# FCC SAR Compliance Test Report

For

**ad notam AG**

**Obere Giesswiesen 11-13, 78247 Hilzingen, Germany**

**Model: SDU-0070-001**
**Additional Model: SDU-0070-002**
**(xxx=002-999)**

| | |
|---|---|
| Test Engineer: | Peng Peng |
| Report Number: | FCC18010018A-SAR |
| Report Date: | Mar. 19, 2018 |
| FCC ID: | 2AOKDSDU0070 |
| Check By: | Zhao Liping |
| Approved By: | Wang Fengbing |
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**Modified History**

| REV. | Modification Description | Issued Date | Remark |
|---|---|---|---|
| REV.1.0 | Initial Test Report Relesse | Mar. 19, 2018 | Wang Fengbing |
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# 1 General information

## 1.1 Notes

The test results of this test report relate exclusively to the test item specified in this test report. World Standardization Certification & Testing Group Co.,Ltd. does not assume responsibility for any conclusions and generalisations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item. The test report is not to be reproduced or published in full without the prior written permission.

## 1.2 Application details

Date of receipt of test item: 2018-03-09
Start of test: 2018-03-15
End of test: 2018-03-15

## 1.3 Statement of Compliance

The maximum results of Specific Absorption Rate (SAR) found during testing for SDU-0070-001 is as below:

| Band | Position | MAX Reported $SAR_{1g}$ (W/kg) |
|---|---|---|
| 2.4G WIFI | Body-Worn | 0.618 |

The device is in compliance with Specific Absorption Rate （SAR）for general population/uncontraolled exposure limits of 1.6 W/Kg as averaged over any 1g tissue according to the FCC rule §2.1093, the ANSI/IEEE C95.1:2005, the NCRP Report Number 86 for uncontrolled environment, according to the Industry Canada Radio Standards Specification RSS-102 for General Population/Uncontrolled exposure, and had been tested in accordance with the measurement methods and procedures specified in IEEE Std 1528-2013.

## 1.4 EUT Information

| Device Information： | | | |
|---|---|---|---|
| **Product Type:** | SDU-0070 | | |
| **Model:** | SDU-0070-001 | | |
| **Brand Name:** | ad notam ® | | |
| **Device Type:** | Portable device | | |
| **Exposure Category:** | uncontrolled environment / general population | | |
| **Production Unit or Identical Prototype：** | Production Unit | | |
| **Antenna Type :** | Internal Antenna | | |
| **Device Operating Configurations:** | | | |
| **Supporting Mode(s) :** | Wi-Fi , BT | | |
| **Modulation:** | OFDM/CCK, GFSK/π/4-DQPSK/ 8-DPSK, GFSK | | |
| **Device Class :** | Class B, No DTM Mode | | |
| **Operating Frequency Range(s)** | Band | TX(MHz) | RX(MHz) |
| | Wi-Fi | 2412~2462 | |
| | BT | 2402~2480 | |
| **Test Channel:** | 1-6-11 (Wi-Fi) | | |
| | 0-39-78(BT 3.0) | | |
| | 0-20-39 (BLE) | | |
| **Power Source:** | Adapter: LS-PAB90AL-E<br>Input: 100-240V 50/60Hz 1.5A<br>Output: 12V-7A | | |

## 2 Testing laboratory

| | |
|---|---|
| Test Site | World Standardization Certification & Testing Group Co.,Ltd. |
| Test Location | Building A-B, Baoshi Science & Technology Park, Baoshi Road, Bao'an District, Shenzhen, Guangdong, China |
| Telephone | +86-755-26996192 |
| Fax | +86-755-86376605 |

## 3 Test Environment

| | Required | Actual |
|---|---|---|
| **Ambient temperature:** | 18 – 25 °C | 22 ± 2 °C |
| **Tissue Simulating liquid:** | 22 ± 2 °C | 22 ± 2 °C |
| **Relative humidity content:** | 30 – 70 % | 30 – 70 % |

## 4 Applicant and Manufacturer

| | |
|---|---|
| **Applicant/Client Name:** | ad notam AG |
| **Applicant Address:** | Obere Giesswiesen 11-13, 78247 Hilzingen, Germany |
| **Manufacturer Name:** | ad notam AG |
| **Manufacturer Address:** | Obere Giesswiesen 11-13, 78247 Hilzingen, Germany |

## 5 Test standard/s:

| | |
|---|---|
| ANSI Std C95.1-2005 | Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz. |
| IEEE Std 1528-2013 | Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques |
| RSS-102 | Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands (Issue 5 March 2015) |
| KDB447498 D01 | General RF Exposure Guidance v06 |
| KDB616217 D04 | SAR for laptop and tablets v01r03 |
| KDB248227 D01 | SAR meas for 802.11 a/b/g v02r02 |
| KDB865664 D01 | SAR Measurement 100 MHz to 6 GHz v01r04 |
| KDB865664 D02 | RF Exposure Reporting v01r02 |

## 5.1 RF exposure limits

| Human Exposure | Uncontrolled Environment General Population | Controlled Environment Occupational |
|---|---|---|
| **Spatial Peak SAR*** (Brain/Body/Arms/Legs) | **1.60 mW/g** | 8.00 mW/g |
| **Spatial Average SAR**** (Whole Body) | 0.08 mW/g | 0.40 mW/g |
| **Spatial Peak SAR***** (Heads/Feet/Ankle/Wrist) | 4.00 mW/g | 20.00 mW/g |

The limit applied in this test report is shown in bold letters

**Notes:**

* The Spatial Peak value of the SAR averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

** The Spatial Average value of the SAR averaged over the whole body.

*** The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

**Uncontrolled Environments** are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

**Controlled Environments** are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation.

## 5.2 SAR Definition

Specific Absorption Rate is defined as 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).

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

SAR is expressed in units of watts per kilogram (W/kg). SAR can be related to the electric field at a point by

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

where:

σ = conductivity of the tissue (S/m)

ρ = mass density of the tissue ($kg/m^3$)

E = rms electric field strength (V/m)

# 6 SAR Measurement System

## 6.1 The Measurement System

Comosar is a system that is able to determine the SAR distribution inside a phantom of human being according to different standards. The Comosar system consists of the following items:

- Main computer to control all the system
- 6 axis robot
- Data acquisition system
- Miniature E-field probe
- Device holder
- Head simulating tissue

The following figure shows the system.

The EUT under test operating at the maximum power level is placed in the phone holder, under the phantom, which is filled with head simulating liquid. The E-Field probe measures the electric field inside the phantom. The OpenSAR software computes the results to give a SAR value in a 1g or 10g mass.

## 6.2 Robot

The COMOSAR system uses the high precision robots KR 6 R900 sixx type out of the newer series from Satimo SA (France).For the 6-axis controller COMOSAR system, the KUKA robot controller version from Satimo is used. The KR 6 R900 sixx robot series have many features that are important for our application:

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

## 6.3 Probe

For the measurements the Specific Dosimetric E-Field Probe SSE 5 with following specifications is used

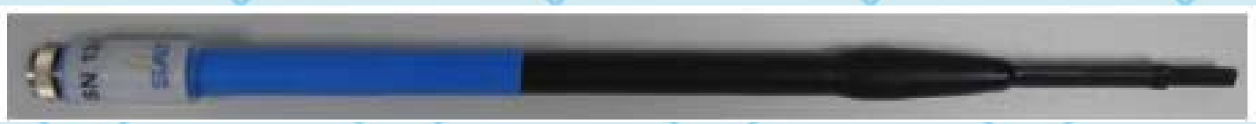


Figure 1 – MVG COMOSAR Dosimetric E field Dipole

- Dynamic range: 0.01-100 W/kg

| | |
|---|---|
| Probe Length | 330 mm |
| Length of Individual Dipoles | 4.5 mm |
| Maximum external diameter | 8 mm |
| Probe Tip External Diameter | 5 mm |
| Distance between dipoles / probe extremity | 2.7 mm |

- Calibration range: 300MHz to 3GHz for head & body simulating liquid.

Angle between probe axis (evaluation axis) and suface normal line:less than 30°

## 6.4 Measurement procedure

The following steps are used for each test position

- Establish a call with the maximum output power with a base station simulator.The connection between the mobile and the base station simulator is established via air interface.
- Measurement of the local E-field value at a fixed location.This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with a grid of 8 to 16 mm * 8 to 16 mm and a constant distance to the inner surface of the phantom.Since the sensors can not directly measure at the inner phantom surface,the values between the sensors and the inner phantom surface are extrapolated.With these values the area of the maximum SAR is calculated by an interpolation scheme.
- Around this point,a cube of 30 * 30 * 30 mm or 32 * 32 * 32 mm is assessed by measuring 5 or 8 * 5 or 8 * 4 or 5 mm.With these data,the peak spatial-average SAR value can be calculated.

## 6.5 Description of interpolation/extrapolation scheme

- The local SAR inside the phantom is measured using small dipole sensing elements inside a probe body.The probe tip must not be in contact with the phantom surface in order to minimise measurements errors,but the highest local SAR will occur at the surface of the phantom.
- An extrapolation is using to determinate this highest local SAR values.
  The extrapolation is based on afourth-order least-square polynomial fit of measured data.The local SAR value is then extrapolated from the liquid surface with a 1 mm step.
- The measurements have to be performed over a limited time(due to the duration of the battery) so the step of measurement is high.It could vary between 5 and 8 mm.To obtain an accurate assessment of the maximum SAR average over 10 grams and 1gram requires a very fine resolution in the three dimensional scanned data array.

