 25   |              |
| 3700 | 67.4 |              | 24.2 |              |



### 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 %                |          |

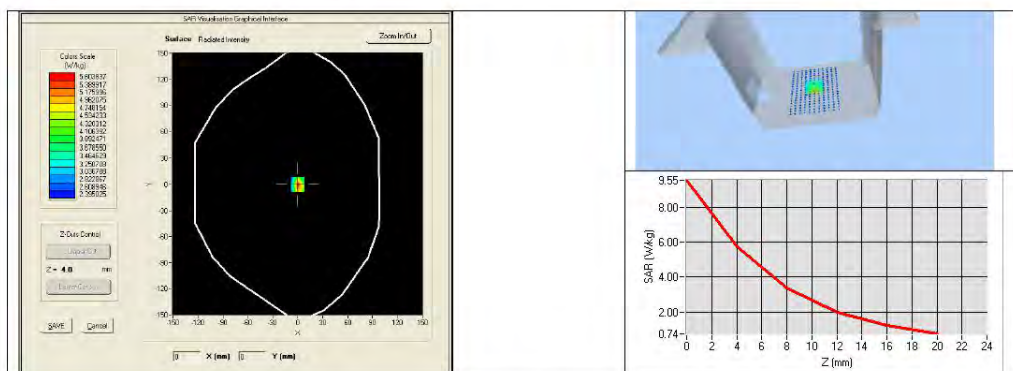


|      |            |      |            |      |
|------|------------|------|------------|------|
| 2300 | 52.9 ±5 %  |      | 1.81 ±5 %  |      |
| 2450 | 52.7 ±5 %  | PASS | 1.95 ±5 %  | PASS |
| 2600 | 52.5 ±5 %  |      | 2.16 ±5 %  |      |
| 3000 | 52.0 ±5 %  |      | 2.73 ±5 %  |      |
| 3500 | 51.3 ±5 %  |      | 3.31 ±5 %  |      |
| 3700 | 51.0 ±5 %  |      | 3.55 ±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: $\epsilon_r$ : 53.2 $\sigma$ : 1.89 |
| 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             | 52.73 (5.27)     | 24.27 (2.43)      |



**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           | 02/2016                                       | 02/2019                                       |
| Calipers                        | Carrera              | CALIPER-01         | 01/2017                                       | 01/2020                                       |
| Reference Probe                 | MVG                  | EPG122 SN 18/11    | 10/2016                                       | 10/2017                                       |
| 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. |
| Temperature and Humidity Sensor | Control Company      | 150798832          | 10/2015                                       | 10/2017                                       |



## **Appendix D. Photographs of EUT and Setup**