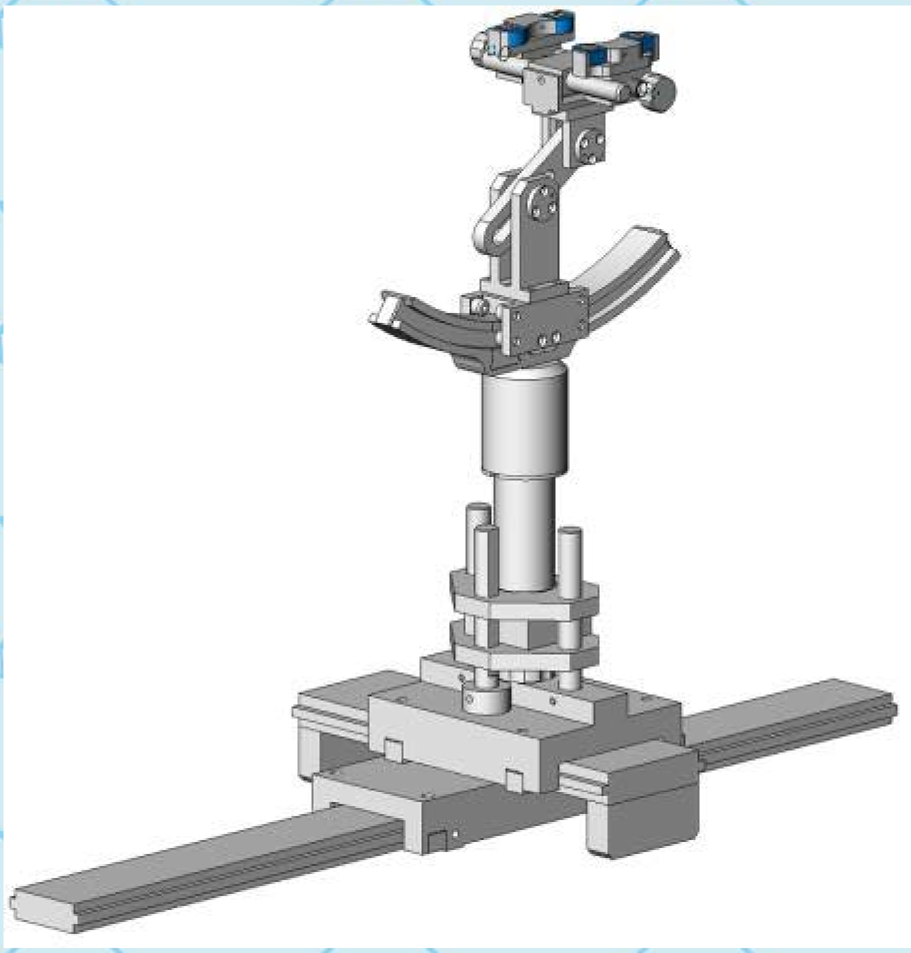
## 6.6 Phantom

For the measurements the Specific Anthropomorphic Mannequin (SAM) defined by the IEEE SCC-34/SC2 group is used. The phantom is a polyurethane shell integrated in a wooden table. The thickness of the phantom amounts to 2mm +/- 0.2mm. It enables the dosimetric evaluation of left and right phone usage and includes an additional flat phantom part for the simplified performance check. The phantom set-up includes a cover, which prevents the evaporation of the liquid.

| System Material | Permittivity | Loss Tangent |
|---|---|---|
| Delrin | 3.7 | 0.005 |

## 6.7 Device Holder

The positioning system allows obtaining cheek and tilting position with a very good accuracy. In compliance with CENELEC, the tilt angle uncertainty is lower than 1°.



Device holder

| System Material | Permittivity | Loss Tangent |
|---|---|---|
| Delrin | 3.7 | 0.005 |

## 6.8 Video Positioning System

- The video positioning system is used in OpenSAR to check the probe. Which is composed of a camera, LED, mirror and mechanical parts. The camera is piloted by the main computer with firewire link.

- During the process, the actual position of the probe tip with respect to the robot arm is measured, as well as the probe length and the horizontal probe offset. The software then corrects all movements, such that the robot coordinates are valid for the probe tip.

- The repeatability of this process is better than 0.1 mm. If a position has been taught with an aligned probe, the same position will be reached with another aligned probe within 0.1 mm, even if the other probe has different dimensions. During probe rotations, the probe tip will keep its actual position.

## 6.9 Tissue simulating liquids: dielectric properties

The following materials are used for producing the tissue-equivalent materials.

(Liquids used for tests are marked with☒):

| **Ingredients**(% of weight) | **Frequency (MHz)** | | | | |
|---|---|---|---|---|---|
| frequency band | ☐ 450 | ☐ 835 | ☐ 1800 | ☐ 1900 | ☐ 2450 |
| Tissue Type | Head | Head | Head | Head | Head |
| Water | 38.56 | 41.45 | 52.64 | 55.242 | 62.7 |
| Salt (NaCl) | 3.95 | 1.45 | 0.36 | 0.306 | 0.5 |
| Sugar | 56.32 | 56.0 | 0.0 | 0.0 | 0.0 |
| HEC | 0.98 | 1.0 | 0.0 | 0.0 | 0.0 |
| Bactericide | 0.19 | 0.1 | 0.0 | 0.0 | 0.0 |
| Triton X-100 | 0.0 | 0.0 | 0.0 | 0.0 | 36.8 |
| DGBE | 0.0 | 0.0 | 47.0 | 44.542 | 0.0 |
| **Ingredients**(% of weight) | **Frequency (MHz)** | | | | |
| frequency band | ☐ 450 | ☐ 835 | ☐ 1800 | ☐ 1900 | ☒ 2450 |
| Tissue Type | Body | Body | Body | Body | Body |
| Water | 51.16 | 52.4 | 69.91 | 69.91 | 73.2 |
| Salt (NaCl) | 1.49 | 1.40 | 0.13 | 0.13 | 0.04 |
| Sugar | 46.78 | 45.0 | 0.0 | 0.0 | 0.0 |
| HEC | 0.52 | 1.0 | 0.0 | 0.0 | 0.0 |
| Bactericide | 0.05 | 0.1 | 0.0 | 0.0 | 0.0 |
| Triton X-100 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| DGBE | 0.0 | 0.0 | 29.96 | 29.96 | 26.7 |

Salt: 99+% Pure Sodium Chloride
Sugar: 98+% Pure Sucrose
Water: De-ionized, 16MΩ+ resistivity
HEC: Hydroxyethyl Cellulose
DGBE: 99+% Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy)ethanol]
Triton X-100(ultra pure): Polyethylene glycol mono [4-(1,1,3,3-tetramethylbutyl)phenyl]ether

## 6.10 Tissue simulating liquids: parameters

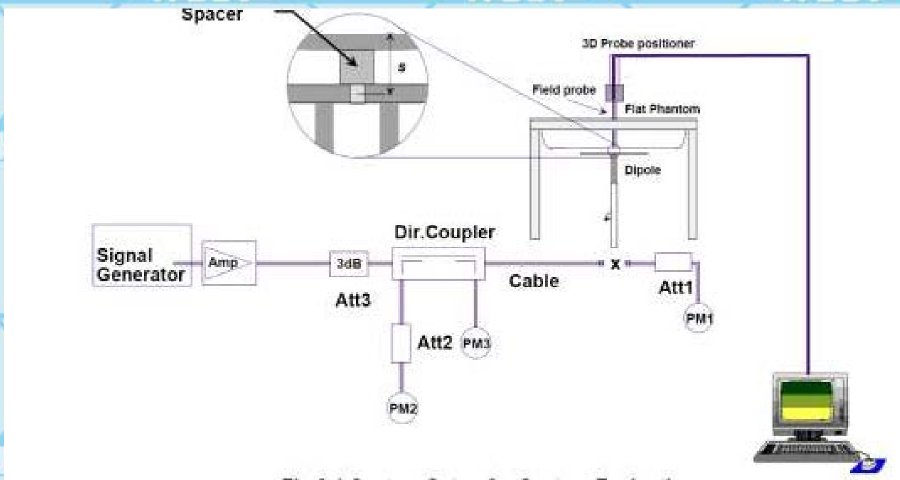
| Tissue Type | Measured Frequency (MHz) | Target Tissue | | | | Measured Tissue | | Liquid Temp. | Test Date |
|---|---|---|---|---|---|---|---|---|---|
| | | Target Permittivity $\varepsilon_r$ | Range of ±5% | Target Conductivity σ (S/m) | Range of ±5% | $\varepsilon_r$ | σ (S/m) | | |
| 2450MHz Body | 2410 | 52.80 | 50.16~55.44 | 1.91 | 1.81~2.00 | 52.50 | 1.94 | 21.6°C | 2018/03/15 |
| | 2435 | 52.70 | 50.07~55.34 | 1.94 | 1.84~2.04 | 52.52 | 1.95 | | |
| | 2450 | 52.70 | 50.07~55.34 | 1.95 | 1.85~2.05 | 52.73 | 1.96 | | |
| | 2460 | 52.70 | 50.07~55.34 | 1.96 | 1.86~2.06 | 52.76 | 1.99 | | |

$\varepsilon_r$= Relative permittivity, σ= Conductivity

# 7 System Check

## 7.1 System check procedure

The System check is performed by using a System check dipole which is positioned parallel to the planar part of the SAM phantom at the reference point. The distance of the dipole to the SAM phantom is determined by a spacer. The dipole is connected to the signal source consisting of signal generator and amplifier via a directional coupler, N-connector cable and adaption to SMA. It is fed with a power of 100 mW. To adjust this power a power meter is used. The power sensor is connected to the cable before the System check to measure the power at this point and do adjustments at the signal generator. At the outputs of the directional coupler both return loss as well as forward power are controlled during the validation to make sure that emitted power at the dipole is kept constant. This can also be checked by the power drift measurement after the test (result on plot).
System check results have to be equal or near the values determined during dipole calibration (target SAR in table above) with the relevant liquids and test system.



## 7.2 System check results

The system Check is performed for verifying the accuracy of the complete measurement system and performance of the software.The following table shows System check results for all frequency bands and tissue liquids used during the tests (plot(s) see annex A).

| System Check | Target SAR (1W) (+/-10%) | | | | Measured SAR (Normalized to 1W) | | Liquid Temp. | Test Date |
|---|---|---|---|---|---|---|---|---|
| | 1-g (W/g) | Range of ±10% 1-g (W/g) | 10-g (W/g) | Range of ±10% 10-g (W/g) | 1-g (W/g) | 10-g (W/g) | | |
| **D2450V2 Body** | 51.39 | 46.25~56.53 | 23.63 | 21.27~25.99 | 53.630 | 22.650 | 21.6°C | 2018/03/15 |
| Note: All SAR values are normalized to 1W forward power. | | | | | | | | |

# 8 SAR Test Test Configuration

## 8.1 Wi-Fi Test Configuration

For the 802.11b/g SAR tests, a communication link is set up with the test mode software for Wi-Fi mode test. The Absolute Radio Frequency Channel Number(ARFCN) is allocated to 1 ,6 and 11 respectively in the case of 2450 MHz.During the test,at the each test frequency channel, the EUT is operated at the RF continuous emission mode. Each channel should be tested at the lowest data rate. 802.11b/g operating modes are tested independently according to the service requirements in each frquency band. 802.11b/g modes are tested on channel 1, 6, 11; however,if output power reduction is necessary for channels 1 and/or 11 to meet restricted band requirements the highest output channel closest to each of these channels must be tested instead.

SAR is not required for 802.11g/n channels when the maximum average output power is less than 0.25dB higher than that measured on the corresponding 802.11b channels.

| Mode | Band | GHz | Channel | "Default Test Channels" | |
|---|---|---|---|---|---|
| | | | | 802.11b | 802.11g |
| 802.11b/g | 2.4 GHz | 2412 | 1# | √ | ▵ |
| | | 2437 | 6 | √ | ▵ |
| | | 2462 | 11# | √ | ▵ |

Notes:

√ = "default test channels"

▵= possible 802.11g channels with maximum average output ¼ dB the "default test channels"

# = when output power is reduced for channel 1 and /or 11 to meet restricted band requirements the highest output channels closest to each of these channels should be tested.

802.11 Test Channels per FCC Requirements

# 9 Detailed Test Results

## 9.1 Conducted Power measurements

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

### 9.1.1 Conducted Power of Wi-Fi 2.4G

| Mode | 802.11b | | |
|---|---|---|---|
| Channel / Frequency (MHz) | 1(2412) | 6(2437) | 11(2462) |
| Average Power(dBm) | 15.63 | **16.64** | 16.53 |
| Mode | 802.11g | | |
| Channel / Frequency (MHz) | 1(2412) | 6(2437) | 11(2462) |
| Average Power(dBM) | 15.59 | 16.37 | 16.50 |
| Mode | 802.11n(HT20) | | |
| Channel / Frequency (MHz) | 1(2412) | 6(2437) | 11(2462) |
| Average Power(dBM) | 13.45 | 14.58 | 14.29 |

Note:

<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 <= 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 <= 0.8 W/kg or all test positions are measured.

(2) For Wi-Fi 2.4 GHz, the highest measured maximum output power channel for DSSS was selected for SAR measurement. When the reported SAR is <= 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 <= 1.2 W/kg.

### 9.1.2 Conducted Power of BT

The maximum output power of BT 3.0 is:

| Mode | 1Mbps | | |
|---|---|---|---|
| Channel / Frequency (MHz) | 0(2402) | 39(2441) | 78(2480) |
| Average Power(dBm) | 8.32 | **8.44** | 8.18 |
| Mode | 2Mbps | | |
| Channel / Frequency (MHz) | 0(2402) | 39(2441) | 78(2480) |
| Average Power(dBm) | 7.77 | 8.15 | 7.86 |
| Mode | 3Mbps | | |
| Channel / Frequency (MHz) | 0(2402) | 39(2441) | 78(2480) |
| Average Power(dBm) | 7.39 | 7.63 | 7.46 |

The maximum output power of BLE is:

| Mode | 1Mbps | | |
|---|---|---|---|
| Channel / Frequency (MHz) | 0(2402) | 20(2422) | 39(2441) |
| Average Power(dBm) | -3.30 | **-2.32** | -2.70 |

### 9.1.3 Tune-up power tolerance

| Band | Tune-up power tolerance(dBm) | |
|---|---|---|
| 2.4G Wi-Fi | 802.11b | Max output power =16.0±1dbm |
| | 802.11g | Max output power =16.0±1dbm |
| | 802.11n (HT20) | Max output power =14.0±1dbm |
| BT3.0 | 1Mbps Power | Max output power =8.5dBm±0.5dbm |
| | 2Mbps Power | Max output power =8.0dBm±0.5dbm |
| | 3Mbps Power | Max output power =7.5dBm±0.5dbm |
| BLE | 1Mbps Power | Max output power =-3.0dBm±1.0dbm |

## 9.2 SAR test results

**Notes:**

1) Per KDB447498 D01v05 r02,the SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the scaled SAR measured at mid-band channel for each test configuration is at least 3.0 dB lower than the SAR limit (< 0.8 W/kg), testing at the high and low channels is optional.

2) Per KDB447498 D01v05r02, testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is: ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz. When the maximum output power variation across the required test channels is > ½ dB, instead of the middle channel, the highest output power channel must be used.

3) Per KDB447498 D01v06, All measurement SAR result is scaled-up to account for tune-up tolerance is compliant.

4) Per KDB648474 D04v01r03, body-worn accessory testing is typically associated with voice operations. Therefore, GSM voice was evaluated for body-worn with headset SAR.

5)Per KDB248227 D01v02r02, the procedures required to establish specific device operating configurations for testing the SAR of 802.11 a/b/g transmitters.

6) Per KDB865664 D01v01r04,for each frequency band,repeated SAR measurement is required only when the measured SAR is ≥0.8W/Kg; if the deviation among the repeated measurement is ≤20%,and the measured SAR <1.45W/Kg,only one repeated measurement is required.

7) Per KDB865664 D02v01r02, SAR plot is only required for the highest measured SAR in each exposure configuration, wireless mode and frequency band combination; Plots are also required when the measured SAR is > 1.5 W/kg, or > 7.0 W/kg for occupational exposure. The published RF exposure KDB procedures may require additional plots; for example, to support SAR to peak location separation ratio test exclusion and/or volume scan post-processing(Refer to appendix B for details).

8) Per KDB6162147 D04v01r02, the SAR requirements for laptop and tablet computers, and its to determine the minimum test separation distance .

### 9.2.1 Results overview of Wi-Fi 2.4G

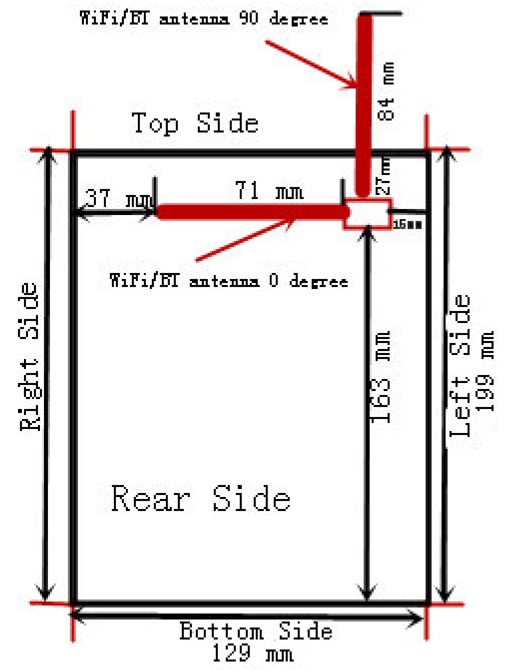
| Test Position of Body with 0mm | Test channel /Freq.(MHz) | Test Mode | SAR Value (W/kg) | | Power Drift (%) | Conducted Power (dBm) | Tune-up Limit (dBm) | Scaled $SAR_{1-g}$ (W/kg) | Scalig factor |
|---|---|---|---|---|---|---|---|---|---|
| | | | 1-g | 10-g | | | | | |
| Wi-Fi antenna (0 degree) to side | | | | | | | | | |
| Front side | 6/2437 | 802.11b | 0.339 | 0.128 | 1.150 | 16.640 | 17.000 | 0.368 | 1.086 |
| Rear side | 6/2437 | 802.11b | 0.569 | 0.254 | -1.470 | 16.640 | 17.000 | **0.618** | 1.086 |
| Top side | 6/2437 | 802.11b | 0.446 | 0.237 | 1.980 | 16.640 | 17.000 | 0.485 | 1.086 |
| Left side | 6/2437 | 802.11b | 0.413 | 0.201 | 1.000 | 16.640 | 17.000 | 0.449 | 1.086 |
| Right side | 6/2437 | 802.11b | 0.302 | 0.156 | 3.100 | 16.640 | 17.000 | 0.328 | 1.086 |
| Wi-Fi antenna (90 degree) to side | | | | | | | | | |
| Front side | 6/2437 | 802.11b | 0.253 | 0.149 | 1.110 | 16.640 | 17.000 | 0.275 | 1.086 |
| Rear side | 6/2437 | 802.11b | 0.374 | 0.192 | -1.090 | 16.640 | 17.000 | **0.406** | 1.086 |
| Left side | 6/2437 | 802.11b | 0.212 | 0.114 | -1.220 | 16.640 | 17.000 | 0.230 | 1.086 |

Note:

1) The maximum SAR value of each test band is shown in **bold** letters.
2) All measurement SAR result is scaled-up to account for tune-up tolerance is compliant.
3) For the antenna-to-edge distance is greater than 2.5cm,so the Right and Top sides do not need to be tested.

## 10 Multiple Transmitter Information

The SAR measurement positions of each side are as below:




<Rear Side>

| Side | Wi-Fi/BT antenna to Side |
|---|---|
| | SAR Consideration |
| Front Side | Yes |
| Rear Side | Yes |
| Left Side | Yes |
| Right Side | Yes |
| Top Side | Yes |
| Bottom Side | No |

**Note:** According to section 6.1.4.5 device with swivel antennas, if the antennas can be rotated to two planes, an evaluation should be performed and documented on the report to decide the highest exposure conditions, and only that position need consideration.

In addition, in case of this antenna, the two representative positions 0 degree and 90 degree shall be evaluated independently for each required EUT edge. When evaluating the test surfaces, the nearest distance between the antenna and the edges is applicable.

### 10.1.1 Stand-alone SAR test exclusion

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR,where

• f(GHz) is the RF channel transmit frequency in GHz

• Power and distance are rounded to the nearest mW and mm before calculation

• The result is rounded to one decimal place for comparison

When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

Body-Worn position

| Mode | Pmax(dBm) | Pmax(mW) | Distance(mm) | f(GHz) | Calculation Result | exclusion Threshold | SAR test exclusion |
|---|---|---|---|---|---|---|---|
| BT | 8.50 | 7.08 | 5.00 | 2.45 | 2.22 | 3.00 | Yes |

### 10.1.2 Simultaneous Transmission Possibilities

Note: The device does not support simultaneous BT and Wi-Fi ,because the BT and Wi-Fi share the same antenna and can't transmit simultaneously.

# 11 Measurement uncertainty evaluation

## 11.1 Measurement uncertainty evaluation for SAR test

The following table includes the uncertainty table of the IEEE 1528. The values are determined by Satimo.The breakdown of the individual uncertainties is as follows:

| Measurement Uncertainty evaluation for SAR test | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Uncertainty Component | Tol. (±%) | Prob. Dist. | Div. | $C_i$ (1g) | $C_i$ (10g) | 1g $U_i$ (±%) | 10g $U_i$ (±%) | $V_i$ |
| **measurement system** | | | | | | | | |
| Probe Calibration | 5.8 | N | 1 | 1 | 1 | 5.8 | 5.8 | ∞ |
| Axial Isotropy | 3.5 | R | $\sqrt{3}$ | $(1-C_p)^{1/2}$ | $(1-C_p)^{1/2}$ | 1.43 | 1.43 | ∞ |
| Hemispherical Isotropy | 5.9 | R | $\sqrt{3}$ | $\sqrt{C_p}$ | $\sqrt{C_p}$ | 2.41 | 2.41 | ∞ |
| Boundary Effect | 1 | R | $\sqrt{3}$ | 1 | 1 | 0.58 | 0.58 | ∞ |
| Linearity | 4.7 | R | $\sqrt{3}$ | 1 | 1 | 2.71 | 2.71 | ∞ |
| system Detection Limits | 1 | R | $\sqrt{3}$ | 1 | 1 | 0.58 | 0.58 | ∞ |
| Modulation response | 3 | N | 1 | 1 | 1 | 3.00 | 3.00 | ∞ |
| Readout Electronics | 0.5 | N | 1 | 1 | 1 | 0.50 | 0.50 | ∞ |
| Response Time | 0 | R | $\sqrt{3}$ | 1 | 1 | 0.00 | 0.00 | ∞ |
| Integration Time | 1.4 | R | $\sqrt{3}$ | 1 | 1 | 0.81 | 0.81 | ∞ |
| RF Ambient Conditions-Noise | 3 | R | $\sqrt{3}$ | 1 | 1 | 1.73 | 1.73 | ∞ |
| RF Ambient Conditions-Reflections | 3 | R | $\sqrt{3}$ | 1 | 1 | 1.73 | 1.73 | ∞ |
| Probe Positioner Mechanical Tolerance | 1.4 | R | $\sqrt{3}$ | 1 | 1 | 0.81 | 0.81 | ∞ |
| Probe positioning with respect to Phantom Shell | 1.4 | R | $\sqrt{3}$ | 1 | 1 | 0.81 | 0.81 | ∞ |
| Extrapolation, interpolation and Integration Algorithms for Max.SAR Evaluation | 2.3 | R | $\sqrt{3}$ | 1 | 1 | 1.33 | 1.33 | ∞ |
| **Test sample Related** | | | | | | | | |
| Test Sample Positioning | 2.6 | N | 1 | 1 | 1 | 2.60 | 2.60 | 11 |
| Device Holder Uncertainty | 3 | N | 1 | 1 | 1 | 3.00 | 3.00 | 7 |
| Output Power Variation-SAR drift measurement | 5 | R | $\sqrt{3}$ | 1 | 1 | 2.89 | 2.89 | ∞ |
| SAR scaling | 2 | R | $\sqrt{3}$ | 1 | 1 | 1.15 | 1.15 | ∞ |

| Phantom and Tissue Parameters | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Phantom Uncertainty (shape and thickness tolerances) | 4 | R | $\sqrt{3}$ | 1 | 1 | 2.31 | 2.31 | ∞ |
| Uncertainty in SAR correction for deviation (in permittivity and conductivity) | 2 | N | 1 | 1 | 0.84 | 2.00 | 1.68 | ∞ |
| Liquid conductivity（meas.） | 2.5 | N | 1 | 0.64 | 0.43 | 1.60 | 1.08 | 5 |
| Liquid conductivity (target.) | 5 | R | $\sqrt{3}$ | 0.64 | 0.43 | 1.85 | 1.24 | 5 |
| Liquid Permittivity（meas.） | 2.5 | N | 1 | 0.60 | 0.49 | 1.50 | 1.23 | ∞ |
| Liquid Permittivity (target.) | 5 | R | $\sqrt{3}$ | 0.60 | 0.49 | 1.73 | 1.42 | ∞ |
| **Combined Standard Uncertainly** | | Rss | | | | 10.63 | 10.54 | |
| **Expanded Uncertainty{95% CONFIDENCE INTERRVAL}** | | k | | | | 21.26 | 21.08 | |

## 11.2 Measurement uncertainty evaluation for system check

The following table includes the uncertainty table of the IEEE 1528. The values are determined by Satimo.The breakdown of the individual uncertainties is as follows:

| Uncertainty For System Performance Check | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Uncertainty Component | Tol. (±%) | Prob. Dist. | Div. | $C_i$ 1g | $C_i$ 10g | 1g $U_i$(±%) | 10g $U_i$ (±%) | $V_i$ |
| **measurement system** | | | | | | | | |
| Probe Calibration | 5.8 | N | 1 | 1 | 1 | 5.80 | 5.80 | ∞ |
| Axial Isotropy | 3.5 | R | $\sqrt{3}$ | $(1-C_p)^{1/2}$ | $(1-C_p)^{1/2}$ | 1.43 | 1.43 | ∞ |
| Hemispherical Isotropy | 5.9 | R | $\sqrt{3}$ | $\sqrt{C_p}$ | $\sqrt{C_p}$ | 2.41 | 2.41 | ∞ |
| Boundary Effect | 1 | R | $\sqrt{3}$ | 1 | 1 | 0.58 | 0.58 | ∞ |
| Linearity | 4.7 | R | $\sqrt{3}$ | 1 | 1 | 2.71 | 2.71 | ∞ |
| system detection Limits | 1 | R | $\sqrt{3}$ | 1 | 1 | 0.58 | 0.58 | ∞ |
| Modulation response | 0 | N | 1 | 1 | 1 | 0.00 | 0.00 | ∞ |
| Readout Electronics | 0.5 | N | 1 | 1 | 1 | 0.50 | 0.50 | ∞ |
| Response Time | 0 | R | $\sqrt{3}$ | 1 | 1 | 0.00 | 0.00 | ∞ |
| Integration Time | 1.4 | R | $\sqrt{3}$ | 1 | 1 | 0.81 | 0.81 | ∞ |
| RF ambient Conditions - Noise | 3 | R | $\sqrt{3}$ | 1 | 1 | 1.73 | 1.73 | ∞ |
| RF ambient Conditions – Reflections | 3 | R | $\sqrt{3}$ | 1 | 1 | 1.73 | 1.73 | ∞ |
| Probe positioned Mechanical Tolerance | 1.4 | R | $\sqrt{3}$ | 1 | 1 | 0.81 | 0.81 | ∞ |
| Probe positioning with respect to Phantom Shell | 1.4 | R | $\sqrt{3}$ | 1 | 1 | 0.81 | 0.81 | ∞ |
| Extrapolation, interpolation and integration Algorithms for Max. SAR Evaluation | 2.3 | R | $\sqrt{3}$ | 1 | 1 | 1.33 | 1.33 | ∞ |
| **Dipole** | | | | | | | | |
| Deviation of experimental source from numerical source | 4 | N | 1 | 1 | 1 | 4.00 | 4.00 | ∞ |
| Input power and SAR drift measurement | 5 | R | $\sqrt{3}$ | 1 | 1 | 2.89 | 2.89 | ∞ |
| Dipole axis to liquid Distance | 2 | R | $\sqrt{3}$ | 1 | 1 | 1.16 | 1.16 | ∞ |

| **Phantom and Tissue Parameters** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Phantom Uncertainty (shape and thickness tolerances) | 4 | R | $\sqrt{3}$ | 1 | 1 | 2.31 | 2.31 | ∞ |
| Uncertainty in SAR correction for deviation (in permittivity and conductivity) | 2 | N | 1 | 1 | 0.84 | 2.00 | 1.68 | ∞ |
| Liquid conductivity（meas.） | 2.5 | N | 1 | 0.64 | 0.43 | 1.60 | 1.08 | 5 |
| Liquid conductivity (target.) | 5 | R | $\sqrt{3}$ | 0.64 | 0.43 | 1.85 | 1.24 | 5 |
| Liquid Permittivity（meas.） | 2.5 | N | 1 | 0.60 | 0.49 | 1.50 | 1.23 | ∞ |
| Liquid Permittivity (target.) | 5 | R | $\sqrt{3}$ | 0.60 | 0.49 | 1.73 | 1.41 | ∞ |
| **Combined Standard Uncertainty** | | Rss | | | | 10.28 | 9.98 | |
| **Expanded Uncertainty (95% Confidence interval)** | | k | | | | 20.57 | 19.95 | |

## 12 Test equipment and ancillaries used for tests

To simplify the identification of the test equipment and/or ancillaries which were used, the reporting of the relevant test cases only refer to the test item number as specified in the table below.

| | Manufacturer | Device Type | Type(Model) | Serial number | calibration | |
|---|---|---|---|---|---|---|
| | | | | | Last Cal. | Due Date |
| ☒ | SATIMO | COMOSAR DOSIMETRIC E FIELD PROBE | SSE5 | SN 09/13 EP170 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 835 MHz REFERENCE DIPOLE | SID835 | SN 14/13 DIP0G835-235 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 900 MHz REFERENCE DIPOLE | SID900 | SN 14/13 DIP0G900-231 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 1800 MHz REFERENCE DIPOLE | SID1800 | SN 14/13 DIP1G800-232 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 1900 MHz REFERENCE DIPOLE | SID1900 | SN 14/13 DIP1G900-236 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 2000 MHz REFERENCE DIPOLE | SID2000 | SN 14/13 DIP2G000-237 | 2017-07-25 | 2018-07-24 |
| ☒ | SATIMO | COMOSAR 2450 MHz REFERENCE DIPOLE | SID2450 | SN 14/13 DIP2G450-238 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 2600 MHz REFERENCE DIPOLE | SID2600 | SN 28/14 DIP2G600-327 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 5200 MHz REFERENCE DIPOLE | SID5200 | SN 14/13 EPG239 | 2017-07-25 | 2018-07-24 |
| ☐ | SATIMO | COMOSAR 5800 MHz REFERENCE DIPOLE | SID5800 | SN 14/13 EPG239 | 2017-07-25 | 2018-07-24 |
| ☒ | SATIMO | Software | OPENSAR | N/A | N/A | N/A |
| ☒ | SATIMO | Phantom | COMOSAR IEEE SAM PHANTOM | SN 14/13 SAM99 | N/A | N/A |
| ☒ | R & S | Universal Radio Communication Tester | CMU 200 | 117528 | 2017-08-19 | 2018-08-18 |
| ☒ | HP | Network Analyser | 8753D | 3410A08889 | 2017-08-19 | 2018-08-18 |
| ☒ | HP | Signal Generator | E4421B | GB39340770 | 2017-08-19 | 2018-08-18 |
| ☒ | Keithley | Multimeter | Keithley 2000 | 4014539 | 2017-08-19 | 2018-08-18 |
| ☒ | SATIMO | Amplifier | Power Amplifier | MODU-023-A-0004 | 2017-10-13 | 2018-10-12 |
| ☒ | Agilent | Power Meter | E4418B | GB43312909 | 2017-10-13 | 2018-10-12 |
| ☒ | Agilent | Power Meter Sensor | E4412A | MY41500046 | 2017-10-13 | 2018-10-12 |
| ☒ | Agilent | Power Meter | E4417A | GB41291826 | 2017-10-13 | 2018-10-12 |
| ☒ | Agilent | Power Meter Sensor | 8481H | MY41091215 | 2017-10-13 | 2018-10-12 |
| ☒ | SATIMO | DAE | SUPR72 | SN 42/13 | 2017-07-25 | 2018-07-24 |

## Annex A: System performance verification

(**Please See the SAR Measurement Plots of annex A.**)

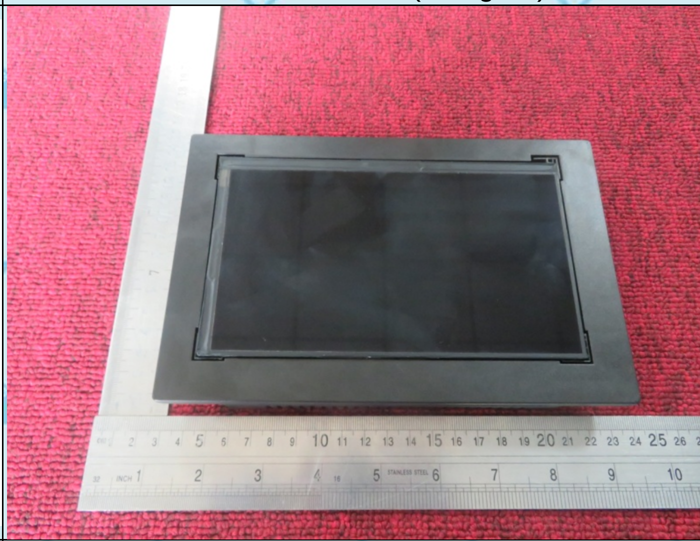
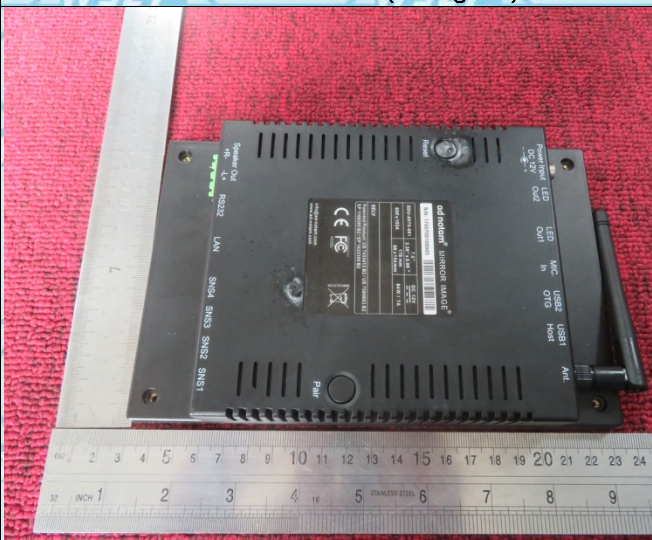
## Annex B: Measurement results

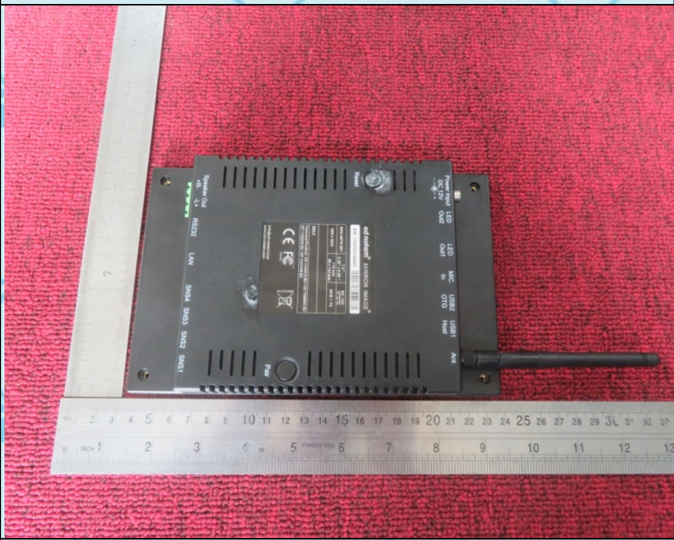
(**Please See the SAR Measurement Plots of annex B.**)

## Annex C: Calibration reports

**(Please See the Calibration reports of annex C.)**

## Annex D: Photo documentation

| Photo 1: Measurement System OPENSAR | Photo 2: Front view(0 degree) |
|---|---|
|  |  |
| Photo 3: Rear View(0 degree) | Photo 4: Front view (90 degree) |
|  |  |

| Photo 5: Rear View (90 degree) | Photo 6: Front Side 0mm(0 degree and 90 degree) |
| --- | --- |
|  |  |
| Photo 7: Rear Side 0mm(0 degree and 90 degree) | Photo 8: Left Side 0mm(0 degree and 90 degree) |
|  |  |

| Photo 9: Top Side 0mm(0 degree) | Photo 10: Right Side 0mm(0 degree) |
|---|---|
|  |  |
| Photo 11: 2450MHz Liquid Depth ≥ 15.0cm | |
|  | N/A |

| | |
|---|---|
| | **Annex A: System Check** |
| | **Tested Model : SDU-0070-001** |
| | **Report Number:**<br>**FCC18010018A** |

# MEASUREMENT 1

BODY

Type: Validation measurement (Complete)

Date of measurement: 15/3/2018

Measurement duration: 9 minutes 46 seconds

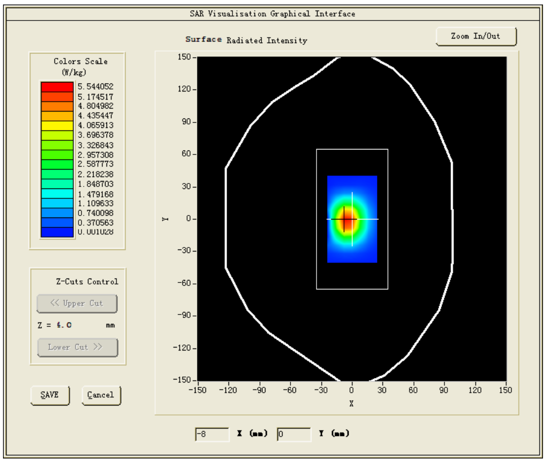
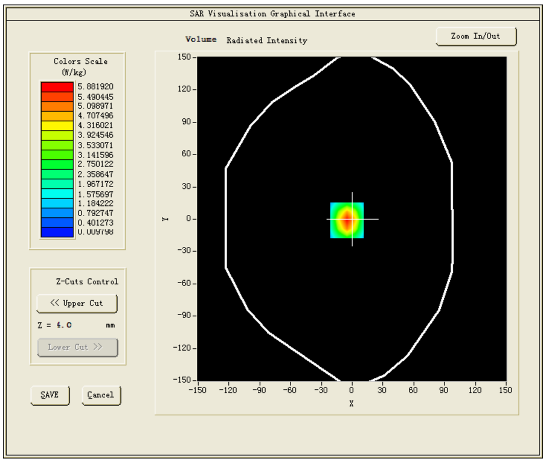
## A. Experimental conditions.

| | |
|---|---|
| **Area Scan** | dx=8mm dy=8mm |
| **ZoomScan** | 5x5x7,dx=8mm dy=8mm dz=5mm,Complete |
| **Phantom** | Validation plane |
| **Device Position** | Dipole |
| **Band** | CW2450 |
| **Channels** | Middle |
| **Signal** | CW (Crest factor: 1.0) |

## B. SAR Measurement Results

Middle Band SAR (Channel -1):

| | |
|---|---|
| **Frequency (MHz)** | 2450.000000 |
| **Relative permittivity (real part)** | 52.735699 |
| **Relative permittivity (imaginary part)** | 14.017300 |
| **Conductivity (S/m)** | 1.907910 |
| **Variation (%)** | 0.390000 |

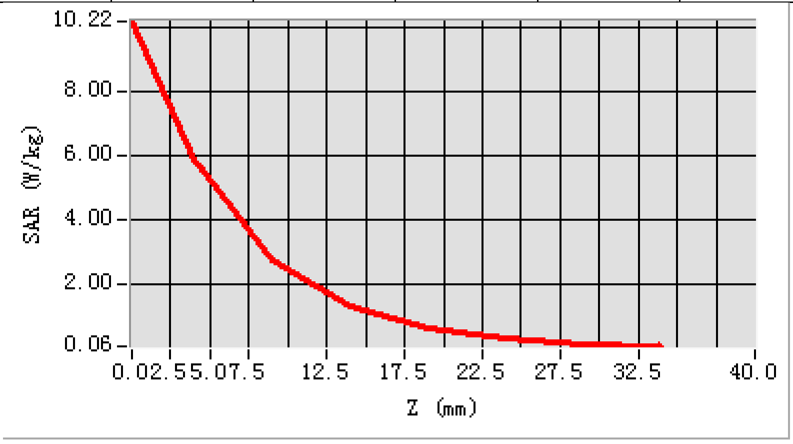
<table>
<tr><th>SURFACE SAR</th><th>VOLUME SAR</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

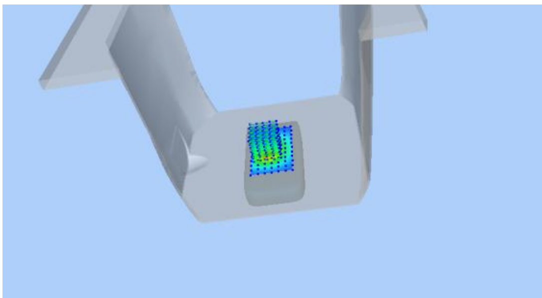
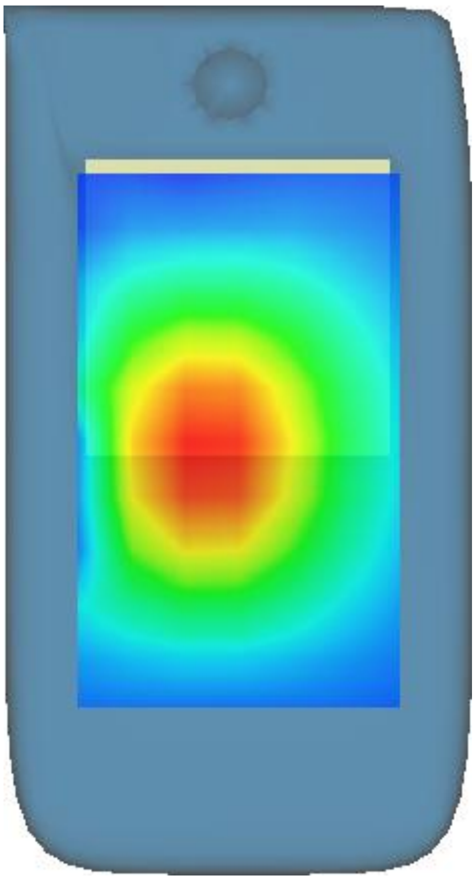
**Maximum location: X=-5.00, Y=-1.00**

**SAR Peak: 10.96 W/kg**

| | |
|---|---|
| **SAR 10g (W/Kg)** | 2.265453 |
| **SAR 1g (W/Kg)** | 5.363343 |

| Z (mm) | 0.00 | 4.00 | 9.00 | 14.00 | 19.00 | 24.00 | 29.00 |
|---|---|---|---|---|---|---|---|
| SAR (W/Kg) | 10.2188 | 5.8819 | 2.7478 | 1.3151 | 0.6266 | 0.2969 | 0.1341 |




| 3D screen shot | Hot spot position |
|---|---|
|  |  |

# Annex B: Measurement Results

## Tested Model : SDU-0070-001

## Report Number: FCC18010018A

# MEASUREMENT 1

Rear-side-middle

Type: Phone measurement (Complete)

Date of measurement: 15/3/2018

Measurement duration: 11 minutes 14 seconds

## A. Experimental conditions.

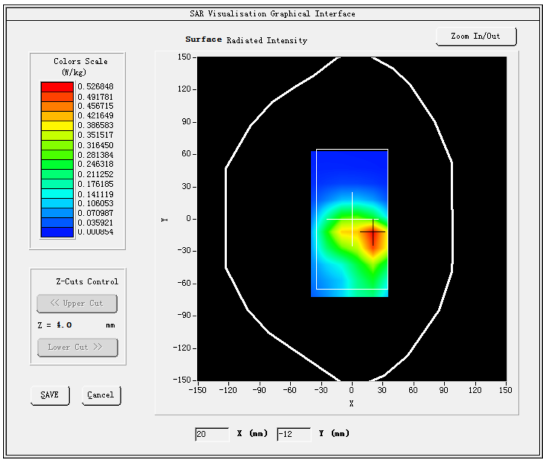
| | |
|---|---|
| **Area Scan** | dx=8mm dy=8mm |
| **ZoomScan** | 7x7x7,dx=5mm dy=5mm dz=5mm,Complete |
| **Phantom** | Validation plane |
| **Device Position** | Body |
| **Band** | IEEE 802.11b ISM |
| **Channels** | Middle |
| **Signal** | Duty cycle:1:1 |
| **Conversion factor** | 4.11 |

## B. SAR Measurement Results

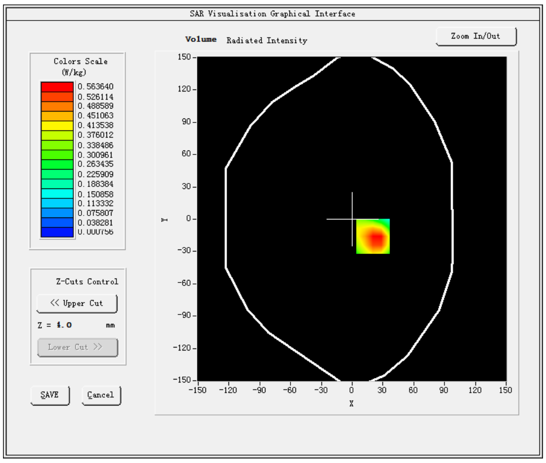
Middle Band SAR (Channel 6):

| | |
|---|---|
| **Frequency (MHz)** | 2437.000000 |
| **Relative permittivity (real part)** | 52.756401 |
| **Relative permittivity (imaginary part)** | 14.076200 |
| **Conductivity (S/m)** | 1.909671 |
| **Variation (%)** | -1.470000 |

## SURFACE SAR




## VOLUME SAR

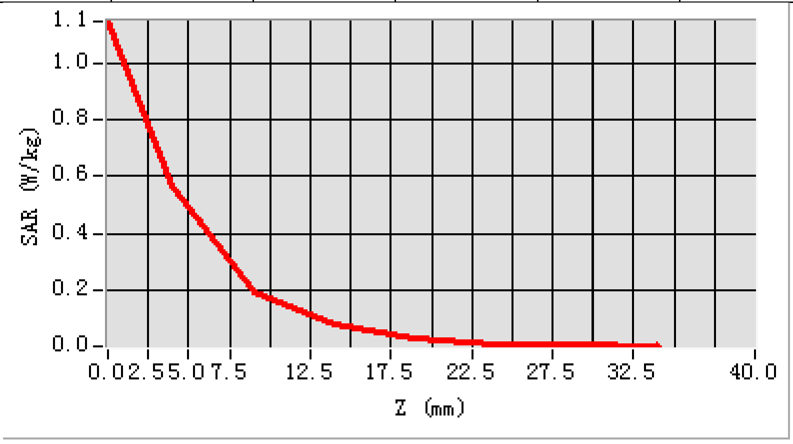


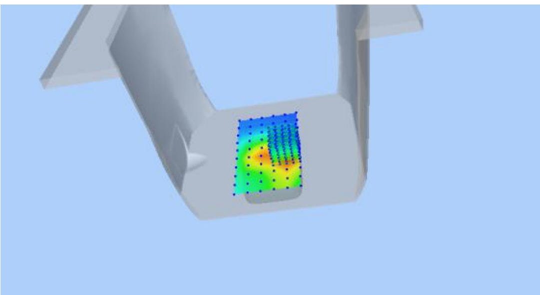
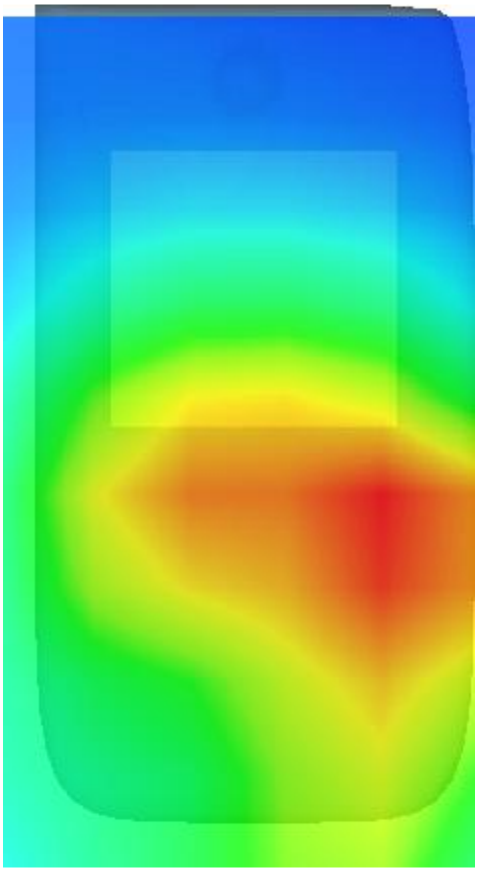

**Maximum location: X=20.00, Y=-16.00**

**SAR Peak: 1.14 W/kg**

| | |
|---|---|
| **SAR 10g (W/Kg)** | 0.253941 |
| **SAR 1g (W/Kg)** | 0.569146 |

| Z (mm) | 0.00 | 4.00 | 9.00 | 14.00 | 19.00 | 24.00 | 29.00 |
|---|---|---|---|---|---|---|---|
| SAR (W/Kg) | 1.1467 | 0.5636 | 0.1899 | 0.0760 | 0.0315 | 0.0111 | 0.0052 |




| 3D screen shot | Hot spot position |
|---|---|
|  |  |

| | |
|---|---|
| SATIMO | **Annex C: Calibration Reports** |
| | **Tested Model : SDU-0070-001** |
| | **Report Number:**<br>**FCC18010018A** |

# SAR Reference Dipole Calibration Report

Ref : ACR.176.6.15.SATU.A

**WORLD STANDARDIZATION CERTIFICATION & TESTING GROUP CO .,LTD**

**BLOCK A-B, BAO SHI SCIENCE PARK,BAO SHI ROAD, BAO'AN DISTRICT**

**SHENZHEN 518108,P.R. CHINA**

## MVG COMOSAR REFERENCE DIPOLE

**FREQUENCY: 2450 MHZ**

**SERIAL NO.: SN 14/13 DIP 2G450-238**

**Calibrated at MVG US**

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

**Calibration Date: 7/25/2017**

*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.

| | *Name* | *Function* | *Date* | *Signature* |
|---|---|---|---|---|
| *Prepared by :* | Jérôme LUC | Product Manager | 7/25/2017 | JS |
| *Checked by :* | Jérôme LUC | Product Manager | 7/25/2017 | JS |
| *Approved by :* | Kim RUTKOWSKI | Quality Manager | 7/25/2017 | Kim Rutkowski |

| | *Customer Name* |
|---|---|
| *Distribution :* | WORLD STANDARDIZATION CERTIFICATION & TESTING GROUP CO .,LTD |

| *Issue* | *Date* | *Modifications* |
|---|---|---|
| A | 7/25/2017 | Initial release |
| | | |
| | | |
| | | |

# TABLE OF CONTENTS

# 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 14/13 DIP 2G450-238 |
| 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 constucted 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

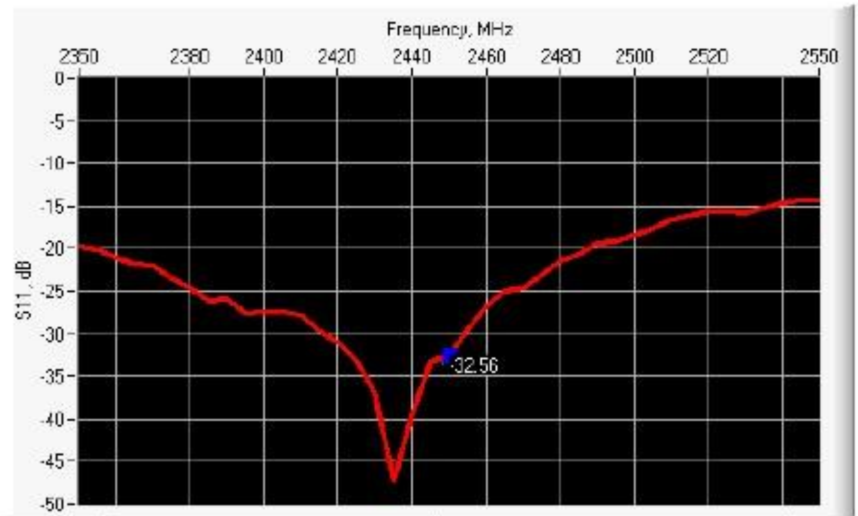
The guidelines outlined in the IEEE 1528, FCC KDBs, CENELEC EN50361 and CEI/IEC 62209 standards were followed to generate the measurement uncertainty for validation measurements.

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

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

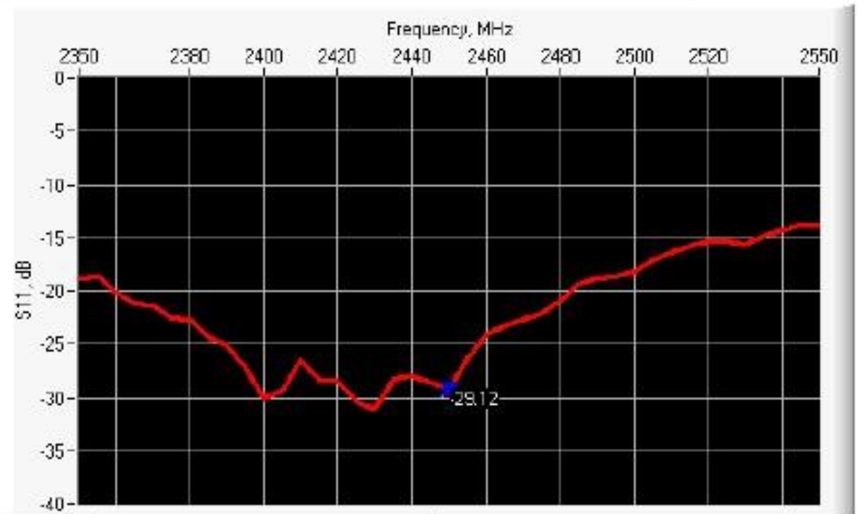
# 6 CALIBRATION MEASUREMENT RESULTS

## 6.1 RETURN LOSS AND IMPEDANCE IN HEAD LIQUID




| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|---|---|---|---|
| 2450 | -32.56 | -20 | 48.3 Ω - 1.6 j |

## 6.2 RETURN LOSS AND IMPEDANCE IN BODY LIQUID




| Frequency (MHz) | Return Loss (dB) | Requirement (dB) | Impedance |
|---|---|---|---|
| 2450 | -29.12 | -20 | 0.0 Ω + 11.0 j |

## 6.3 MECHANICAL DIMENSIONS

| **Frequency** MHz | **L** mm | | **h** mm | | **d** mm | |
|---|---|---|---|---|---|---|
| | **required** | **measured** | **required** | **measured** | **required** | **measured** |
| 300 | 420.0 ±1 %. | | 250.0 ±1 %. | | 6.35 ±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 MHz | Relative permittivity ($\varepsilon_r'$) | | Conductivity (σ) S/m | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 300 | 45.3 ±5 % | | 0.87 ±5 % | |
| 450 | 43.5 ±5 % | | 0.87 ±5 % | |
| 750 | 41.9 ±5 % | | 0.89 ±5 % | |
| 835 | 41.5 ±5 % | | 0.90 ±5 % | |
| 900 | 41.5 ±5 % | | 0.97 ±5 % | |
| 1450 | 40.5 ±5 % | | 1.20 ±5 % | |
| 1500 | 40.4 ±5 % | | 1.23 ±5 % | |
| 1640 | 40.2 ±5 % | | 1.31 ±5 % | |
| 1750 | 40.1 ±5 % | | 1.37 ±5 % | |

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

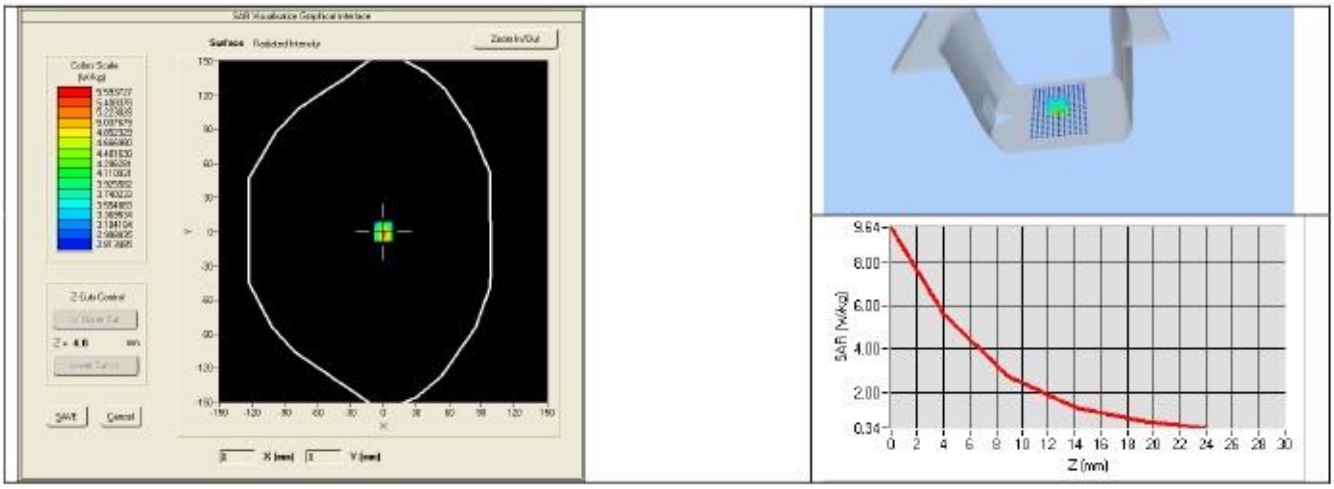
## 7.2 SAR MEASUREMENT RESULT WITH HEAD LIQUID

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

| | |
|---|---|
| Software | OPENSAR V4 |
| Phantom | SN 20/09 SAM71 |
| Probe | SN 18/11 EPG122 |
| Liquid | Head Liquid Values: eps' : 38.3 sigma : 1.80 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=5mm/dy=5mm/dz=5mm |
| Frequency | 2450 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

| Frequency 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 | 53.41 (5.34) | 24 | 23.95 (2.40) |
| 2600 | 55.3 | | 24.6 | |
| 3000 | 63.8 | | 25.7 | |
| 3500 | 67.1 | | 25 | |




## 7.3 BODY LIQUID MEASUREMENT

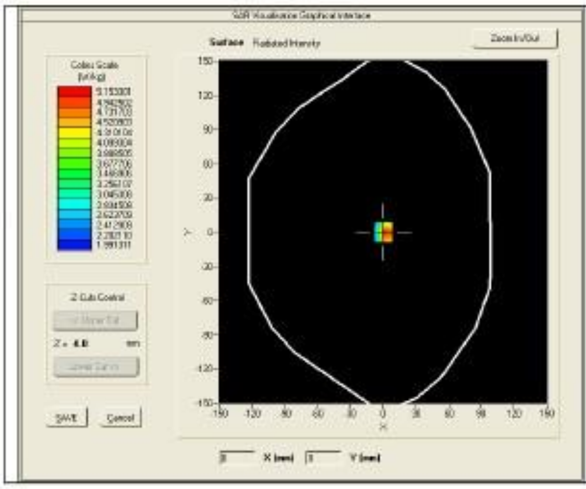
| Frequency MHz | Relative permittivity ( ′) | | Conductivity (σ) S/m | |
|---|---|---|---|---|
| | required | measured | required | measured |
| 150 | 61.9 ±5 % | | 0.80 ±5 % | |
| 300 | 58.2 ±5 % | | 0.92 ±5 % | |
| 450 | 56.7 ±5 % | | 0.94 ±5 % | |
| 750 | 55.5 ±5 % | | 0.96 ±5 % | |
| 835 | 55.2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

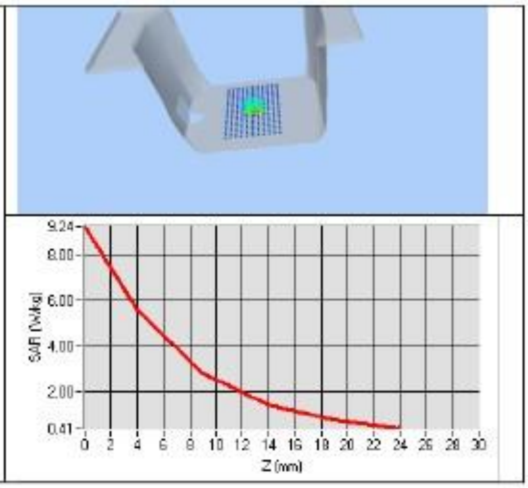
| | | | | |
|---|---|---|---|---|
| 2600 | 52.5 ±5 % | | 2.16 ±5 % | |
| 3000 | 52.0 ±5 % | | 2.73 ±5 % | |
| 3500 | 51.3 ±5 % | | 3.31 ±5 % | |
| 5200 | 49.0 ±10 % | | 5.30 ±10 % | |
| 5300 | 48.9 ±10 % | | 5.42 ±10 % | |
| 5400 | 48.7 ±10 % | | 5.53 ±10 % | |
| 5500 | 48.6 ±10 % | | 5.65 ±10 % | |
| 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: eps' : 52.7 sigma : 1.94 |
| Distance between dipole center and liquid | 10.0 mm |
| Area scan resolution | dx=8mm/dy=8mm |
| Zoon Scan Resolution | dx=5mm/dy=5mm/dz=5mm |
| Frequency | 2450 MHz |
| Input power | 20 dBm |
| Liquid Temperature | 21 °C |
| Lab Temperature | 21 °C |
| Lab Humidity | 45 % |

| **Frequency** MHz | **1 g SAR (W/kg/W)** | **10 g SAR (W/kg/W)** |
|---|---|---|
| | **measured** | **measured** |
| 2450 | 51.39 (5.14) | 23.63 (2.36) |





## 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 | 02/2015 | 02/2018 |
| Calipers | Carrera | CALIPER-01 | 12/2016 | 12/2019 |
| Reference Probe | MVG | EPG122 SN 18/11 | 06/2017 | 06/2020 |
| Multimeter | Keithley 2000 | 1188656 | 12/2016 | 12/2019 |
| Signal Generator | Agilent E4438C | MY49070581 | 12/2016 | 12/2019 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 12/2016 | 12/2019 |
| Power Sensor | HP ECP-E26A | US37181460 | 12/2016 | 12/2019 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Temperature and Humidity Sensor | Control Company | 11-661-9 | 12/2014 | 12/2017 |

# COMOSAR E-Field Probe Calibration Report

Ref : ACR.331.3.17.SATU.A

**WORLD STANDARDIZATION CERTIFICATION & TESTING GROUP CO .,LTD**

**BLOCK A, BAO SHI SCIENCE PARK,BAO SHI ROAD, BAO'AN DISTRICT**

**SHENZHEN 518108,P.R. CHINA**

**MVG COMOSAR DOSIMETRIC E-FIELD PROBE**

**SERIAL NO.: SN 07/15 EP252**

**Calibrated at MVG US**

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

**Calibration Date: 11/27/2017**

*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.

| | *Name* | *Function* | *Date* | *Signature* |
|---|---|---|---|---|
| *Prepared by :* | Jérôme LUC | Product Manager | 11/27/2017 | |
| *Checked by :* | Jérôme LUC | Product Manager | 11/27/2017 | |
| *Approved by :* | Kim RUTKOWSKI | Quality Manager | 11/27/2017 | |

| | *Customer Name* |
|---|---|
| *Distribution :* | World Standardization Certification & Testing Group Co .,Ltd |

| *Issue* | *Date* | *Modifications* |
|---|---|---|
| A | 11/27/2017 | Initial release |
| | | |
| | | |
| | | |

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# 1 DEVICE UNDER TEST

| Device Under Test | |
|---|---|
| Device Type | COMOSAR DOSIMETRIC E FIELD PROBE |
| Manufacturer | MVG |
| Model | SSE5 |
| Serial Number | SN 07/15 EP252 |
| Product Condition (new / used) | New |
| Frequency Range of Probe | 0.7 GHz-3GHz |
| Resistance of Three Dipoles at Connector | Dipole 1: R1=0.202 MΩ<br>Dipole 2: R2=0.233 MΩ<br>Dipole 3: R3=0.206 MΩ |

A yearly calibration interval is recommended.

# 2 PRODUCT DESCRIPTION

## 2.1 GENERAL INFORMATION

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

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

| | |
|---|---|
| Probe Length | 330 mm |
| Length of Individual Dipoles | 4.5 mm |
| Maximum external diameter | 8 mm |
| Probe Tip External Diameter | 5 mm |
| Distance between dipoles / probe extremity | 2.7 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% |
| **Combined standard uncertainty** | | | | | 5.831% |
| **Expanded uncertainty**<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 % |

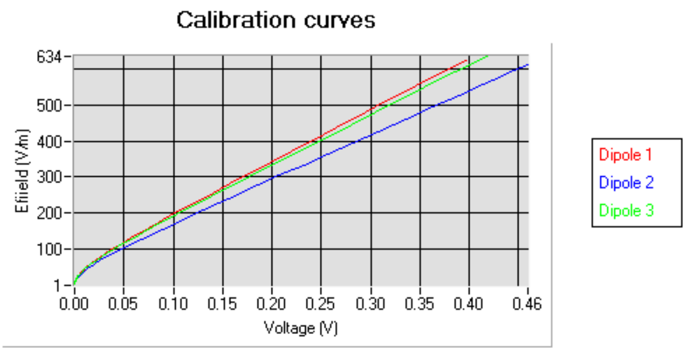
## 5.1 SENSITIVITY IN AIR

| Normx dipole 1 ($\mu V/(V/m)^2$) | Normy dipole 2 ($\mu V/(V/m)^2$) | Normz dipole 3 ($\mu V/(V/m)^2$) |
|---|---|---|
| 5.11 | 6.67 | 5.81 |

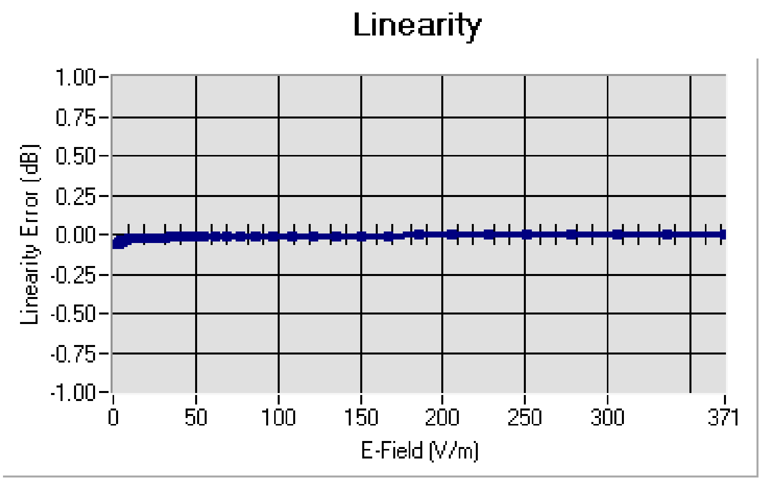
| DCP dipole 1 (mV) | DCP dipole 2 (mV) | DCP dipole 3 (mV) |
|---|---|---|
| 99 | 99 | 95 |

Calibration curves ei=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:+/-1.35% (+/-0.06dB)

## 5.3 SENSITIVITY IN LIQUID

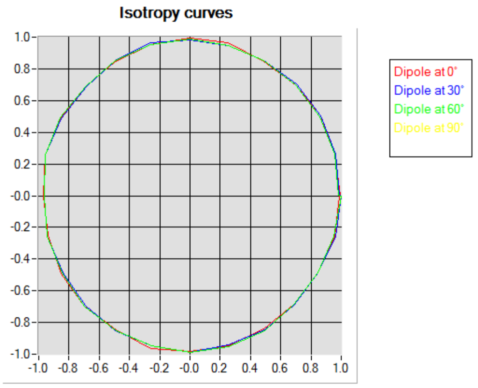
| Liquid | Frequency (MHz +/- 100MHz) | Permittivity | Epsilon (S/m) | ConvF |
|---|---|---|---|---|
| HL750 | 750 | 42.09 | 0.91 | 5.38 |
| BL750 | 750 | 55.69 | 0.95 | 5.54 |
| HL850 | 835 | 42.71 | 0.89 | 5.54 |
| BL850 | 835 | 57.52 | 1.03 | 5.75 |
| HL900 | 900 | 41.94 | 0.93 | 5.53 |
| BL900 | 900 | 52.87 | 1.09 | 5.74 |
| HL1800 | 1800 | 40.62 | 1.39 | 4.65 |
| BL1800 | 1800 | 53.22 | 1.47 | 4.80 |
| HL1900 | 1900 | 41.22 | 1.37 | 5.17 |
| BL1900 | 1900 | 50.99 | 1.52 | 5.28 |
| HL2000 | 2000 | 40.39 | 1.36 | 5.00 |
| BL2000 | 2000 | 54.39 | 1.54 | 5.14 |
| HL2300 | 2300 | 38.10 | 1.74 | 4.89 |
| BL2300 | 2300 | 53.33 | 1.85 | 4.93 |
| HL2450 | 2450 | 40.46 | 1.87 | 4.83 |
| BL2450 | 2450 | 54.62 | 1.95 | 5.02 |
| HL2600 | 2600 | 38.46 | 2.01 | 4.51 |
| BL2600 | 2600 | 51.98 | 2.16 | 4.66 |

LOWER DETECTION LIMIT: 8mW/kg

## 5.4 ISOTROPY

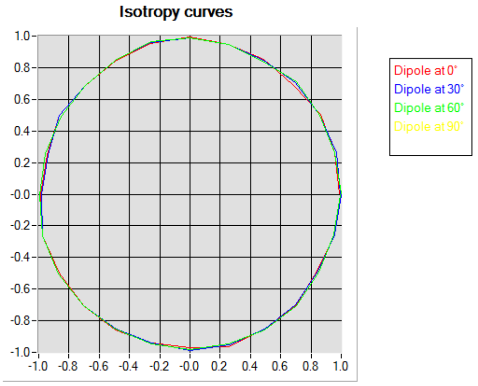
**HL900 MHz**

- Axial isotropy: 0.04 dB
- Hemispherical isotropy: 0.07 dB




**HL1800 MHz**

- Axial isotropy: 0.04 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 | 10/2017 | 10/2018 |
| Multimeter | Keithley 2000 | 1188656 | 01/2017 | 01/2020 |
| Signal Generator | Agilent E4438C | MY49070581 | 01/2017 | 01/2020 |
| Amplifier | Aethercomm | SN 046 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Power Meter | HP E4418A | US38261498 | 01/2017 | 01/2020 |
| Power Sensor | HP ECP-E26A | US37181460 | 01/2017 | 01/2020 |
| Directional Coupler | Narda 4216-20 | 01386 | Characterized prior to test. No cal required. | Characterized prior to test. No cal required. |
| Waveguide | Mega Industries | 069Y7-158-13-712 | Validated. No cal required. | Validated. No cal required. |
| Waveguide Transition | Mega Industries | 069Y7-158-13-701 | Validated. No cal required. | Validated. No cal required. |
| Waveguide Termination | Mega Industries | 069Y7-158-13-701 | Validated. No cal required. | Validated. No cal required. |
| Temperature / Humidity Sensor | Control Company | 150798832 | 11/2017 | 11/2020 |